METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Patent Application No. 16/203,128, filed November 28, 2018, which is a divisional of U.S. Patent Application No. 15/162,113, filed May 23, 2016, that claims the benefit of U.S. Provisional Application No. 62/262,767, filed December 3, 2015, which are all incorporated herein by reference in their entireties.

BACKGROUND

1. Field of the Description.

[0002] The present invention relates, in general, to anti-counterfeiting devices for currency and brand authentication, and, more particularly, to currency and brand authentication elements, and methods of designing and manufacturing such authentication elements, that are configured to provide a multi-planar image that is viewable without special eyewear and that is difficult, if not nearly impossible, to replicate or copy.

2. Relevant Background.

[0003] Anti-counterfeiting efforts often involve use of an anti-counterfeiting device or element that is made up of an array of lenses and an image printed onto the back of the lens array or onto an underlying substrate or surface (e.g., a sheet of paper or plastic). The anti-counterfeiting element may be used to display an image that is chosen to be unique and be an indicator that the item carrying the anti-counterfeiting element is not a counterfeit. The anti-counterfeiting market is rapidly growing worldwide with anti-counterfeiting elements placed on a wide range of items such as upon currency (e.g., on a surface of a paper bill to help prevent copying) and on labels for retail products (e.g., labels on clothing showing authenticity).

[0004] In this regard, moiré patterns have been used for years in anti-counterfeiting elements with arrays of round lenses and with arrays of hexagonal lenses (or round and hexagonal lens arrays). Typically, the printed images provided in an ink layer under these lens arrays are small, fine images relative to the size of the lenses. A moiré pattern is provided in the printed images in the form of a

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secondary and visually evident superimposed pattern that is created when two identical patterns on a surface are overlaid while being displaced or rotated a small amount from each other.

[0005] In such moiré pattern-based anti-counterfeiting elements, some of the images may be printed in a frequency slightly more or less frequent than the one-to-one dimension of the lenses in two axes, and some of the images may be printed slightly differently relative to each other. While helpful to reduce counterfeiting, use of moiré patterns with round lens arrays has not been wholly satisfactory for the anti-counterfeiting market. One reason is that the effects that can be achieved with moiré patterns are limited, and the effect is often relatively easy to reverse engineer, which limits its usefulness as an anti-counterfeiting element. For example, printing the underlying image is becoming easier to accomplish due to high resolution lasers and setters and other printing advances. Typically, for an element, the micro-lenses are printed using an emboss and fill technology, which limits the printing to one color due to the fact that the process tends to be self-contaminating after one color and also due to the fact that the process is difficult to control from a relative color-to-color pitch in the emboss-and-fill printing process.

[0006] In other cases, holograms and lens features are used for security devices in currency, brand authentication and brand protection as well as on high security documents. Holograms are becoming increasingly less secure, in part, due to the rise in technology, programming, and general availability of programs that allow one to easily create holograms. In many applications, the cheaper dot matrix holograms are "good enough" to simulate many of the effects of the more expensive elaborate holograms used in anti-counterfeiting elements. While lens features done properly can be more secure than hologram elements, there is a need for new technology to combat the currency and product counterfeiting. Ideally, new technology would have attributes that are not possible with holography or micro-lenses.

[0007] Hence, there remains a need for advancements in the design and fabrication of assemblies or elements that display imagery useful for anti-counterfeiting and/or product/document authentication. For example, such improvements may allow new anti-counterfeiting devices or elements to be produced for use with currency, labels, credit/debit cards, and other items, and these anti-counterfeiting devices preferably would be much more difficult if not nearly impossible to duplicate or copy. Further, there is a growing demand for such anti-counterfeiting devices to provide a

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surprising or "wow factor" with their displayed imagery such as images that float above and/or below a focal plane (e.g., more true 3D displays) rather than merely laterally reflecting back light such as with a sequence of mirrors or mirrored surface or using reproducible holograms.

SUMMARY

[0008] Briefly, the inventors recognized that an anti-counterfeiting or security device can be provided that is configured to "write" images with light in one, two, or more spatial planes above and below the surface of an array of micro mirrors. Each of the micro mirrors is oriented (or "programmed") to act with a number of other such micro mirrors (e.g., a "set of pixel-providing micro mirrors") as one pixel in the written image(s) as the set of micro mirrors each directs its reflected light to a particular location in the image(s) display plane(s) (e.g., an apex of a cone with each of the micro mirrors in the set of pixel-providing micro mirrors being within the base of the cone) that when viewed with a number of other such pixels (each provided by a different set of pixel-providing micro mirrors) makes up a written image in one or more spaced apart image display planes.

[0009] In other words, text, imagery, and so forth can be written with ambient light by focusing the micro-mirrors to different spatial planes above the plane of the security device (which is typically provided on a surface of a document (e.g., currency) or product being authenticated with the security device). Conversely, the technology can then "reverse" to the viewer by having the "bright" pixels go to "dark" and the backgrounds reverse from "light' to "dark" with a change of perspective (e.g., occurring when the viewer changes their viewing angle or rotates the document/product containing the security device).

[0010] Also, since the technology is made of mirrors (made from thin aluminum, silver or gold depositions on an upper surface of the document/product on which the security element is provided (e.g., any supporting substrate)), the anti-counterfeiting or security device will work from two sides in a film process (e.g., when the supporting substrate is transparent). This type of two-sided or two-view image cannot be done with holography or other presently available anti-counterfeiting technologies. The technology can be embossed into films, metallized, and then processed into currency threads, foil stamps, labels and packaging. It can also be directly stamped onto coins or other metallic surfaces (e.g., provided on nearly any supporting substrate). Color can also be added

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to the displayed or "written" image(s) by using a reflective ink printing method or with the use of dielectric nanostructures (e.g., with plasmonic resonance and/or other techniques).

[0011] More particularly, a visual display assembly is provided that is useful as a security element on paper and coin currency, product labels, and other objects. The assembly includes a substrate (which may be part of the object upon which the security element is provided such as a piece of currency or a product label). The assembly also includes, on a surface of the substrate, an array of micro mirrors receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate. The image includes or is "written" with a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

[0012] In some embodiments, each of the sets of the micro mirrors includes at least twenty of the micro mirrors (e.g. a number in the range of 20 to 40 such as about 30 mirrors). To provide a "bright" or light pixel, the reflected ambient light from the twenty or more micro mirrors intersects or crosses at (or passes near to) the point corresponding to the one of the pixels (e.g., each pixel is displayed or lit by beams/rays from reflective surfaces of the micro mirrors crossing at a common point on the image display plane). The point on the plane may correspond to an apex of a cone, and the twenty or more micro mirrors can be located within a base of the cone coplanar with the surface of the substrate. The micro mirrors within the base of the cone but excluded from (or not included in or used for) the set of the micro mirrors displaying the pixel are oriented to reflect the ambient light away from point on the plane corresponding to the pixel to provide a dark background for the image.

[0013] The assembly may be configured to display images in more than one image display plane or in two or more levels/layers. In this regard, the array of mirrors may be configured to behave further in response to the receiving of the ambient light to display a second image in a second plane spaced a distance apart from the plane displaying the image. The second image may be provided or "written" with a plurality of pixels (as was the case with the first image). The array of micro mirrors includes, for each of the pixels of the second image, a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the second plane corresponding to one of the pixels of the second image. The first image has a first viewing angle and the second image has a

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second viewing angle offset from the first viewing angle by at least 10 degrees (such as an offset angle in the range of 10 to 45 degrees with offset angles of 20 to 30 degrees being useful in some embodiments).

[0014] In some particular implementations, the substrate is transparent, whereby the image is displayed to be spaced apart the distance from a first side of the substrate and further whereby a second image including a second set of pixels is displayed by the array of micro mirrors to be spaced apart a second distance from a second side of the substrate opposite the first side. In this manner, the array of micro mirrors can be said to be completely functional on the reverse side of the substrate (or film) to present a mirror image or a reverse image (in the image plane) to the viewer on the opposite side of the substrate.

[0015] In the same or other embodiments, the micro mirrors are rectangular (e.g., square) with a smallest side having a length of at least 35 microns such as 50 microns or more while other embodiments use mirrors that are circular with a diameter of at least 35 microns (e.g., 50 microns or larger in diameter). In practice, the plane in which the image is displayed may be above, below, or coinciding with the focal plane for the array of the micro mirrors. Also, the image may be displayed using only (or mostly) white light (and off or dark pixels) or the micro mirrors may be configured to display the image with colors (in addition to white). This may be achieved with at least one of ink, plasmonic resonance, and dielectric material being used to configure the micro mirrors to display the image with the desired colors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Fig. 1 is a top perspective, partial view of a visual display assembly for use as an anti-counterfeiting element or device showing a single micro mirror that would be provided in an array of such micro mirrors;

[0017] Fig. 2 is a side view (e.g., a functional schematic) of an object (such as currency, a document, a financial card, or the like) including an anti-counterfeiting or authentication (or security) element/device of the present description;

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[0018] Fig. 3 is an enlarged view of a subset of the micro mirrors of the security element of Fig. 2 corresponding to micro mirrors in an area of one cone base associated with one cone apex or written pixel in one of the displayed/written images provided by the security element of Fig. 2;

[0019] Fig. 4 is a schematic or graphic side view or diagram of a security element during its use to provide a two-layer or level image;

[0020] Fig. 5 is a side schematic view or diagram of a security element during its use to provide a display that combines a light image and a dark image;

[0021] Fig. 6 is a functional block diagram of a computer or computing device configured to run an array design program to allow an operator to generate a design of an array of micro mirrors for displaying a particular image(s) when provided in a security element;

[0022] Fig. 7 is a flow diagram of an exemplary design method for an array of micro mirrors for use in a security element, such as may be carried out by operation of the system of Fig. 6;

[0023] Figs. 8A and 8B illustrate a micro mirror design GUI that can be displayed on a monitor or display by the design program;

[0024] Figs. 9A-9C are graphs illustrating images that can be displayed on various levels or image display planes by an array of micro mirrors of the present description;

[0025] Fig. 10 is a plot illustrating a ray tracing near a first image display plane or first level/layer for one modeled array of micro mirrors;

[0026] Fig. 11 illustrates a representative GUI or ray tracing menu that allows a user to specify parameters to utilize in performing the ray tracing;

[0027] Fig. 12 is a plot of a representative ray tracing showing beams/rays reflected from micro mirrors in a mirror plane and converging on a viewer's retina;

[0028] Figs. 13A and 13B illustrate written or displayed images provided by an array of micro mirrors with an angular offset between image display planes or levels/layers of the imagery;

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[0029] Figs. 14A and 14B illustrate plots of floating pixels in a space above an array of micro mirrors; and

[0030] Figs. 15A and 15B illustrate plots generated and displayed by a preview program (which may be a subroutine of the design program described herein) for previewing likely or predicted results of a design of an array of micro mirrors.

DETAILED DESCRIPTION

[0031] Briefly, the present description is directed toward visual display assemblies that can be used as anti-counterfeiting or authentication elements or devices such as on currency, coins, documents, products, and so on. Each visual display assembly includes an array of a large number of micro mirrors, and this array can be provided on a surface of nearly any supporting substrate (e.g., a surface of a piece of currency, on a coin, on a surface of a product or its sales/identification label, and so on). Sets (or subsets) of the micro mirrors are used to work in unison to "write" pixels of images in one, two, or more image display planes above the supporting substrate by having each of the micro mirrors in each of the pixel-providing sets direct light striking its first or upper reflective surface to a location of a pixel in one of the image display planes. The sets of pixels may be configured to provide angular offset viewing (e.g., by an offset angle in the range of 15 to 35 degrees or the like with 20 degrees used in some cases between the viewing angles of the written images of each adjacent image display plane) in the different image display planes such that a viewer typically only observes or perceives the written pixels of one image display plane at a time (or at a single viewing angle or perspective) and switching occurs as the viewer changes their viewing angle or rotates the substrate supporting the visual display assembly and its many micro mirrors.

[0032] The visual display assembly (or security element/device) is designed to create a floating image(s) of pixels, and the pixel-providing sets of micro mirrors are chosen to have a large enough number to effectively display a great enough quantity of light to allow a viewer to perceive each separate, floating pixel in the written or displayed image. The number of micro mirrors used in each set may vary due to a large number of parameters such as material used to provide the reflective upper surface, size of each micro mirror (e.g., with 35 to 100 micron mirrors used in some implementations and 50 micron mirrors used in one prototype of the present invention), and the like. Each of these micro mirrors in each pixel-providing set is oriented to try to have all of these micro mirrors direct

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their reflected light to intersect at a point (the written pixel of the displayed image) in an image display plane above the supporting substrate, and each pixel of the written image is either on or off (or providing light or no light) at various viewing angles.

[0033] A basic or underlying idea of the micro mirror-based visual display assembly is to use ambient light and a plane (an upper surface of a supporting substrate) containing many, small mirrors. The ambient light that is reflected off the mirrors is aimed or targeted toward desired points (or pixels) above the plane that contains the mirrors. The image displayed by all the pixel-providing sets of micro mirrors targeting a first image display plane above the supporting substrate may be considered a first layer image. The first layer image can be defined by artwork that has light or dark pixels to be produced in this first layer (or a multi-layer image) or first image display plane. To this end, the mirrors in a pixel-providing set of micro mirrors are carefully selected from the micro mirror array as being within a circle (or cone base) defined by the intersection of the cone defined by an apex angle and a pixel from the desired image display plane/layer (e.g., the first image display plane) that is chosen to coincide with the apex of the cone. Each of these mirrors (which are in the base of the cone) is then aimed or targeted (or "oriented") toward the cone apex (image's pixel) so that the resulting effect is a point source of light floating a height or distance above (or below in some cases) the plane of the supporting surface containing the array of micro mirrors at the location of the pixel.

[0034] Prior to explaining a design or configuration of an entire array of micro mirrors in a visual display assembly, it may be useful to first look at a single one of these mirrors. Figure 1 illustrates a portion of a visual display assembly 100 (or a substrate with a security element or device) according to the present description. As shown, a supporting substrate 110 with a surface 112 is provided that receives and supports a micro mirror 120. For example, the substrate 110 may be a piece of currency, a coin, a product label, a document, a credit/debit/bank card, or the like for which it is desired to provide anti-counterfeiting or authentication functionality with the visual display assembly or security element 100. The micro mirror 120 is shown to include a body (or lower layer/surface) 122 that is affixed to or integrally formed with the surface 112 of the substrate 110. The view in Figure 1 is only "partial" as it will be understood that the assembly 100 typically would include many (e.g., hundreds to many thousands) of the micro mirrors 120 (i.e., an array of micro mirrors 120). Each of such micro mirrors 120 is individually oriented or "programmed" as discussed below such that the micro mirrors

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120 of the array act together to display one or more floating images made up of a plurality of pixels in one or more image display planes above the substrate surface 112.

[0035] The micro mirror 120 also includes an upper (or exposed) reflective surface 124 facing away from the surface 112 of the supporting substrate 110. This surface 124 is reflective as the micro mirror 120 typically will be formed of a metal or metallic compound or other material chosen for its reflective properties. For example, the micro mirror 120 may be a thin layer of aluminum, silver, gold, or the like provided by deposition upon the surface 112 of the substrate 110. When the image display assembly 100 is in use, ambient light 130 strikes the reflective upper surface 124 of the micro mirror 120 and is reflected as shown at 134 from the upper surface 124. Particularly, the micro mirror's upper surface 124 is to have a normal vector 135 (e.g., as may be defined as output of a design program with X, Y, and Z coordinates), and the incoming ray 130 and the normal vector 135 from the same angle, β, as is formed between the normal vector 135 and the reflected light 134.

[0036] The reflected light 134 is preferably directed or aimed so as to cross an image display plane 140, which is spaced apart a height, H_1, above or away from the substrate surface 112 (and reflective surface 124 which may be substantially coplanar due to the small thickness of the body 122), at a location (X-Y-Z coordinates may define this location relative to the surfaces 112 and 124) coinciding with or defining one of a plurality of written pixels 142 of an image displayed by the assembly 100 in the plane 140. While not shown, a plurality of other micro mirrors configured similar to mirror 120 would also reflect their received ambient light to the point/pixel 142 in the plane 140 (a plurality of reflected light beams from micro mirrors would intersect at the point/pixel 142) so as to provide a point source of light at 142 viewable by a viewer 102.

[0037] To provide this desired reflection of light 134, the micro mirror 120 is oriented or has its reflective surface 124 oriented in a particular, predefined (e.g., by a visual display assembly configuration computer program or algorithm) manner. Particularly, each micro mirror 120 may be individually oriented by rotating its body 122 (or surface 124) about one or both of first and second rotation axes 150, 152 as shown with arrows 151, 153 during design processes (prior to fabrication). Then, the micro mirror 120 may be formed with these design parameters so that the reflective upper surface 124 (with its known location in the array of micro mirrors by X-Y coordinates of its center) is oriented (at first and second angles) relative to the two axes 150, 152 to have its normal vector 135

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aimed or targeted in a particular manner (X-Y-Z coordinates of the normal vector for the mirror 120), e.g., to have ambient light 130 reflected as shown at 134 to cross the image display plane 140 at the location of the pixel 142. As noted above, the size (and shape) of each micro mirror 120 may be varied to practice the invention with some embodiments utilizing square-shaped bodies 122 that have sides with a length, L_{Side}, that is typically greater than about 35 microns (such as 50 microns) and often in the range of 40 to 60 microns while some embodiments may use larger micro mirrors.

[0038] Figure 2 is a side view (e.g., a functional schematic) 200 of an object (such as currency, a document, a financial card, or the like) 210 including an anti-counterfeiting or authentication (or security) element/device 220 of the present description. The object or substrate 210 includes an upper or first surface 212 upon which is provided or formed the security device 220 (which may take the form of the visual display assembly 100 of Figure 1). The security device 220 has an exposed or upper surface 222 that is configured to provide an array of micro mirrors 224, which may be individually oriented to provide reflection of ambient light striking the surface 222 of the security element 220 so as to display one or more floating images that can be observed by a viewer 202 to authenticate the object 210.

[0039] To this end, a first number of the micro mirrors 224 may be configured to provide sets of pixel-providing micro mirrors that reflect ambient light as shown with arrows 230 to "write" or display a first displayed image 242 made up of a plurality of pixels 243 (with each of these pixels 243 associated with one of the sets of pixel-providing micro mirrors 224). A second number of the micro mirrors 224 is configured to provides sets of pixel-providing micro mirrors that reflect ambient light as shown with arrows 250 to "write" or display a second displayed image 262 made up of a plurality of pixels 263 (with each of these pixels 263 being associated or written by one of the sets of pixel-providing micro mirrors 224). As discussed with reference to Figure 1, each of the micro mirrors 224 in the same set of pixel-providing micro mirrors 224 used to create/write a particular pixel 243, 263 in one of the images 242, 262 is configured or oriented with its reflective surface oriented (with rotation relative to one and/or two rotation axes) to target or direct a point/location on the plane 240 or 260 coinciding with the pixel 243, 263. This, in most embodiments, coincides with an apex of a cone with each of the pixels 243, 263 in the set of micro mirrors 224 being in the base of the cone (e.g., within the circular area on the surface 222 defined by the cone base). Note, each of these micro

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mirrors 224, though, is oriented uniquely and differently to provide the reflected light 230, 250 along a normal vector to its reflective surface.

[0040] To the viewer 202, the first displayed image 242 appears to float in the first image display plane 240 that is a height, H_1, above the surface 212 of the object/substrate 210 while the second displayed image 262 appears to float in the second image display plane 260 that is a different (typically greater) height, H_2, above the surface 212. The micro mirrors 224 are oriented so that the pixels 243 of the first image 242 are a viewing angle offset, θ_{Offset}, (e.g., 10 to 30 degrees or the like) from the pixels 263 of the second image 262 so that the viewer 202 typically only views one of the floating images 242, 262 at a time (at a range of viewing angles).

[0041] As discussed above, micro mirrors for each set of pixel-providing micro mirrors are chosen from a set of available micro mirrors located within an area on the security element surface (or substrate surface) that corresponds with a base of the cone with an apex coinciding with the pixel being created by these micro mirrors. Figure 3 is an enlarged view of a subset of the micro mirrors 224 on the surface 222 of the security element 220 of Figure 2, which correspond to micro mirrors 224 in an area of one cone base with diameter, $Diam_{Cone\ Base}$, associated with one cone apex or written pixel 243 or 263 in one of the displayed/written images 242 or 262 provided by the security element 220.

[0042] Figure 3 illustrates all the available micro mirrors 224 in the cone base, but the security element 220 typically is designed so that only a subset of these available mirrors 224 (such as 20 to 40 or more with 30 shown in use in Figure 3 at 324) are used to write or display a particular pixel. The unused mirrors 224 typically are oriented to reflect received ambient light away from the location of the pixel being written/created by the chosen mirrors 324, which may be considered as providing a mask with the unused mirrors 224. The chosen mirrors 324 (or mirrors in the set of pixel-providing micro mirrors) are shown with shading/patterning that would not be actually present in a security element but that is useful for differentiating these mirrors 324 from the other/unused ones of the mirrors 224.

[0043] As will be explained below, the micro mirrors 324 in the set of pixel-providing micro mirrors are randomly chosen such that the mirrors 324 do not provide an obvious, regular pattern and each pixel's set of micro mirrors 224 likely will have a very different pattern within a cone base or circular

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area of the surface 222 of the security element 220. Also, each of the micro mirrors 324 in the set used to provide a particular pixel 243 or 263 will be differently oriented so as to have the normal vectors of all the mirrors 324 intersect at the X-Y-Z coordinates of the same pixel 243 or 263 in the appropriate one of the image display planes 240 or 260.

[0044] Significantly, the mirrors 324 are not pointing toward a viewer but, instead, are aimed or targeted toward the intersection point (or pixel coordinates) in the image display plane or layer. The use of sets of micro mirrors to provide or create floating pixels that in combination can write or display an image in one, two, or more layers is effective in providing a displayed image with depth and with high contrast. Further, the image appears to switch from light to dark with rotation of the object/substrate with the security element (or with movement of the viewer's eyes to change their viewing angle or perspective).

[0045] Figure 4 is a schematic or graphic side view or diagram 400 of a security element 410 during its use to provide a two-layer or level image. The security element 410 includes a micro mirror array 412 made up of numerous (e.g., thousands) micro mirrors (e.g., 50 micron diameter mirrored surfaces). As shown, three sets of micro mirrors in the array 412 have been oriented or configured to display pixels 422 in a first plane or at a first level 420 above the security element 410 (or its surface containing the array 412). As shown with arrows 423, light is reflected so that beams from a set of the micro mirrors intersect to create a pixel 422 in the first level 420. These are provided within a cone angle, β_{Cone}, Further, as shown with arrows 425, a mask or mask image may defined to block some rays by having the mirrors that would provide this light directed outside of the conical angle, β_{Cone}, region (e.g., the arrows 425 are associated with light that is not actually reflected for viewing with the light 423 but is, instead, directed elsewhere).

[0046] Also, as shown two sets of micro mirrors in the array 412 have been oriented or configured to display pixels 432 in a second plane or at a second level 430 spaced apart from level 420. Arrows 433 represent beams of reflected light that are directed from these sets of mirrors to intersect or cross at the locations of the pixels 432. Also, as shown, the pixels are displayed to the viewer at viewing angles that are offset by an angle (pixel offset angle), γ (such as 10 to 30 degrees or the like). The basic angle direction of the pixels 432 is chosen to offset the image in the plane/level 430 for the viewer (or at the viewer) from the image in the plane/level 420.

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[0047] Figure 5 is a schematic or diagram 500 similar to that of Figure 4 but showing an embodiment of a security element 510 with an array of mirrors adapted specifically to provide two light and dark images. The diagram 500 illustrates that the sets of pixel-providing micro mirrors on the security element 510 (or in a mirror planar surface) can be oriented to provide a light image (with bright pixels with a dark background) that when going in reverse provides a dark image with a light background as the viewer rotates the element 510 or otherwise changes their perspective.

[0048] As shown, the security element 510 has a planar mirror surface with an array of micro mirrors adapted to reflect light in directed beams 514 and 518. The beams/rays 514 are directed so as to display/create pixels 522 on a first plane 520 that is more proximate to the mirror plane of security element 510 (with only two pixels 522 shown in each image plane 520 and 530 (in each displayed image) for clarity with it being understood that any number of pixels (1 to more typically many (e.g., a few hundred to several thousand or the like)) may be used to create each image with the size of the mirrors and overall array provided in security element 510 being the only limitations). The beams/rays 518 provided by the other sets of pixel-providing mirrors in element 510 are directed/aimed to cross/intersect on the second image displaying plane 530 (which is spaced apart from the first plane 520 some distance such 0.25 to 1 inch to several inches or more) to display/create pixels 532.

[0049] To make the images provided by the pixels 522, 532 appear light and dark, the beams 514 and 532 are separated by an angle, ϕ, (e.g., 15 to 30 degrees or more) as may be measured between proximate ones of the beams in each group 514 and 518 (e.g., after the beams cross proximate to the mirror plane of security element 510 such as at or after the first image display plane 520). The angle of image separation, ϕ, and the cone angles at pixels 522, 532 are chosen to give this angular separation. Images of bright and dark zones do not overlap, and images provided by pixels 522 and 532 appear to the viewer to be in the two spaced apart or different planes 520, 530. One image darkens as the other lightens as the view angle changes.

[0050] Figure 6 is a functional block diagram of a computer or computing device 600 configured to run an array design program to allow an operator to generate a design of an array of micro mirrors for displaying a particular image(s) when provided in a security element (e.g., to perform steps of the method of manufacturing a security element with an array of micro mirrors according to the present

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description). The computer 600 includes a processor(s) 610 that executes code/instructions in computer readable media to run or provide the functionality of the micro mirror array design program 630 as well as those of the ray tracing module(s) 635. The processor 610 also manages operation of input/output (I/O) devices 620 such as a keyboard, a mouse, a touch pad or screen, voice recognition software, and the like configured to allow a user to provide input such as to select design parameters for a particular security element. The I/O devices 620 may include a monitor/display 624 and the design program 630 may be configured to generate one or more graphical user interfaces (GUIs) 628 displayed on the monitor/display device 624 to facilitate a user providing input and to display calculated results (such as the calculated angular orientations of each mirror in the array).

[0051] The processor 610 during the running of the design program 630 may access and manage memory (or data storage device) 640, which may be onboard as shown or offboard but accessible by the processor 610. The output of the design program 630 is stored at 650 in memory 640 and provides a design for an array of micro mirrors for a particular security element to be manufactured. The design 650 is shown at 651 to include a calculated angular orientation for each mirror in the array. This may be defined at 652 with a center location of the mirror (e.g., X-Y coordinates) combined with coordinates of a normal vector (e.g., X-Y-Z coordinates) for the mirror. This information can be used in a manufacture (e.g., deposition or other processes) of a security element for an object (such as for currency, coins, product labels, documents, and the like).

[0052] To allow the design program 630 to generate the array design 650, a user typically initially chooses a digital image 660 as a base or starting image for creating an anti-counterfeit or authentication image to be displayed in one or more planes or levels relative to the array of micro mirrors. The user/operator then may use the GUI 628 or other I/O devices 620 to identify one or more images to be displayed on each level of the image displayed by the security element being designed as shown at 662, 663. For example, images in the first plane or level 662 may be foreground images in the base/start image 660 while images 663 in the second (or later) plane or level 663 may be background (or intermediate) images of the base/start image 660. The design program 630 or another program on the computer 600 or available to the processor 610 may then be used to convert the digital base/start image 660 into a text or other file that identifies each pixel in the base/start image as being assigned to a particular one of the levels/planes (e.g., a text file with a plurality of numbers replacing

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the pixels of the image 660 representing one of the planes/levels of the image to be displayed by the security element being designed using the design program 630).

[0053] At this stage of operations, the design program 630 may function to generate a GUI 628 with a number of data entry boxes/fields prompting the user to accept default design parameter values or to enter/modify such values. The design program 630 may then operate to calculate the array design 650 including the angular orientations of each of the micro mirrors in an array. For example, the user may set or define a cone angle, as shown at 666 in memory 640, for use for generating the pixels of images in each level/plane used to display a security image. The cone angle often will differ for each level such as with larger values assigned to earlier/lower levels/planes (but this is not required), and exemplary cone angles for image pixels may be in the range of 10 to 30 degrees or the like.

[0054] The user may also be asked to provide or select an angular offset between each pair of image levels/planes as shown at 668 in memory 640, and this offset may range from 0 to 30 or more degrees to achieve a desired effect for a displayed image. Other parameters that may be entered or set by the user of the system 600 may include the dots per inch (DPI) 670 that defines the spacing of the pixels in each image display level or plane (the cone apex planes). The user may also be allowed to set the number mirrors to be used to create or display each pixel as shown in memory 640 at 680 (with 20 to 40 mirrors likely to be useful in some implementations). Further, the user may define heights of the image display levels or planes as shown at 688 (such as a first plane at 10000 microns, a second plane at 20000 microns, a third plane at 30000 microns or other useful spacings/heights).

[0055] With the parameters defined, the user may instruct the design program 630 to run to first choose, for each pixel in each image to be displayed in the levels/planes, a set of micro mirrors to be used to display or create the pixel. The other pixels may be considered unused pixels or pixels that can be used in a mask, and these pixels may be angularly oriented to direct light outside of the cone angle. The design program 630 may then continue with determining an array design 650 with these sets of pixel-providing mirrors 684 by calculating for each of the micro mirrors of the array its angular orientation 651, which may be provided by the coordinates (e.g., X-Y coordinates or the like) of the center of each mirror and the coordinates (e.g., X-Y-Z coordinates or the like) of the normal vector for the mirror with such center coordinates. This determination of the design 650 is carried out such that the micro mirrors in each set of pixel-providing mirrors is oriented to direct its reflected ambient

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light (a reflected light stream or beam or ray) onto the same image display plane at the same location (e.g., at a location of a pixel). The ray tracing module 635 may be configured to test the effectiveness of the array design 650 as explained below to ray trace reflected light providing images to a viewer's eye (or expected viewing positions relative to a security element with the array of micro mirrors having angular orientations as called out in the array design 650).

[0056] Figure 7 is a flow diagram of an exemplary design method 700 for an array of micro mirrors for use in a security element, such as may be carried out by operation of the system 600 of Figure 6. The method 700 starts at 705 such as with loading a design program onto a computing device and initiating or running the program. The method 700 continues at 710 with selecting a base or start image such as selecting a file in memory of a computing device providing a digital image of objects that may be useful for providing a multi-layer display for use in authenticating an object (e.g., an image with one or more components that can be presented as foreground images and one or more components that can be presented as background and/or intermediate images or on layers that appear behind the foreground images).

[0057] In step 720, the method 700 involves a user indicating which portions/components of the base/start image from step 710 should be presented in the image(s) displayed on each of the one, two, or more image display layers for this security element. Hence, step 720 may be thought of as including first deciding how many display layers/planes to use with this array of micro mirrors (and this value can be affirmed/set in later step 730 as one of the design parameters). Step 720 may involve assigning differing colors of a colored base/start image to differing image display planes/levels. In other cases, a component/object in the image may be chosen as a foreground image and one or more of the other components/objects in the image may be selected to be background images to be on different levels/planes. At step 725, the method 700 continues with converting the base image into a file (such as a text document or file with each pixel replaced with 0's and 1's when two levels/planes are used and so on) that indicates for each pixel in the base image which level/plane that pixel is assigned for display by the array of micro mirrors.

[0058] The method 700 continues at 730 with the user choosing/setting design parameters (or accepting default ones such as may be predefined by the design program or as previously saved for other arrays). For example, the spacing of pixels in each image plane may be set (e.g., set the DPI for

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each image display plane/level), and the user may also set the cone angle and, in some cases, the mirror size. Step 730 may also include setting the height of each image display level/plane (which also sets the spacing between adjacent pairs of the planes/levels).

[0059] The method 700 continues at 740 with selecting or identifying a set of mirrors in the array to use to display each of the pixels in the images chosen in step 720 (with more detail provided for this process provided below). Step 740 may involve determining the number of mirrors that should be used for each pixel (typically a number between 1 and 40 or more that is used throughout the design) based on a cone angle, mirror size, and the DPI of the image (or pixel pitch). In some implementations, a program implementing the method 700 provides the average number of mirrors per pixel after step 730, and the user may determine it is useful to modify the design parameters (repeat step 730) to achieve a better result (e.g., some prototyping indicates that a "sweet spot" may exist around 25 mirrors per pixel with 10 being too few in some cases and 40 being too many in others). Step 740 may also involve defining a cone with an apex coinciding at the pixel location and with a cone angle set by the design parameters, and the cone base or area on the mirror plane may be used to define which micro mirrors may be chosen to display or "write" the particular pixel. The design parameters also define how many mirrors among the available ones in this circular or cone base area to use in the set of pixel-providing mirrors. A first mirror is chosen randomly (any useful random selection algorithm may be used and it may have "memory" in that a next run may remember which mirrors in the available set have already been chosen), and then this random process is repeated for the available mirrors until the set includes the number of mirrors needed for a complete set based on the design parameters for this array of micro mirrors.

[0060] At step 750, the method 700 includes for a next one of the pixels in the images, calculating angular orientation of all mirrors in the set of mirrors chosen for displaying that pixel. At 760, it is determined whether there remain additional pixels in the images, and, if yes, the method 700 proceeds with repeating steps 750 and 760 until all the angular orientations for the mirrors in the sets of pixel-providing micro mirrors are determined. If no at step 760, the method 700 continues at 770 with directing all mirrors not in one of these sets (or unused mirrors) so that they do not interfere with image display, e.g., by assigning an angular orientation that is outside the viewing cone for each of the pixels used to display the images on each of the levels/planes.

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[0061] At step 780, the method 700 is shown to include a decision step based on the number and/or location of the unused mirrors. The method 700 (or computer program functioning to implement the method 700) may plot the position of all the unused mirrors. If there are too many unused mirrors (e.g., above a predefined maximum unused mirror number) and/or the unused mirrors are too close to each other (e.g., not scattered over the canvas or array of micro mirrors), the method 700 may return to step 730 to change the design parameters and repeat the other steps of the method 700 after step 730. The parameters that may be changed at 730 can include the cone angle (e.g., to have more surface from which to choose mirrors) and the height of the floating images (e.g., the closer the images are floating to the mirror plane the more difficult it can be to find useful mirrors so that higher or lower display/floating levels or planes will decrease the number of unused mirrors). In some cases, the DPI can be changed from the original image and/or the image design may need to be changed to obtain a useful result with method 700.

[0062] If the number and/or location of the unused mirrors is determined to be satisfactory at 770, the method 700 then may end at 790. The design of the angular array may then be output for use in fabricating a security element with an array of micro mirrors individually oriented to provide one or more images (with a number of displayed pixels) on one or more image display planes/levels.

[0063] As discussed previously, an underlying idea of the security elements of the present description is to use ambient light and a planar surface containing many small mirrors and to aim the ambient light reflected off the mirrors toward a desired point in space above the planar surface that contains the mirrors. This is called the first layer image and is defined by artwork that has light or dark pixels to be produced in a layer or level (or first image display plane). By carefully selecting the mirrors within a circle defined by the intersection of the cone defined by an apex angle and a pixel from the first layer/level as the apex of the cone, the cone apex from various mirrors in the circular base of the cone provides a point source of light floating above the level of the mirror plane at the location of a pixel, containing the mirrors. A computer algorithm (as shown with the program 630 in Figure 6) completes this process on a pixel-by-pixel basis. If the pixel in the first layer/level is a dark pixel (e.g., a pixel not associated with the image or image component/portion from a base/start image chosen for display in the first image display plane), no rays will be aimed toward it.

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[0064] In addition, the program has the capability of using a second layer of pixels that acts as a mask for the first layer of pixels so that various portions of the pixel image at level one are "hidden" or visible depending on the viewing angle. The algorithm that generates the first layer of floating pixels looks at the rays aimed to the pixel in the first layer and the continuation of the rays to the second layer. The intersection location in the second layer is calculated and is searched for nearby dark pixels of the second layer/level (mask layer and/or second image display plane). If dark pixels are found in the intersection area on the second layer, the mirror that reflected that ray to the first layer is not used to aim the ray at that pixel to the first layer (e.g., this additional processing can be used to modify or originally select the mirrors to be used to display the pixel of the first image display plane).

[0065] Thus, there is a masking effect of the mask layer as is desired. To form a mask that appears to "float" over the pixels in the first layer (or first image display plane), some pixels of the first layer will have partial cones of pixels depending on the mask geometry defined by the pixels on/off of the second layer and on the angle the pixels are viewed (as can be seen with reference to the diagram 400 of Figure 4). As the viewer's eye is moved (or the mirror assembly tilted to the viewer), pixels of the first layer will change brightness and appear or disappear from view in a way that causes the mask to appear to move.

[0066] To insure uniform illumination across pixels, during the aiming process as described above, only one of the available mirrors is used in each pixel's cone of acceptance by the design program, and the mirror is selected at random from the available mirrors in the cone of acceptance. After the direction cosines of the selected mirror are calculated, the mirror is marked by the design program as "no longer available for use by any other pixel." The design program moves on to the next pixel, and the same sequence of events or design steps are repeated until all the pixels are used (or oriented for desired light reflection). At that point in the design algorithm, the entire sequence of pixels is again used to pick up one of the available mirrors for each pixel. After a number of cycles of the pixels, all the mirrors are used depending on the image and mask patterns. If some mirrors cannot be used because of the geometry of the image layer and mask layer, they will be aimed out of the viewing zone.

[0067] The design program allows the user to choose the values of the spacing of image levels from the mirror plane, as well as pixel cone angles, mirror sizes and pixel pitches. These all can be

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optimized or selected by the user to make (or try to make) the best image to present to the viewer. The inputs to the design program in some embodiments are pixel image files for the first layer image and for the mask for the second image display plane or layer/level. However, there are also capabilities for the program to make its own test input layers. The output of the program is a data file containing mirror locations and the coordinates of the normal vector to each mirror in a format suitable to make the mirrors or to form an array of micro mirrors on a supporting substrate (such as a piece of currency, a coin, a product label, a document, or the like).

[0068] In some embodiments, the design program allows the user to see the input files, ray traces to different levels (e.g., via operation of the ray tracking module 635 shown in Figure 6), and the expected image seen on the retina of a viewer. Tracings can be done using input cones of light on the mirrors to see the affects ambient light distributions on the viewer's retina. As an example of the GUI 628 of Figure 6 that can be generated by the design program 639, Figure 8 illustrates a micro mirror design GUI 800 that is displayed in one prototype of the design program created and used in prototyping by the inventors.

[0069] The main GUI or menu 800 shows an exemplary set of inputs (design parameters, for example) that can be chosen, input, or modified by the user. These include pixel pitch, level/image display plane values, and cone angles for pixels, mirror size, and selection of test patterns. The right side of the GUI/menu 800 shows some of the details or results of the calculations performed by the design algorithm based on the user's input or selected (or default) design parameters provided on the left side. These include the number of mirrors that are dark (aimed away from pixels of images chosen for display on level or image display plane), numbers of mirrors used, algorithm used, and time required to calculate direction cosines of mirrors.

[0070] The level height parameter can be used to define or set how far above or below the mirror plane, in microns, that the image designated will appear for a mirror array design. The level cone angle degree parameter sets the angle at the floating pixel of the cone in which specific mirrors can be selected. A narrower angle means that there will be fewer potential mirrors for each pixel, and the opposite for a larger angle. The level angle offset parameter defines or sets the angle of offset that you would like the image level to appear, in respect to the Z axis. The "Assign Image (1,2) color (0,1,3,4) to level#" input box allows the user to place the various image colors to the specified levels.

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The "Border Edge Width Add" input box allows the user to expand or shrink the canvas to allow for movement of the images.

[0071] As noted earlier, the design process begins with inputting or providing an image file for the design program to process to create or calculate the design for the micro mirrors. One significant parameter in such design calculations is the resolution (DPI), and, in some applications, it may be useful to input or use lower resolution files (or digital images). For instance, an image that is 100 DPI is equivalent to having a pixel every 254 microns, and in the GUI 800 in Figure 8 this is the input shown under "image focal points X pitch = 254" (and the same value for Y pitch). Based on this resolution or how many pixels you need floating to represent that specific image along with the mirror size (in the attached menu 800 this is 50 microns), the design program calculates "avg Num Mirrors available per pixel," which in this example is 25.7685291. In other words, a little over 25 mirrors that can be used to represent one pixel from the original or base/starting image file.

[0072] Figures 9A-9C illustrate with graphs 910, 920, 930 images that can be displayed on various levels or image display planes by an array of micro mirrors of the present description. Graph 910 of Figure 9A shows a first layer image, with the light or on pixels providing an "X" pattern that would be displayed by a number of sets of pixel-providing mirrors to be floating in a first image display plane. In Figure 9B, graph 920 shows a second layer image, with the light or on pixels providing a rectangular background pattern or object that would be displayed by a number of sets of pixel-providing mirrors so as to be floating in a second image display plane. The graph 930 of Figure 9C shows a partial "X" of light or on pixels displayed with micro mirrors of an array and shows the effect of a mask blocking part of the image.

[0073] Figure 10 is a plot 1000 illustrating a ray tracing of light rays 1015 and dark rays 1017 near a first image display plane or first level/layer 1020 for one modeled array of micro mirrors 1010. As can be seen, the array of micro mirrors 1010 provides converging rays of reflected ambient light meeting or intersecting at a number of pixels 1022 at the floating pixel level or image display plane 1020 (or a first level as discussed above). It can also be seen that dark rays 1017 are directed away from the converging points/pixels 1022 and do not converge at the first level 1020.

[0074] One useful analysis tool of the design program and/or the ray tracing module is that a designer of an array of micro mirrors for a security element is able to evaluate the image as seen by a viewer.

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To this end, a ray tracing part of the design module (or a separate module as shown in Figure 6) is used to view the image on a simulated retina. Thus, the effectiveness of array design including a mask can be analyzed by putting the viewer's eye in various locations, which is equivalent to tilting the mirror plane, and plotting the ray traced image on the simulated retina. Figure 11 illustrates a representative GUI or ray tracing menu 1100 that allows a user to specify parameters to utilize in performing the ray tracing. Figure 12 illustrates a plot 1200 of a representative ray tracing showing the mirror plane 1210, traced reflected rays/beams 1220, a face plane 1230, location of a viewer's eyeball at 1240, and a corresponding retina at 1245 upon which rays converge indicating display of a set or number of pixels of a "written" or displayed image by the mirrors oriented in a desired manner at the plane 1210.

[0075] A number of manufacturing approaches may be used to fabricate an array of micro mirrors for attachment to or upon a surface of a substrate (such as currency, coins, product labels, and so on). In some embodiments, a photo resist process has been implemented by the inventors in creating security elements or devices as taught herein. As discussed earlier, the design program or software generates an output file (as explained in more detail below). To form the micro mirrors according to this output file, a laser system is used to expose the photo resist material, usually on a quartz or lime glass master. The photo resist material is normally at least 25 microns thick. The laser or laser system may expose the material in steps such as in about .5μ steps. The exposure settings correspond to the amount of material that will be washed away and not hardened, and this exposure creates a "Z" axis or height of the feature. The resulting micro mirrors (which may be flat or may be concaved for better focus depending upon design) are made in the photo resist material. The photo resist is generally still light sensitive and will "melt" in white light. In some cases, the photo resist is chrome plated in house before processing. The photo resist is then placed in an electroforming tank. The resist is charged and attracts nickel (or other metallic) particles, and nickel is "grown" on the photo resist as a nickel "shim." This nickel shim can be "turned" as needed from negative to positive and back again for tooling. The nickel shim is then used in the cast and cure process to form the array of micro mirrors oriented as indicated by the output file of the design program or software.

[0076] In other fabrication processes, a UV (ultraviolet light) or energy-cured polymer is used, and the process includes metallizing the mirrors to form an array as taught herein. In other cases, the

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fabrication process involves stamping or forming the micro mirrors into surfaces such as chrome or aluminum containers.

[0077] In general, the inventors teach a method of fabricating a security or branding element. The method includes providing a substrate and forming an array of micro mirrors on a surface of the substrate. The array of micro mirrors is configured for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate. The image comprises a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

[0078] In some embodiments of the fabrication method, the forming the array of micro mirrors step includes casting the micro mirrors with a mirror tool in contact with the surface of the substrate. In these embodiments, the substrate may be a clear, energy-cured polymer, and the mirror tool can be formed of nickel or a polymer.

[0079] In some cases, the step of forming the array of micro mirrors includes metallization of surfaces of the micro mirrors. This may be performed so as to apply a thin layer of aluminum, gold, or silver to form reflective surfaces or form the mirror structures of the array. The metallization may be performed in a vacuum chamber using a deposition system or the like. Further, the forming step may include, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors. In this regard, it may be useful for the surface of the substrate to include or be made up of an embossable coating or layer.

[0080] In performing the fabrication method, the substrate may be (or include or be provided on) a coin, an automobile part, a computer part, a bumper, or a container, and the displayed image provides branding or authentication for the component that includes the array of micro mirrors. In such cases, the array forming step may include stamping the micro mirrors into the surface of the substrate.

[0081] In the same or other embodiments, the step of forming the array of micro mirrors may involve filling in recessed surfaces associated with the micro mirrors with a filler so as to make duplication (e.g., by molding) more difficult if not impossible. The filler may take the form of an ultraviolet (UV) varnish, an e-beam solvent, a water-based varnish, or the like. In some cases, it may be desirable for

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the filler to have a higher refractive index such as an index of at least 1.55, such that at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image for a viewer.

[0082] From the description and figures, it can be seen that there are numerous advantages and unique features of security elements/devices that include or are formed of arrays of micro mirrors. The individual mirrors can be programmed or oriented in two axes to focus to a specific pixel in any visual plane (e.g., in a first image display plane, in a second image display plane, and so on). In this way, the micro mirrors are used to image pixels forming drawings or text that appear to float relative to the planar surface containing the array of micro mirrors. The micro mirrors can be configured or designed to focus above or below the visual plane forming pixels that in combination display images with depth (multi-layered or multi-depth imagery). The program performs a unique design method providing an output file that can be used in fabricating or generating the micro mirrors.

[0083] In practice, the shape of the micro mirrors can be round, square, and rectangular with the reflective surface being flat, concave, or convex to provide desired focusing upon a pixel (or location on one of the image display planes). The size of the mirrors may vary to practice the arrays of micro mirrors such as from about 1000 microns down to one micron with mirrors in the 35 to 70 micron range likely being desirable (with 50 micron square mirrors being used in a prototype/model).

[0084] An array of micro mirrors can be designed to provide a variety of visual effects such as showing images above or below the visual planes and in first, second, third, or more image display planes relative to the mirror-containing planar surface. In other cases, the mirrors are used to provide an effect of light images with dark backgrounds animating to light backgrounds and dark images with a change of perspective. In the same or other cases, an array of micro mirrors can be configured with selective orienting of mirror reflective surfaces to provide a masking effect showing one image receding as it goes across another image. In many cases, the micro mirrors generate more than one level of imagery to the viewer (two or more). Particularly, the micro mirrors can generate one image made up of a set of pixels at one level above the focal plane while also (or separately) generating an image below the focal plane. In the same or other cases, the micro mirrors may be configured to generate an image at the focal plane. In these embodiments, the images are displayed/written either with bright pixels (light) or dark pixels (the absence of light or reflected light from the viewer).

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Images created by the micro mirrors can provide an animation effect, and, in the same or other embodiments, the images created by the micro mirrors may provide a 3D effect.

[0085] The array of micro mirrors can be used in (or provided as part of) a currency thread, which may be about 10 to 50 microns thick. The array of micro mirrors or security element can be used as a foil stamp that may be about 10 to 100 microns thick. The array may be formed by stamping the micro mirrors into any metallic surface, such as a surface of a coin, or by placing the micro mirrors on glass, ceramic, or plastic substrates, which may be clear so as to create a unique visual display or imaging effect that allows a viewer to see images in display planes on two sides of the substrate supporting the array of micro mirrors (or transparent film including such mirrors). In these and other ways, an array of micro mirrors may be successfully used in any high security application including, but not limited to, passports and other high security documents including currency.

[0086] In some embodiments, the displayed or written image is colored (e.g., is not simply black and white). In one embodiment, a color display is created by forming the mirrors of the array with plasmonic resonance for color while other fabrication processes use tinting of the reflective mirrors with ink. In other embodiments, diffractive material is added to the reflective surface of the mirrors or diffraction grating may be used to create color with the micro mirrors. In some embodiments, dielectrics are used to provide color with the array of micro mirrors. In still other colored display embodiments, a protective cover layer may be applied to the mirrors that is transparent (to-translucent), and then coloring may be provided by printing on this cover layer with translucent color squares (or other mirror shape-matching coloring filters) aligned over the proper micro mirrors to achieve a desired colored image in one or more of the image display planes or levels/layers.

[0087] Figures 13A and 13B illustrate plots 1310 and 1320 provided by the design program of images chosen for display on first and second image display planes or levels, respectively, and these are the two images that would be written or displayed by micro mirrors of an array. In Figure 13A, a user has input an image with a colored or plain background with a circular boarder enclosing a leaf, and the circular boarder and the outline of the leaf have been chosen for display or writing on a first level or first image display plane (at a first height such as 10000 microns away from the planar surface containing the mirrors). The offset angle may be set at 0 degrees (or some other value), and Figure 13A represents an approximation of what a viewer would see when viewing the security element with

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this design of an array of micro mirrors. Particularly, a plurality of bright or "on" pixels showing the circular boundary and the outer edges/boundary of the leaf.

[0088] Figure 13B shows the first layer imagery 1310, but it also shows with plot 1320 that as the viewer rotates the mirror plane or changes their perspective (e.g., from a 0 degree viewing angle to the offset angle that may be 20 degrees or the like) the original images 1315 are replaced with the new images 1325 at the second level or second image display plane (which may be at 20000 microns or some other height such that the two levels/image display planes are spaced apart some desired distance). As shown, the designer/program user has indicated that the background of the input image, the inner portion of the circle, and the inner portion of the leaf should be written or have their associated pixels "on" in the second layer while the portions chosen for image 1315 of the first layer are "off" or dark. In this manner, the image sees a transition between displaying imagery with light and then with dark pixels as their perspective or viewing angel changes to view the images in the two spaced apart levels/layers or image display planes.

[0089] Figures 14A and 14B illustrate plots 1410 and 1420 that show the results of programming or orienting an array of micro mirrors to display an object or image 1415 (here an eagle or hawk). The plot 1410 of Figure 14A may be considered a top view as the intersections of normal vectors from the micro mirrors are shown relative to X and Y axes while the plot 1420 of Figure 14B may be considered a side view as the same intersections are shown relative to the X and Z axes. Figure 14A is useful for showing a representation of what a viewer would perceive when looking in an orthogonal direction to the plane containing the mirrors, e.g., the viewer perceives the outline of an eagle (which may be displayed or written with bright or dark pixels). The intersections act to display "pixels" that, as can be seen at 1415, work in combination to display an object/subimage (as may be chosen by a user of the design program from an input image file for display in a particular level or image display plane). Figure 14B shows that the pixels (or normal vector intersections) are generally planar or provided in a plane coinciding with a preset/defined level or image display plane relative to the planar surface containing the micro mirrors (e.g., a plane spaced apart a predefine distance from the array of micro mirrors), and this acts to provide a floating image 1415 or an image with depth or 3D effects.

[0090] As discussed above, the design program or algorithm functions to create an output file that may be used in manufacturing an array of micro mirrors adapted to display one or more floating

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images above (or below) the planar surface containing the array. Table 1 below provides exemplary data that may be provided in such an output file (with only a small number of mirrors being shown for ease of explanation but with it understood that similar data would be provided for each mirror in the array). The X and Y columns of Table 1 show mirror positions (in microns), e.g., in the second row a mirror is located in the array at 35 microns on the X axis and at 0 microns on the Y axis. In the table, next to each mirror location in the array, the DX, DY, and DZ columns provide the coordinates of the normal vectors for each of the mirrors. In this way, each mirror has a defined position in the array and a precise direction its reflective surface is pointing in space.

[0091] In creating the exemplary data in Table 1, the following assumptions were made for the design of the array of micro mirrors: (1) units are microns; (2) the array is configured to have flat mirrors with tilted reflective surfaces; (3) the mirrors were square in shape with 35 micron sides; (4) the array was also assumed to be square in shape with 27,930 micron sides; (5) the number of mirrors was calculated to be 798 along the X and Y axes such that the total number of mirrors was 636,804; and (6) the maximum mirror tilt angle was requested to be 30 degrees (e.g., due to vendor/manufacturer limitations so may be set at 20 degrees).

Table 1

X	Y	DX	DY	DZ
0.00	0.00	-0.061672	0.021122	0.997873
35.00	0.00	-0.020315	0.050724	0.998506
70.00	0.00	-0.063424	0.008449	0.997951
105.00	0.00	-0.064293	0.008449	0.997895
140.00	0.00	-0.056737	0.016904	0.998246
175.00	0.00	-0.053402	0.000000	0.998573
210.00	0.00	-0.058482	0.012677	0.998208
245.00	0.00	-0.025586	0.008464	0.999637
280.00	0.00	-0.051801	0.000000	0.998657
315.00	0.00	-0.061093	0.012675	0.998052
350.00	0.00	-0.061967	0.004225	0.998069
385.00	0.00	-0.058619	0.016902	0.998137
420.00	0.00	-0.046852	0.000000	0.998902
455.00	0.00	-0.018142	0.004233	0.999826
490.00	0.00	-0.061225	0.021122	0.997900
525.00	0.00	-0.062100	0.016898	0.997927
560.00	0.00	-0.062979	0.000000	0.998015
595.00	0.00	-0.063848	0.004225	0.997951

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[0092] Figures 15A and 15B illustrate plots generated and displayed by a preview program (which may be a subroutine of the design program described herein) for previewing likely or predicted results of a design of an array of micro mirrors. Specifically, Figure 15A illustrates a plot 1510 of a 3D image that may be displayed with a selected image and a particular design of an array of micro mirrors. The plot 1510 illustrates a foreground or first layer image 1514 (e.g., a bird such as a flying eagle) relative to a background or second layer image 1518 (e.g., a colored frame with stars) relative to each other and X and Y coordinates. The plot 1510 previews what a viewer looking directly at or downward at the security device may see via the array of micro mirrors. Figure 15B illustrates a plot 1520 illustrating the foreground image 1514 and background image 1518 not only relative to the X and Y axes but also relative to the Z axis (e.g., the depth that would be provided by the array of micro mirror design).

[0093] The preview program providing the plots 1510 and 1520 takes as input the output file of the design program, with all the mirror positions and normal vector coordinates. The preview program calculates the intersection of the reflected rays (e.g., rays coming straight down and bouncing out of the mirrors to the viewer) with the plane where the image is supposed to (or is designed to) float. With the plots 1510 and 1520 provided by the preview program, the operator or designer can verify the combination of foreground and background images 1514, 1518 provides a desired 3D image or representation as shown in Figures 15A and 15B. In this example, an eagle 1514 is floating in a first image plane at +30,000 microns above the mirror plane while the frame 1518 (with stars) is floating in a pushed back second image plane at -30,000 microns (or the two image planes are spaced apart 60,000 microns for the viewer providing a desirable 3D effect). Stated differently, the preview program takes the normal vectors corresponding to the eagle's mirrors and plots the intersection to the plane at 30,000 microns (and does a similar processing for the frame/background image's mirrors and the plane at -30,000 microns).

[0094] Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter claimed.

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WE CLAIM:

1. A method of fabricating a security element, comprising:

assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane;

with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane;

for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; and

generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors.

2. The method of claim 1, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.

3. The method of claim 1 wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.

4. The method of claim 3, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.

5. The method of claim 1, wherein the angular orientations are calculated based on heights of the first and second image display.

6. The method of claim 1, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.

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7. A method of fabricating a security element, comprising:

with a processor of a computing device, executing code to provide an array design module configured to select a set of micro mirrors in an array of the micro mirrors to display pixels of a first object in a first image display plane and to display pixels of a second object in a second image display plane spaced apart from the first image display plane;

for each of the pixels, determining, with the array design module, an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; and

generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors,

wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.

8. The method of claim 7, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.

9. The method of claim 7, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.

10. The method of claim 7, wherein the angular orientations are calculated based on heights of the first and second image display.

11. The method of claim 7, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.

12. A method of fabricating a security element useful on paper and coin currency and on product labels, comprising:

with a processor of a computing device, executing code to provide an array design module configured to define an array of micro mirrors to be formed on a surface of a substrate; and

generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors,

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wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate,

wherein the image comprises a plurality of pixels, and

wherein the array of micro mirrors includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

13. The method of claim 12, wherein a voxel is created at each of the point on the plane via intersection of two or more beams of the reflected ambient light, and wherein each of the created voxels produces an effect of a point source of light floating above the surface of the substrate in the plane.

14. The method of claim 12, wherein each of the different sets concurrently reflect the ambient light to concurrently generate the plurality of pixels.

15. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by casting the micro mirrors with a mirror tool in contact with the surface of the substrate,

16. The method of claim 15, wherein the substrate provided in the providing step comprises a clear, energy-cured polymer.

17. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by metallization of surfaces of the micro mirrors, wherein the metallization applies a layer of aluminum, gold, or silver to form reflective surfaces.

18. The method of claim 17, wherein the forming the array of micro mirrors includes, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors and wherein the surface of the substrate includes an embossable coating or layer.

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19. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by filling in recessed surfaces associated with the micro mirrors with a filler comprising at least one of an ultraviolet (UV) varnish, an e-beam solvent, and a water-based varnish.

20. The method of claim 19, wherein the filler has a refractive index of at least 1.55, whereby at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image.

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ABSTRACT OF THE DISCLOSURE

A visual display assembly useful as an authentication or anti-counterfeiting element. The assembly includes a substrate and, on a surface of the substrate, an array of micro mirrors receiving ambient light. Each mirror includes a reflective surface to reflect the ambient light to display an image that appears to float in a plane, which is spaced a distance apart from the surface of the substrate. The image includes a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels. Each of the sets of the micro mirrors includes a plurality of the micro mirrors, and the reflected ambient light each set of micro mirrors intersects to illuminate or write a pixel of an image.

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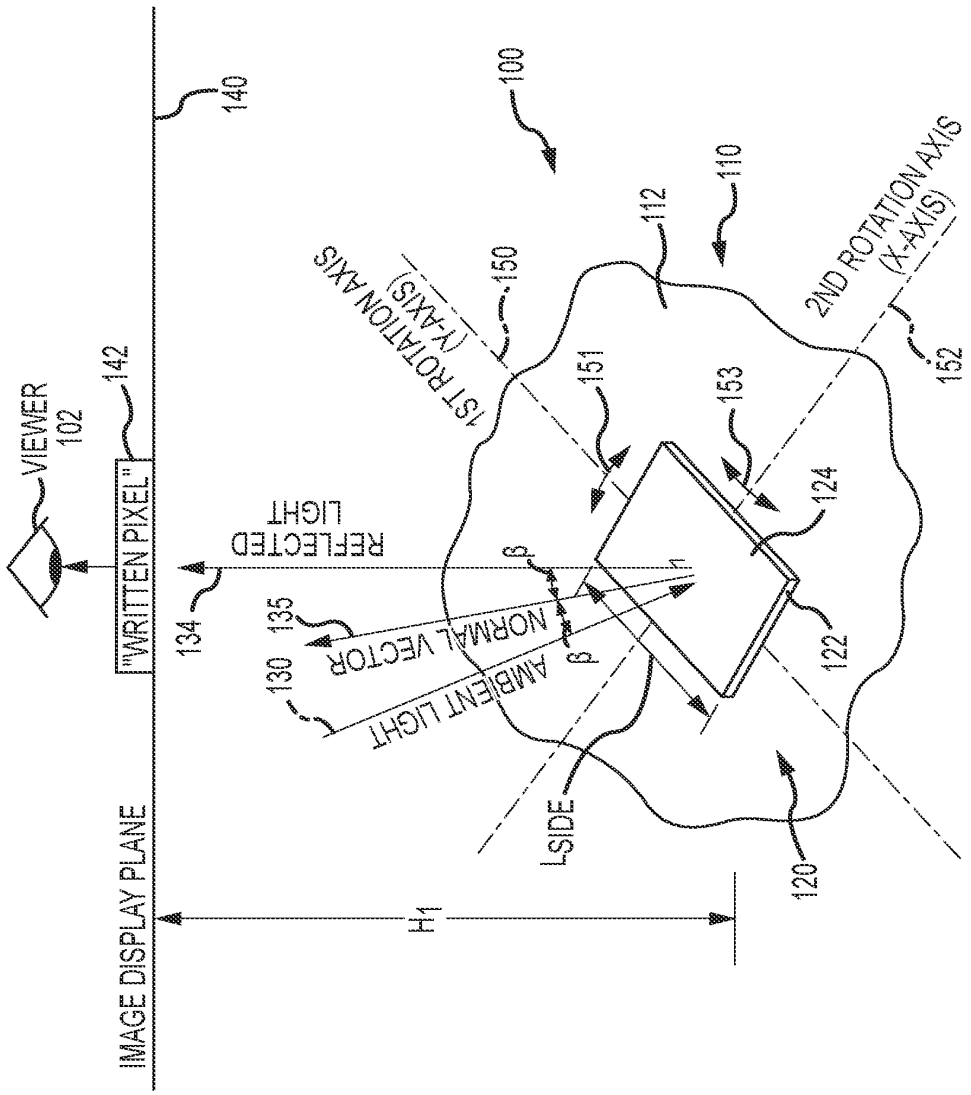


FIG.1

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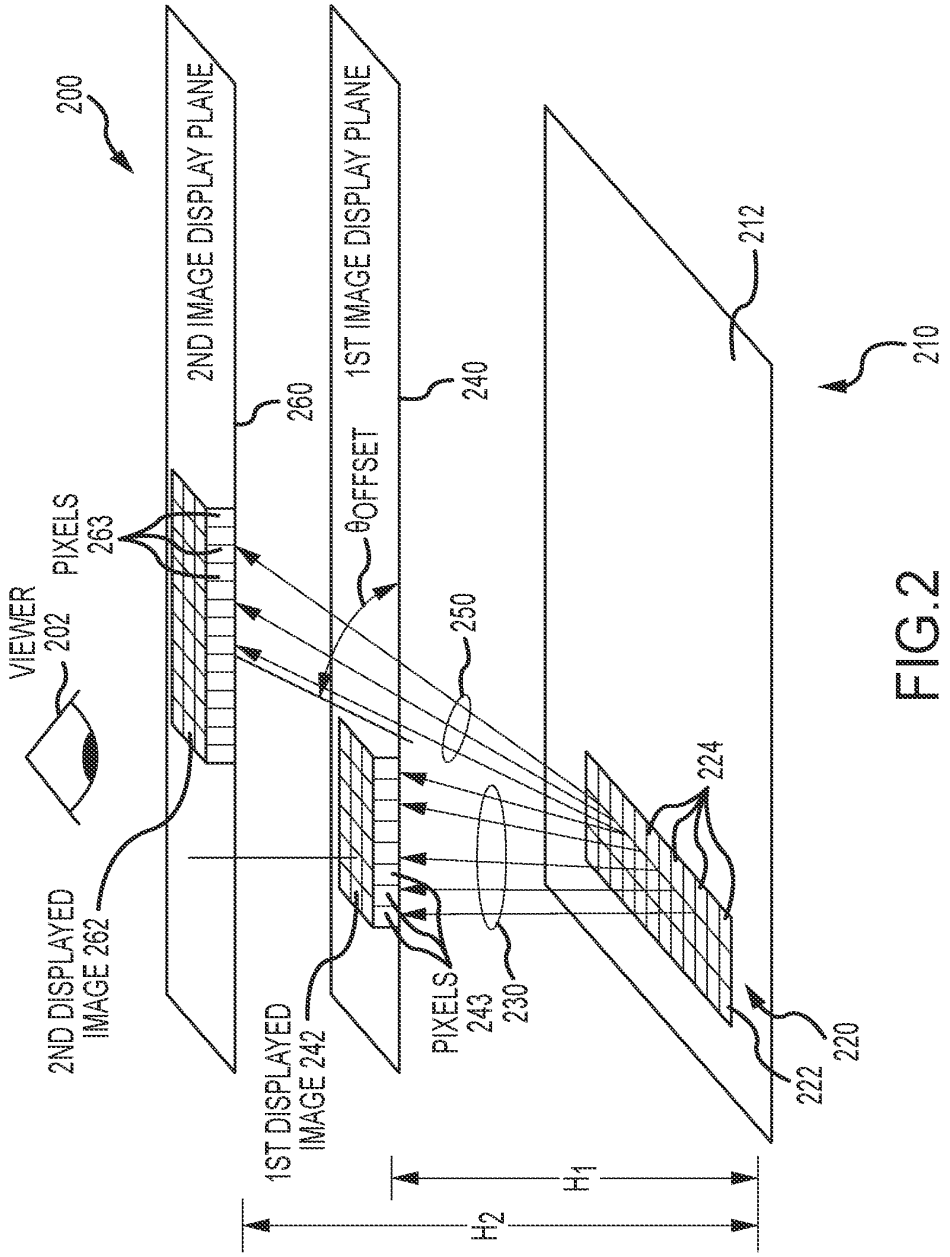


FIG.2

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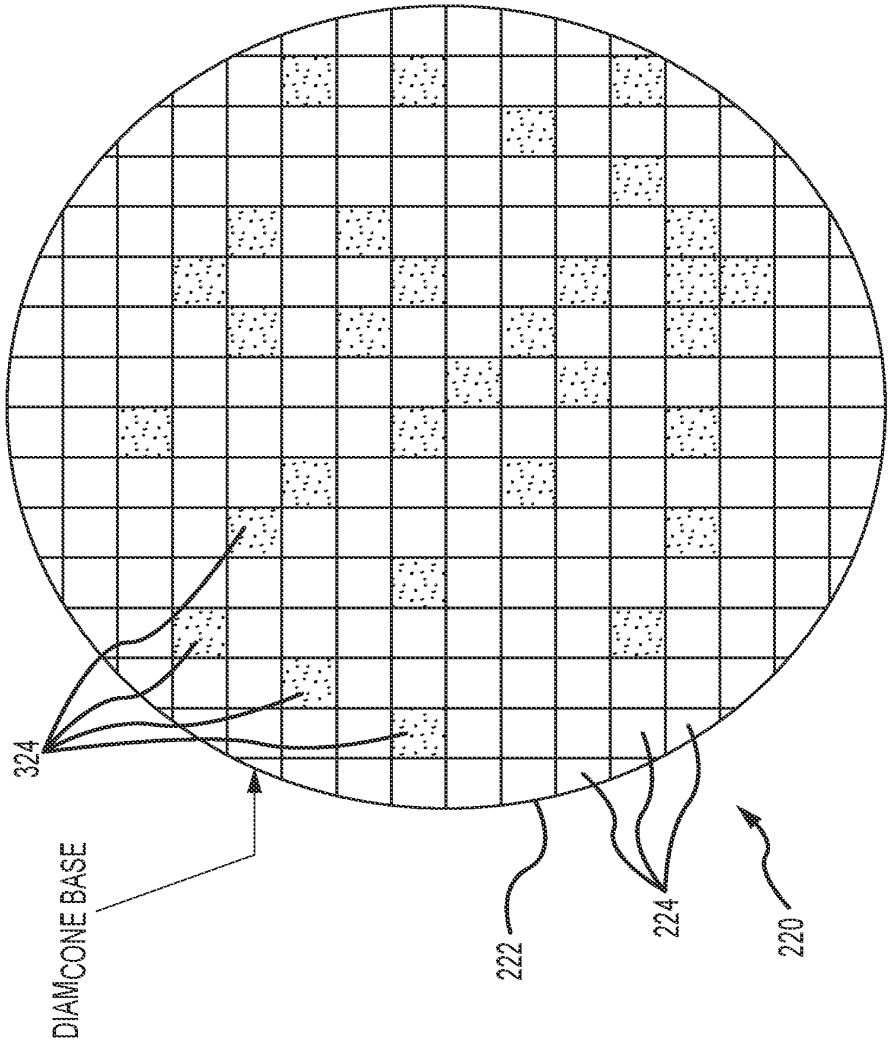


FIG.3

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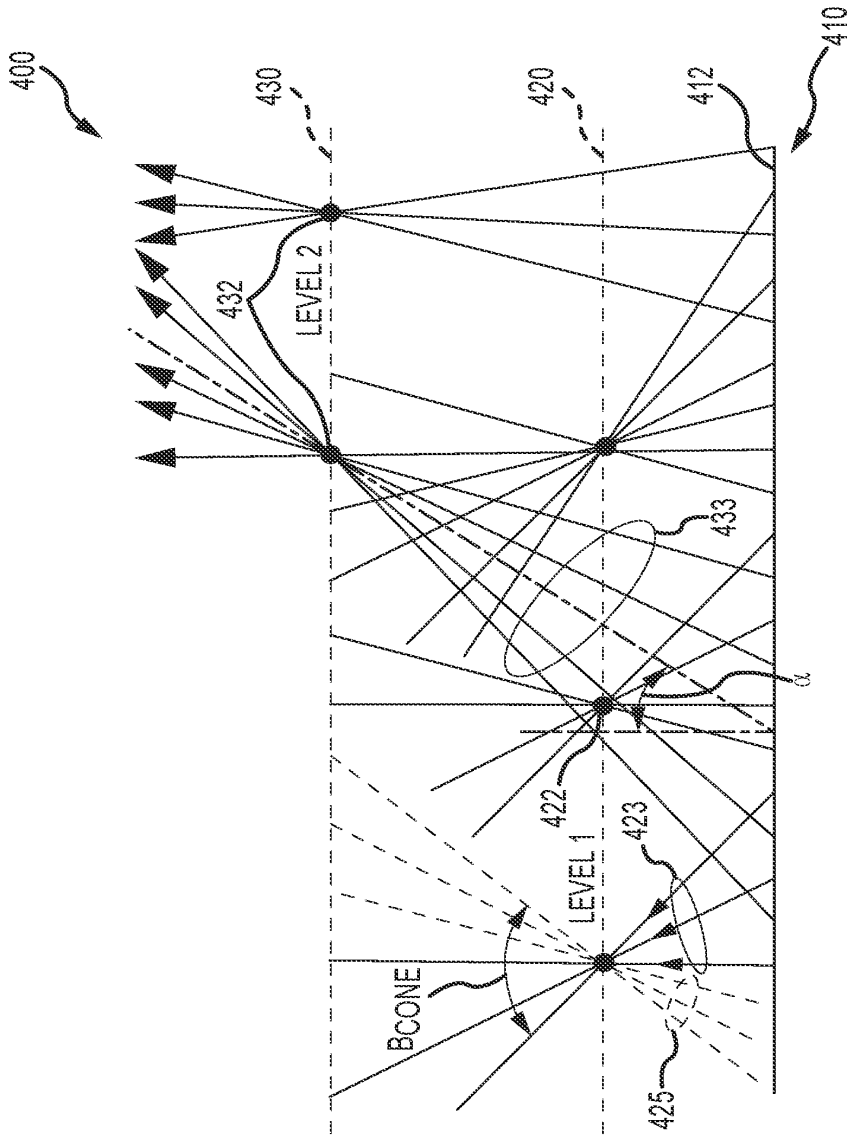


FIG.4

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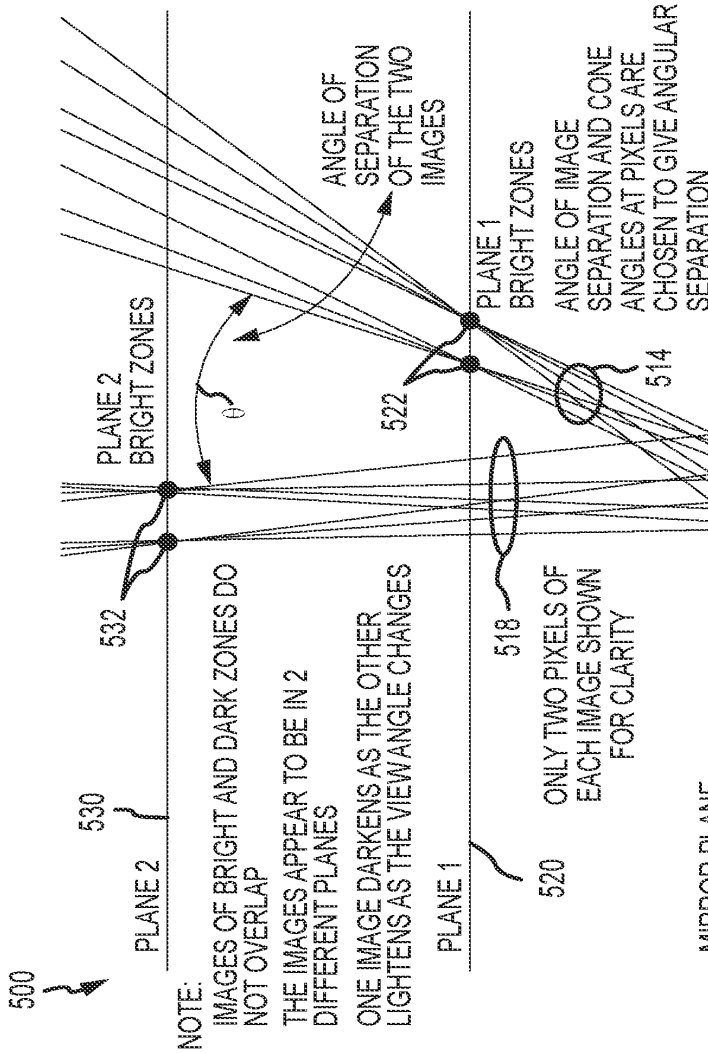


FIG.5

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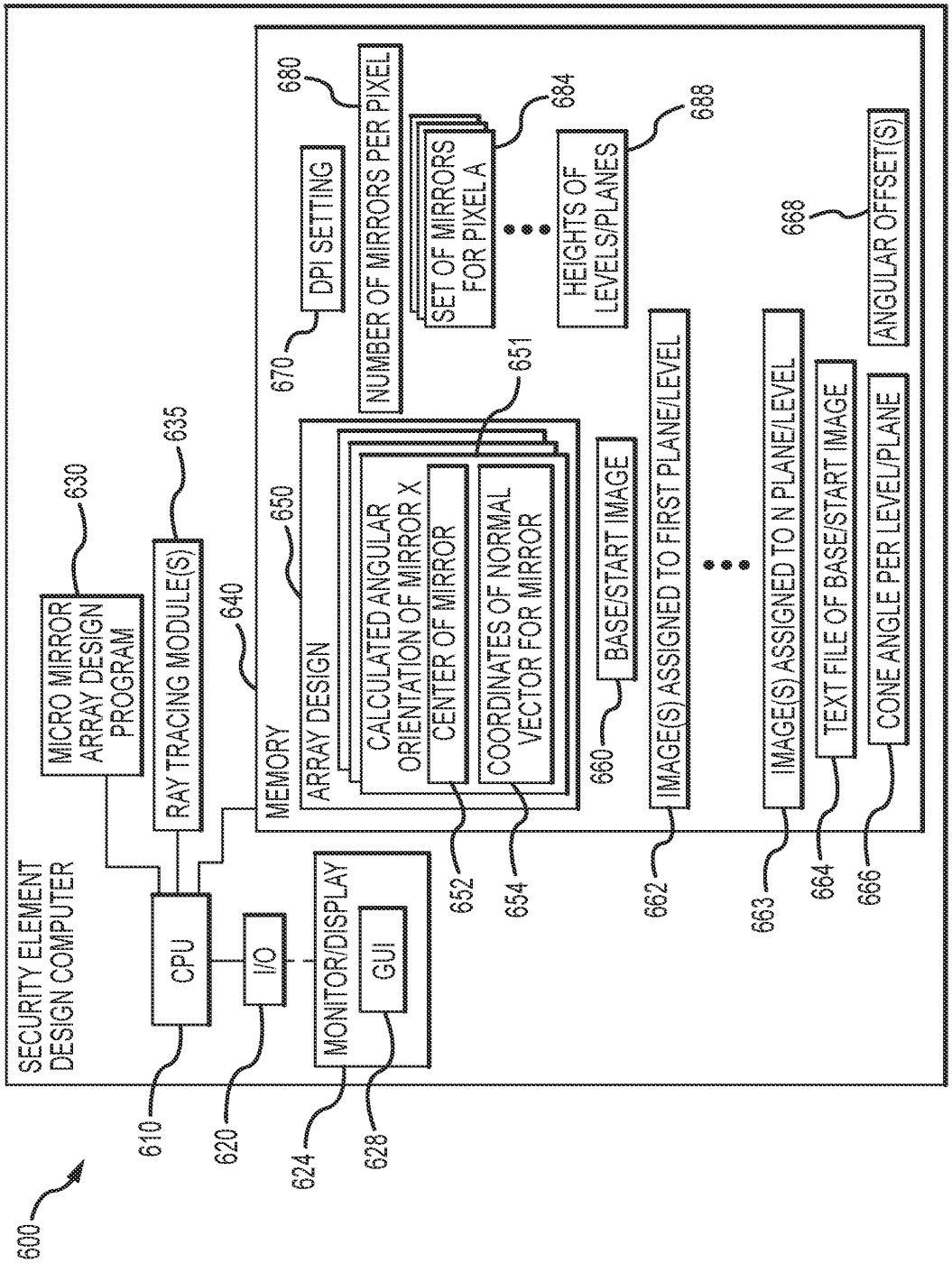


FIG.6

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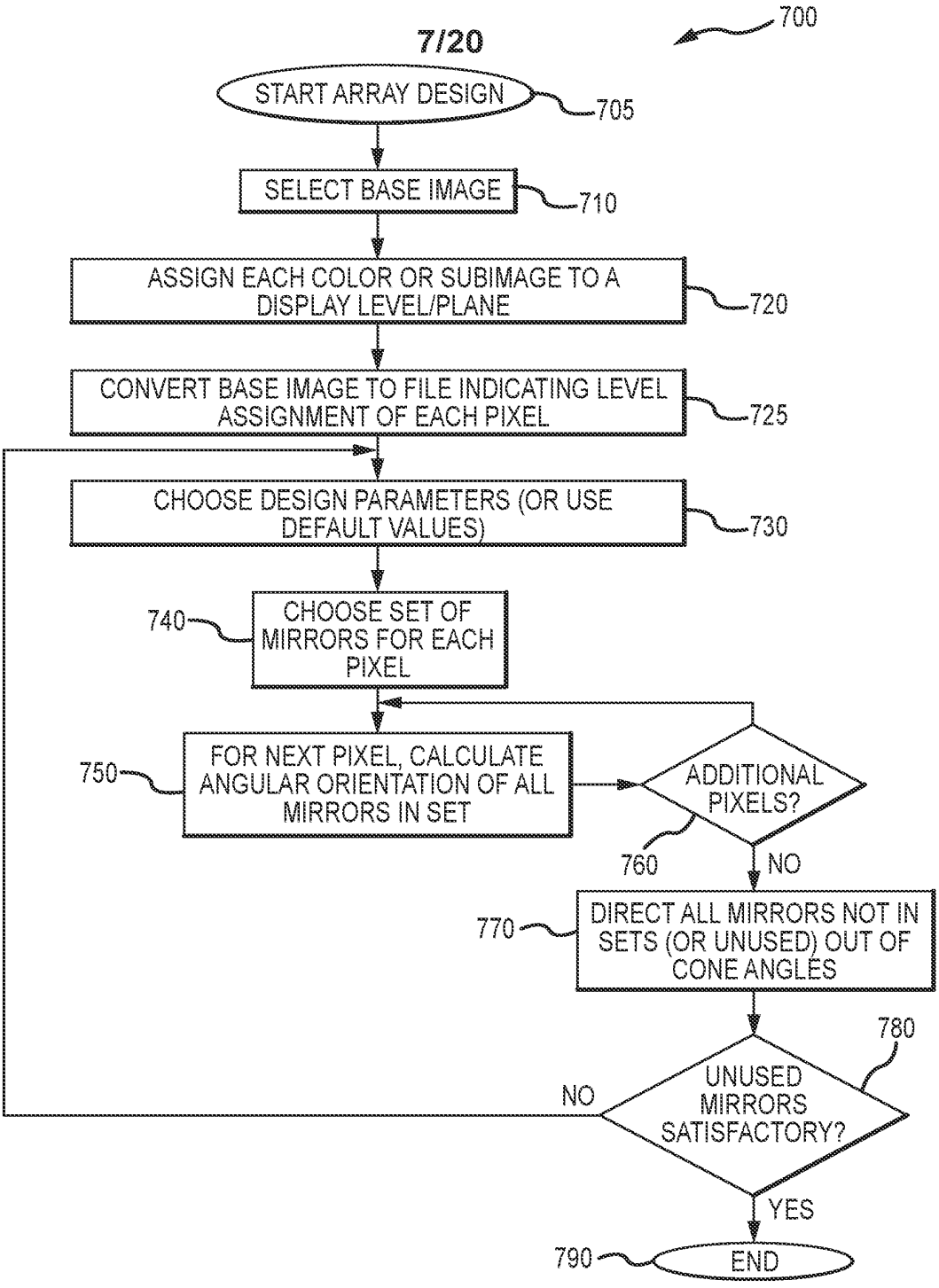


FIG.7

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FIG.8A

CONTINUED ON FIG.8B

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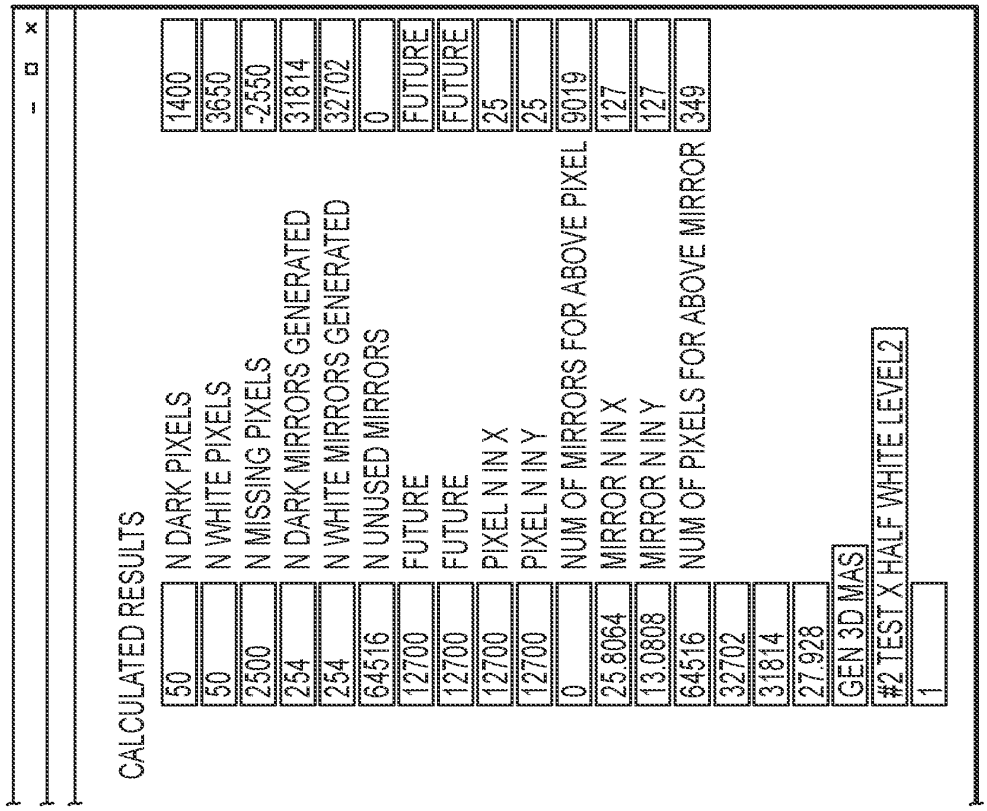


FIG.8B

CONTINUED FROM FIG.8A

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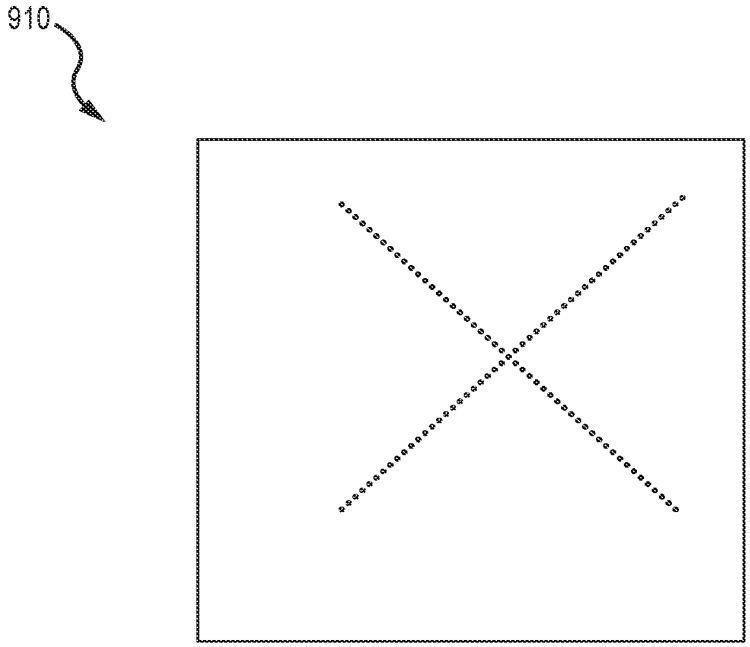


FIG.9A

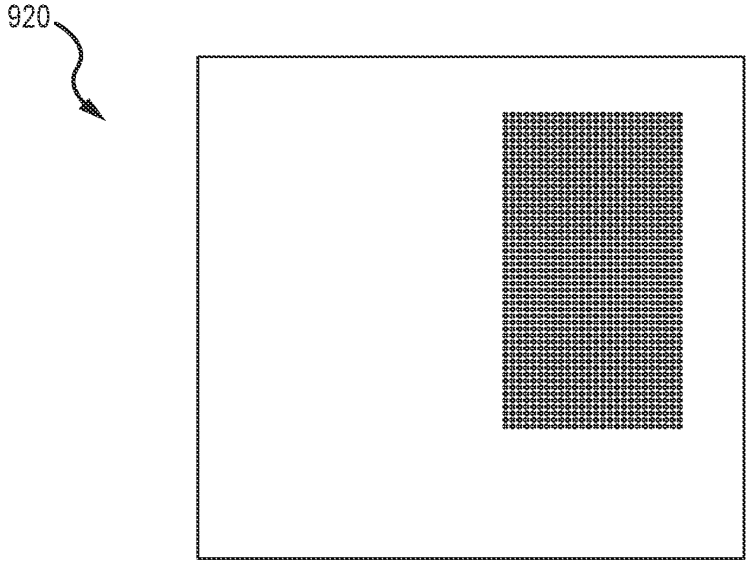


FIG.9B

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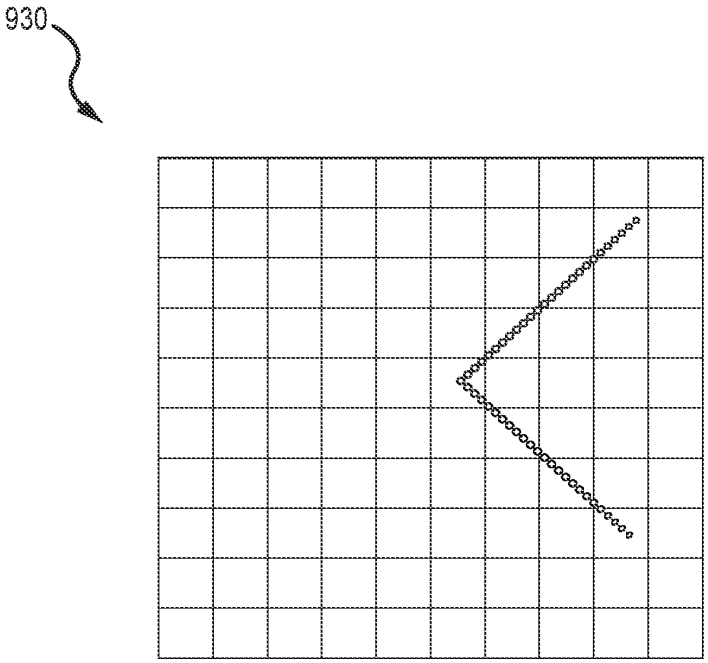


FIG.9C

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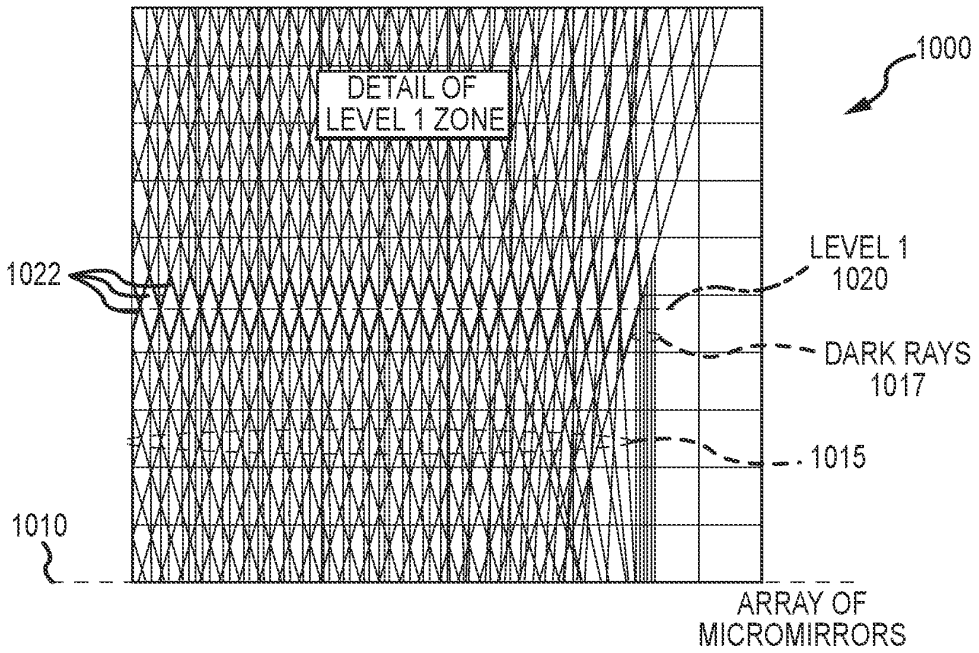


FIG.10

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FIG. 11

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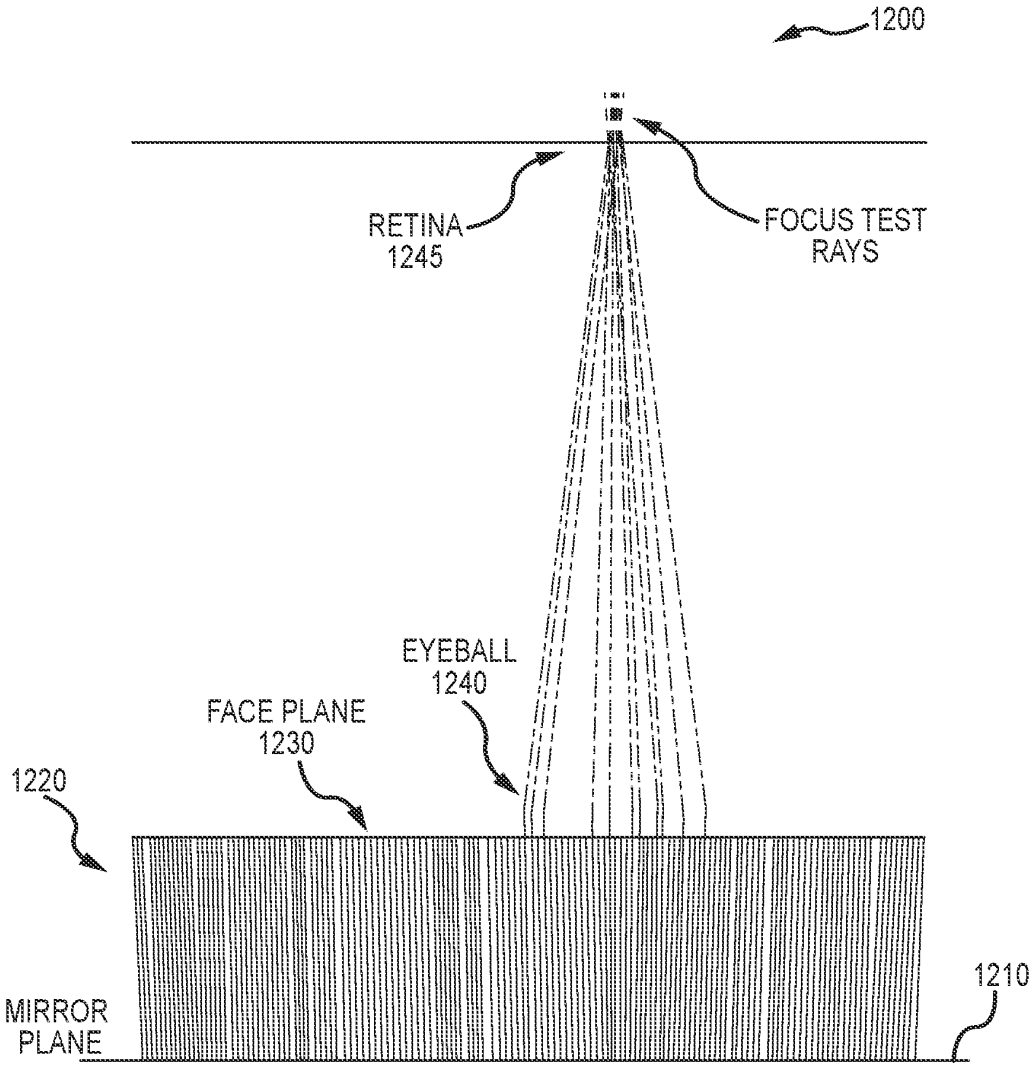


FIG.12

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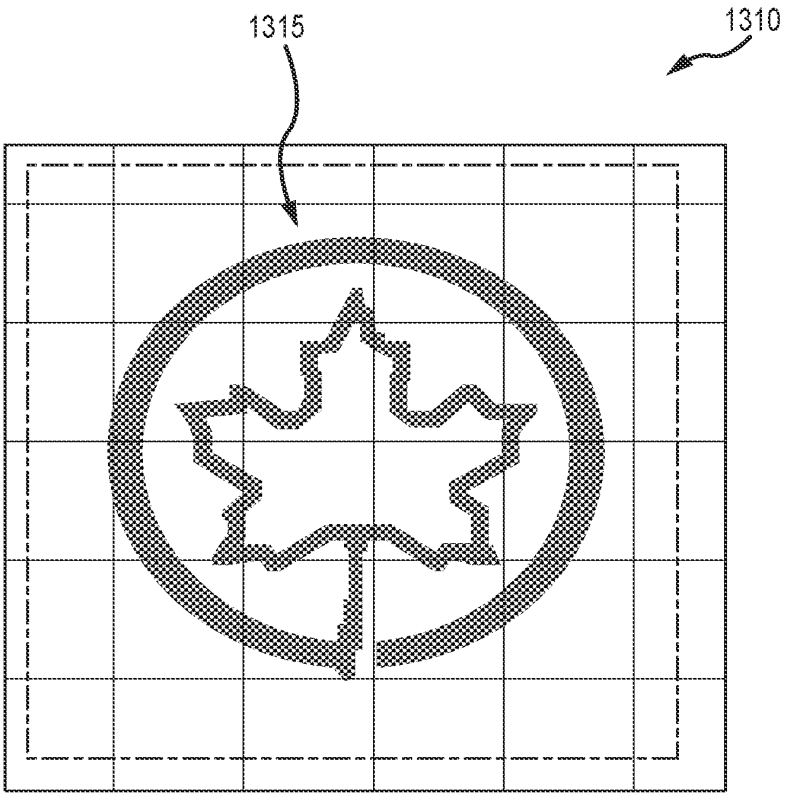


FIG.13A

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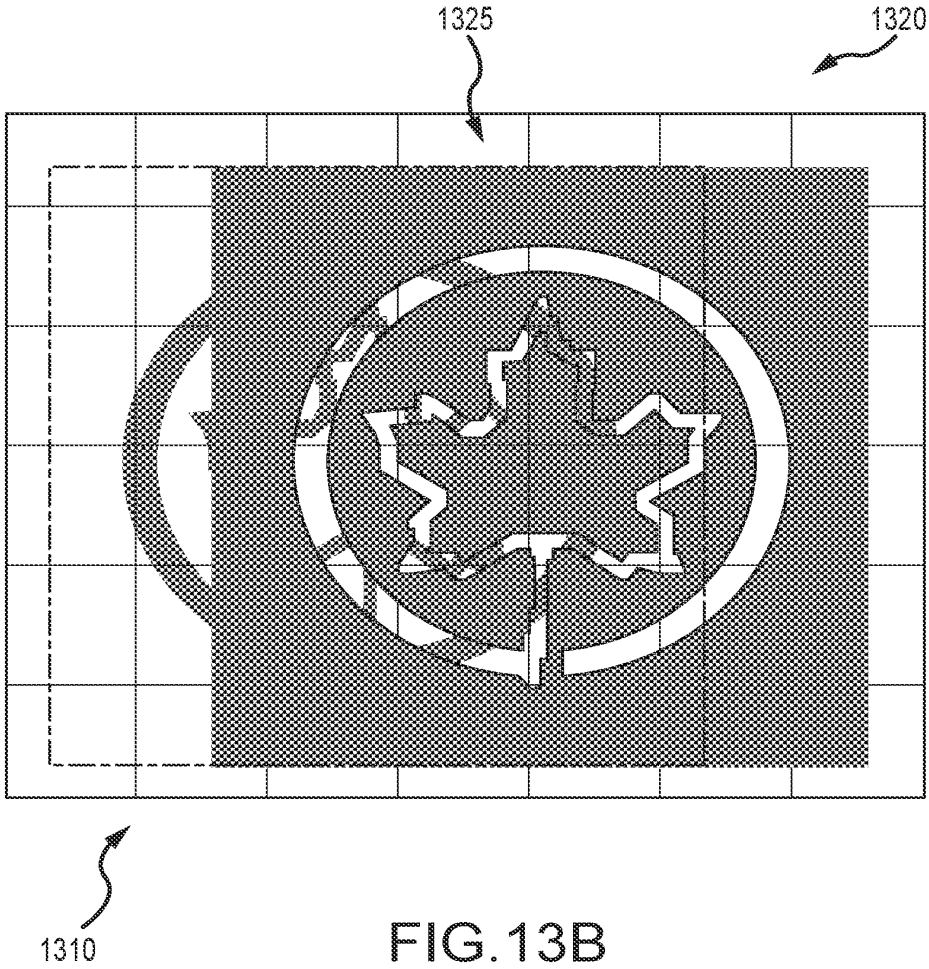


FIG.13B

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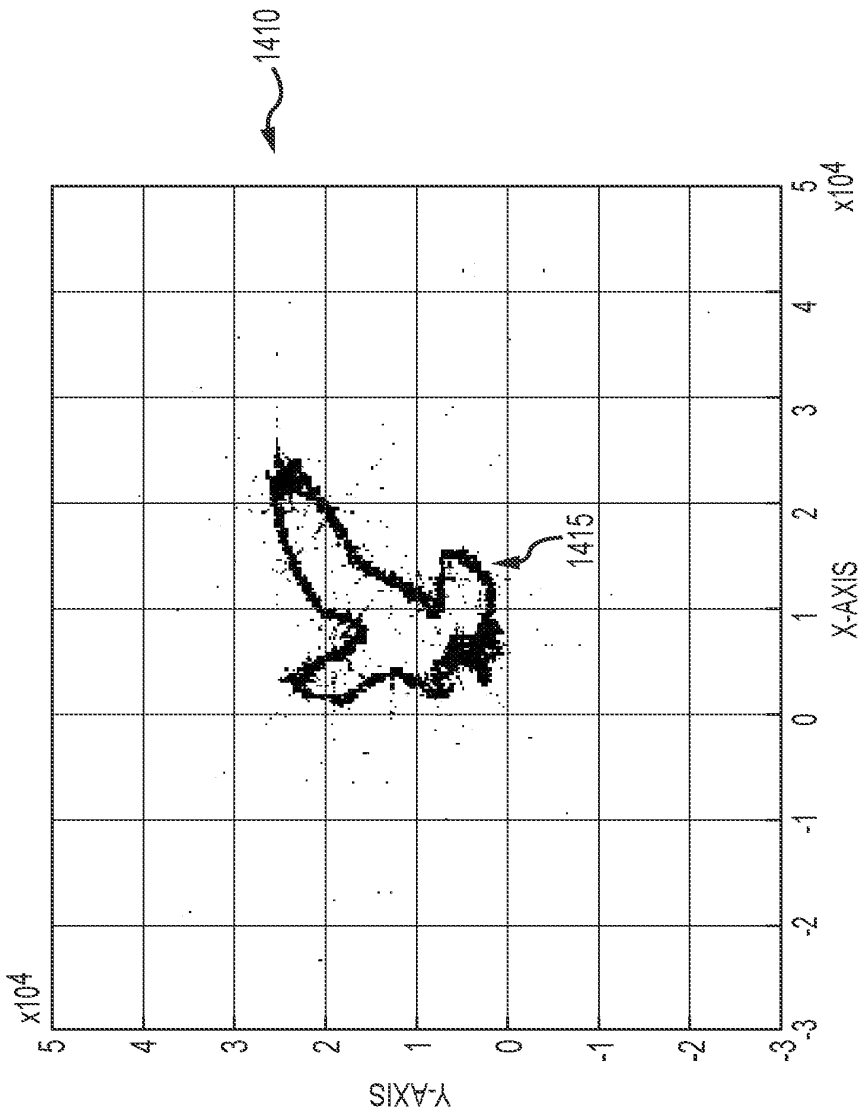


FIG.14A

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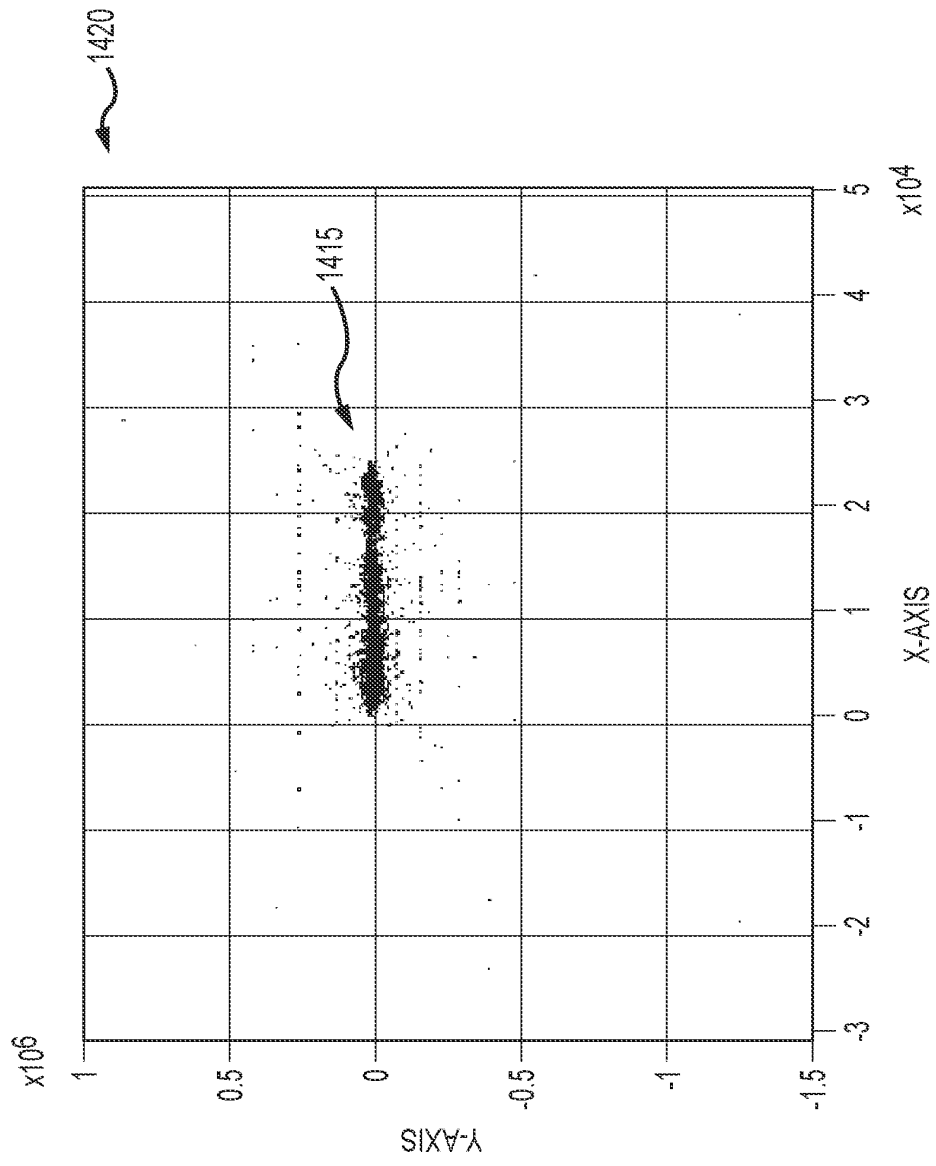


FIG.14B

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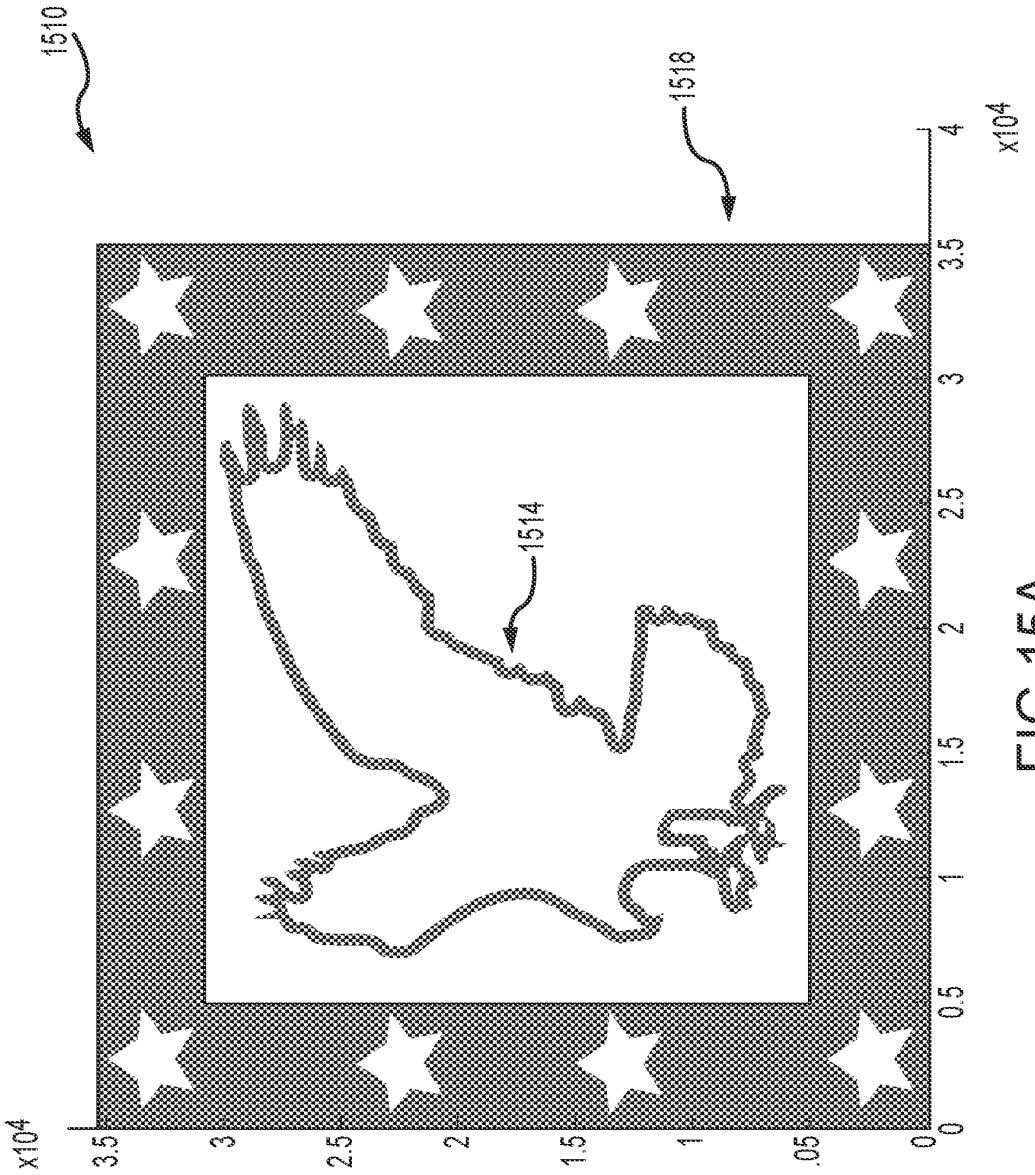


FIG.15A

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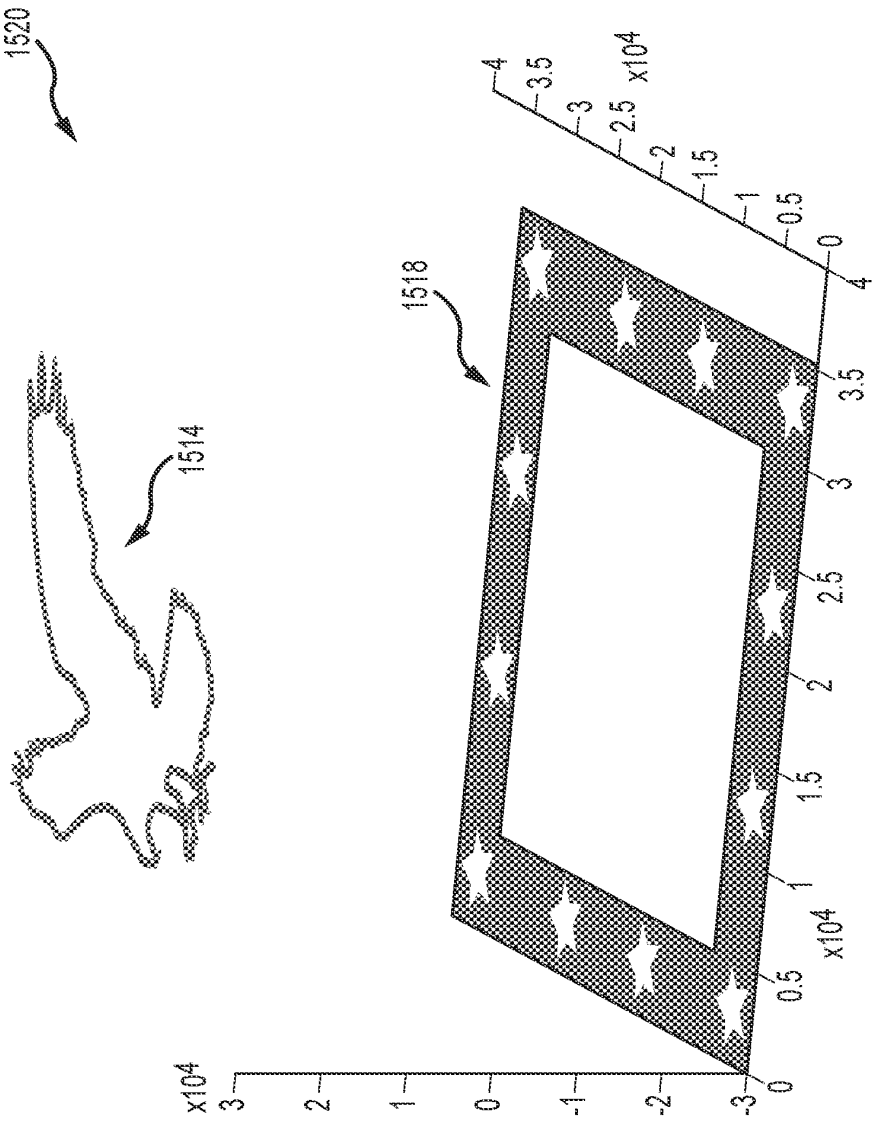


FIG.15B

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
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Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	MARK	A.	RAYMOND	

Residence Information (Select One) ● US Residency Non US Residency Active US Military Service

City	State/Province	Country of Residence
LITTLETON	CO	US

Mailing Address of Inventor:

Address 1	3600 SOUTH HURON STREET
Address 2	
City	ENGLEWOOD
State/Province	CO
Postal Code	80110
Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	HECTOR	ANDRES	PORRAS SOTO	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

City	State/Province	Country of Residence
LITTLETON	CO	US

Mailing Address of Inventor:

Address 1	3600 SOUTH HURON STREET
Address 2	
City	ENGLEWOOD
State/Province	CO
Postal Code	80110
Country	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	HOWARD	G.	LANGE	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

City	SAN DIEGO	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	3600 SOUTH HURON STREET		
Address 2			
City	ENGLEWOOD	**State/Province**	CO
Postal Code	80110	**Country**	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

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Application Information:

Title of the Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES		
Attorney Docket Number	79897.01436	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	20	**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

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☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	◯ Limited Recognition (37 CFR 11.9)
Customer Number	166539		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	16203128	2018-11-28

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16203128	Division of	15162113	2015-05-23	10189294	2019-01-29

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
15162113	Claims benefit of provisional	62262767	2015-12-03

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	LUMENCO, LLC		
Mailing Address Information For Applicant:			
Address 1	3600 SOUTH HURON STREET		
Address 2			
City	ENGLEWOOD	**State/Province**	CO
Country	US	Postal Code	80110
Phone Number		Fax Number	
Email Address	IPDOCKET@SWLAW.COM		

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country [i]		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/KENT A. LEMBKE/			Date (YYYY-MM-DD)	2021-01-19
First Name	KENT A.	Last Name	LEMBKE	Registration Number	44866

Additional Signature may be generated within this form by selecting the Add button. Add

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	79897.01436
		Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

EFS Web 2.2.13

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES FOR CURRENCY AND BRAND AUTHENTICATION

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [■] The attached application, or
- [ ] United States application or PCT international application number _____

filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: MARK A. RAYMOND Date (Optional) :_____

Signature: Mark A Raymond

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES FOR CURRENCY AND BRAND AUTHENTICATION

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [■] The attached application, or
- [ ] United States application or PCT international application number _____ filed on _____

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

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LEGAL NAME OF INVENTOR

Inventor: HOWARD G. LANGE Date (Optional): 5-19-2016

Signature: Howard G. Lange

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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- [x] The attached application, or
- [ ] United States application or PCT international application number _____

filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: HECTOR ANDRES PORRAS SOTO Date (Optional) :_____

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES			
First Named Inventor/Applicant Name:	MARK A. RAYMOND			
Filer:	Kent Alan Lembke./Lisa Root			
Attorney Docket Number:	79897.01436			
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	**Fee Code**	**Quantity**	**Amount**	**Sub-Total in USD($)**
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	80	80
UTILITY SEARCH FEE	2111	1	350	350
UTILITY EXAMINATION FEE	2311	1	400	400
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

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Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**830**

Electronic Acknowledgement Receipt	
EFS ID:	41686680
Application Number:	17152623
International Application Number:	
Confirmation Number:	9833
Title of Invention:	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES
First Named Inventor/Applicant Name:	MARK A. RAYMOND
Customer Number:	166539
Filer:	Kent Alan Lembke./Lisa Root
Filer Authorized By:	Kent Alan Lembke.
Attorney Docket Number:	79897.01436
Receipt Date:	19-JAN-2021
Filing Date:	
Time Stamp:	19:41:34
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$830
RAM confirmation Number	E20211IJ42093147
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Lumenco_Continuation_application.pdf	250130 0fb748ab2e7e34481100af1d3d6773baeb3dbaa1	yes	33
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Abstract		33	33	
	Claims		29	32	
	Specification		1	28	
Warnings:					
Information:					
2	Drawings-only black and white line drawings	Lumenco_drawings.pdf	146183 c93b75f0437ee14f42767bd3e1463a1014511393	no	20
Warnings:					
Information:					
3	Application Data Sheet	ADS_1.pdf	1256484 a022193b4512f9da22f0f7d62f090a88fb577ae0	no	9
Warnings:					
Information:					
4	Oath or Declaration filed	Raymond_Decl.pdf	137616 cf2aa0b5778e33e4b985d654bec615c70fa64d80	no	2
Warnings:					
Information:					
5	Oath or Declaration filed	Lange_Decl.pdf	154397 351fe74eaeea729d00797527ae418afb4a01136d	no	1

Warnings:					
Information:					
6	Oath or Declaration filed	Soto_Decl.pdf	269629 06dba692fd9103eb4fb2600048cddac96b1c1dd0	no	2
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	35074 a71eed20b7c89bbef252f07aa96fc9603a20c3b7	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	2249513	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/152,623	01/19/2021		830	79897.01436	20	3

CONFIRMATION NO. 9833

166539
Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004

FILING RECEIPT



Date Mailed: 02/24/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

MARK A. RAYMOND, LITTLETON, CO;
HECTOR ANDRES PORRAS SOTO, LITTLETON, CO;
HOWARD G. LANGE, SAN DIEGO, CA;

Applicant(s)

LUMENCO, LLC, Englewood, CO;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 16/203,128 11/28/2018 PAT 10901191
which is a DIV of 15/162,113 05/23/2016 PAT 10189294 *
which claims benefit of 62/262,767 12/03/2015
(*)Data provided by applicant is not consistent with PTO records.

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 02/22/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/152,623**

Projected Publication Date: To Be Determined - pending completion of Corrected Papers

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

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countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/152,623

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE($)	FEE($)		RATE($)	FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 240 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	830		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/152,623	01/19/2021	MARK A. RAYMOND	79897.01436

CONFIRMATION NO. 9833

166539
Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004

FORMALITIES LETTER

OC000000123596697

Date Mailed: 02/24/2021

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Filing Date Granted

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given **TWO MONTHS** from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

The required item(s) identified below must be timely submitted to avoid abandonment:

- A substitute specification in compliance with 37 CFR 1.52, 1.121(b)(3), and 1.125, is required. The substitute specification must be submitted with markings and be accompanied by a clean version (without markings) as set forth in 37 CFR 1.125(c) and a statement that the substitute specification contains no new matter (see 37 CFR 1.125(b)). The specification, claims, and/or abstract page(s) submitted is not acceptable and cannot be scanned or properly stored because:
  - The application papers (including any electronically submitted papers) are not in compliance with 37 CFR 1.52 because pages 27 contain text that is unreadable or of insufficient clarity.
    Application papers (including any electronically submitted papers) must be presented in a form having sufficient clarity and contrast between the background of the paper and the writing thereon to permit the Office to electronically reproduce the papers by use of digital imaging and optical character recognition. See 37 CFR 1.52(a)(1)(v).

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

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Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/dtdinh/

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit:
LUMENCO, LLC	)	Examiner: Not Yet Assigned
Serial No.: 17/152,623	)	
Filed: 9/16/2020	)	TRANSMITTAL OF CORRECTED APPLICATION DATA SHEET
Confirmation No.: 9833	)	
Atty. File No.: 79897.01436	)	
For: "METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES"	)	

Commissioner for Patents
Mail Stop Missing Parts
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir or Madam:

Applicant hereby submits a Corrected Application Data Sheet.

The attached ADS includes a correction to the filing date of the Prior Application 15/162,113. No new subject matter has been added.

Although the Applicant believes that no fees are due with filing this Amendment, please charge any fees deemed necessary to Deposit Account No. 19-2814.

Respectfully submitted,

Date: February 25, 2021

By: /Kent A. Lembke/
Russell T. Manning
Registration No. 44866

Snell & Wilmer L.L.P.
Tabor Center
1200 Seventeenth Street
Suite 1900
Denver, CO 80202
Phone: 303-634-2148

Giesecke+Devrient GmbH,
Giesecke+Devrient Currency Technology GmbH,
and Papierfabrik Louisenthal GmbH. - Ex. 1002

Fax: 303-634-2020
E-mail: rmanning@swlaw.com
\4834-9206-0638.1

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	MARK	A.	RAYMOND	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	LITTLETON	State/Province	CO	Country of Residence	US

Mailing Address of Inventor:

Address 1	3600 SOUTH HURON STREET		
Address 2			
City	ENGLEWOOD	State/Province	CO
Postal Code	80110	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	HECTOR	ANDRES	PORRAS SOTO	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	LITTLETON	State/Province	CO	Country of Residence	US

Mailing Address of Inventor:

Address 1	3600 SOUTH HURON STREET		
Address 2			
City	ENGLEWOOD	State/Province	CO
Postal Code	80110	Country	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	HOWARD	G.	LANGE	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

City	SAN DIEGO	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	3600 SOUTH HURON STREET		
Address 2			
City	ENGLEWOOD	State/Province	CO
Postal Code	80110	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	166539		
Email Address	IPDOCKET@SWLAW.COM	Add Email	Remove Email

Application Information:

Title of the Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES		
Attorney Docket Number	79897.01436	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	20	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897 01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	(●) Customer Number	( ) US Patent Practitioner	( ) Limited Recognition (37 CFR 11.9)
Customer Number	166539		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	16203128	2018-11-28

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16203128	Division of	15162113	~~2015-05-23~~ 2016-05-23	10189294	2019-01-29

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
15162113	Claims benefit of provisional	62262767	2015-12-03

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[j] (if applicable)

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897 01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:	
If the Applicant is an Organization check here.	☒
Organization Name	LUMENCO, LLC

Mailing Address Information For Applicant:

Address 1	3600 SOUTH HURON STREET		
Address 2			
City	ENGLEWOOD	**State/Province**	CO
Country	US	Postal Code	80110
Phone Number		Fax Number	
Email Address	IPDOCKET@SWLAW.COM		

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897 01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/KENT A. LEMBKE/			Date (YYYY-MM-DD)	2021-01-19
First Name	KENT A.	Last Name	LEMBKE	Registration Number	44866

Additional Signature may be generated within this form by selecting the Add button.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	79897.01436
	Application Number	
Title of Invention	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

EFS Web 2.2.13

Electronic Acknowledgement Receipt	
EFS ID:	42025244
Application Number:	17152623
International Application Number:	
Confirmation Number:	9833
Title of Invention:	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES
First Named Inventor/Applicant Name:	MARK A. RAYMOND
Customer Number:	166539
Filer:	Kent Alan Lembke./Lisa Root
Filer Authorized By:	Kent Alan Lembke.
Attorney Docket Number:	79897.01436
Receipt Date:	25-FEB-2021
Filing Date:	19-JAN-2021
Time Stamp:	15:50:00
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	79897_01436_Transmittal_Corr ADS.pdf	71842 308ed55b12e132bdd166db43633b1d8f132bf12c	no	2
Warnings:					

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Information:					
2	Application Data Sheet	79897_01436_ADS.pdf	3903866 0db63fffb7e448ab45e11803936c20cee38a0b59	no	9
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
			Total Files Size (in bytes):	3975708	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Patent Application of:	)	Group Art Unit:
Lumenco, LLC	)	Examiner:
Serial No.: 17/152,623	)	
Conf. No.: 9833	)	RESPONSE TO NOTICE TO FILE CORRECTED APPLICATION PAPERS
Filed: January 19, 2021	)	
Atty File No.: 79897.01436	)	
For: "METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES"	)))	ELECTRONIC SUBMISSION

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sirs:

Responsive to the notice to file corrected application papers mailed February 24, 2021, Applicant submits herewith a substitute specification to replace the original specification. The substitute specification removes the shading in the table on page 27. Although Applicant does not believe any fees are due in conjunction with submission, please charge any such fees to Deposit Account No. 19-2814.

No new matter was introduced in the substitute specification.

In light of the submitted substitute specification, Applicant submits that all informalities noted in the notice to file corrected application papers have been corrected and respectfully requests that the requirement to file correct application papers be withdrawn.

Dated: February 25, 2021.

Sincerely,

SNELL & WILMER L.L.P.
/Kent A. Lembke/
Kent A.Lembke
Reg. No. 44866
Snell & Wilmer L.L.P.
1200 Seventeenth Street, Suite 1900
Denver, CO 80202
Phone: 303.634.2149

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METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Patent Application No. 16/203,128, filed November 28, 2018, which is a divisional of U.S. Patent Application No. 15/162,113, filed May 23, 2016, that claims the benefit of U.S. Provisional Application No. 62/262,767, filed December 3, 2015, which are all incorporated herein by reference in their entireties.

BACKGROUND

1. Field of the Description.

[0002] The present invention relates, in general, to anti-counterfeiting devices for currency and brand authentication, and, more particularly, to currency and brand authentication elements, and methods of designing and manufacturing such authentication elements, that are configured to provide a multi-planar image that is viewable without special eyewear and that is difficult, if not nearly impossible, to replicate or copy.

2. Relevant Background.

[0003] Anti-counterfeiting efforts often involve use of an anti-counterfeiting device or element that is made up of an array of lenses and an image printed onto the back of the lens array or onto an underlying substrate or surface (e.g., a sheet of paper or plastic). The anti-counterfeiting element may be used to display an image that is chosen to be unique and be an indicator that the item carrying the anti-counterfeiting element is not a counterfeit. The anti-counterfeiting market is rapidly growing worldwide with anti-counterfeiting elements placed on a wide range of items such as upon currency (e.g., on a surface of a paper bill to help prevent copying) and on labels for retail products (e.g., labels on clothing showing authenticity).

[0004] In this regard, moiré patterns have been used for years in anti-counterfeiting elements with arrays of round lenses and with arrays of hexagonal lenses (or round and hexagonal lens arrays). Typically, the printed images provided in an ink layer under these lens arrays are small, fine images

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relative to the size of the lenses. A moiré pattern is provided in the printed images in the form of a secondary and visually evident superimposed pattern that is created when two identical patterns on a surface are overlaid while being displaced or rotated a small amount from each other.

[0005] In such moiré pattern-based anti-counterfeiting elements, some of the images may be printed in a frequency slightly more or less frequent than the one-to-one dimension of the lenses in two axes, and some of the images may be printed slightly differently relative to each other. While helpful to reduce counterfeiting, use of moiré patterns with round lens arrays has not been wholly satisfactory for the anti-counterfeiting market. One reason is that the effects that can be achieved with moiré patterns are limited, and the effect is often relatively easy to reverse engineer, which limits its usefulness as an anti-counterfeiting element. For example, printing the underlying image is becoming easier to accomplish due to high resolution lasers and setters and other printing advances. Typically, for an element, the micro-lenses are printed using an emboss and fill technology, which limits the printing to one color due to the fact that the process tends to be self-contaminating after one color and also due to the fact that the process is difficult to control from a relative color-to-color pitch in the emboss-and-fill printing process.

[0006] In other cases, holograms and lens features are used for security devices in currency, brand authentication and brand protection as well as on high security documents. Holograms are becoming increasingly less secure, in part, due to the rise in technology, programming, and general availability of programs that allow one to easily create holograms. In many applications, the cheaper dot matrix holograms are "good enough" to simulate many of the effects of the more expensive elaborate holograms used in anti-counterfeiting elements. While lens features done properly can be more secure than hologram elements, there is a need for new technology to combat the currency and product counterfeiting. Ideally, new technology would have attributes that are not possible with holography or micro-lenses.

[0007] Hence, there remains a need for advancements in the design and fabrication of assemblies or elements that display imagery useful for anti-counterfeiting and/or product/document authentication. For example, such improvements may allow new anti-counterfeiting devices or elements to be produced for use with currency, labels, credit/debit cards, and other items, and these anti-

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counterfeiting devices preferably would be much more difficult if not nearly impossible to duplicate or copy. Further, there is a growing demand for such anti-counterfeiting devices to provide a surprising or "wow factor" with their displayed imagery such as images that float above and/or below a focal plane (e.g., more true 3D displays) rather than merely laterally reflecting back light such as with a sequence of mirrors or mirrored surface or using reproducible holograms.

SUMMARY

[0008] Briefly, the inventors recognized that an anti-counterfeiting or security device can be provided that is configured to "write" images with light in one, two, or more spatial planes above and below the surface of an array of micro mirrors. Each of the micro mirrors is oriented (or "programmed") to act with a number of other such micro mirrors (e.g., a "set of pixel-providing micro mirrors") as one pixel in the written image(s) as the set of micro mirrors each directs its reflected light to a particular location in the image(s) display plane(s) (e.g., an apex of a cone with each of the micro mirrors in the set of pixel-providing micro mirrors being within the base of the cone) that when viewed with a number of other such pixels (each provided by a different set of pixel-providing micro mirrors) makes up a written image in one or more spaced apart image display planes.

[0009] In other words, text, imagery, and so forth can be written with ambient light by focusing the micro-mirrors to different spatial planes above the plane of the security device (which is typically provided on a surface of a document (e.g., currency) or product being authenticated with the security device). Conversely, the technology can then "reverse" to the viewer by having the "bright" pixels go to "dark" and the backgrounds reverse from "light' to "dark" with a change of perspective (e.g., occurring when the viewer changes their viewing angle or rotates the document/product containing the security device).

[0010] Also, since the technology is made of mirrors (made from thin aluminum, silver or gold depositions on an upper surface of the document/product on which the security element is provided (e.g., any supporting substrate)), the anti-counterfeiting or security device will work from two sides in a film process (e.g., when the supporting substrate is transparent). This type of two-sided or two-view image cannot be done with holography or other presently available anti-counterfeiting technologies. The technology can be embossed into films, metallized, and then processed into

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currency threads, foil stamps, labels and packaging. It can also be directly stamped onto coins or other metallic surfaces (e.g., provided on nearly any supporting substrate). Color can also be added to the displayed or "written" image(s) by using a reflective ink printing method or with the use of dielectric nanostructures (e.g., with plasmonic resonance and/or other techniques).

[0011] More particularly, a visual display assembly is provided that is useful as a security element on paper and coin currency, product labels, and other objects. The assembly includes a substrate (which may be part of the object upon which the security element is provided such as a piece of currency or a product label). The assembly also includes, on a surface of the substrate, an array of micro mirrors receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate. The image includes or is "written" with a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

[0012] In some embodiments, each of the sets of the micro mirrors includes at least twenty of the micro mirrors (e.g. a number in the range of 20 to 40 such as about 30 mirrors). To provide a "bright" or light pixel, the reflected ambient light from the twenty or more micro mirrors intersects or crosses at (or passes near to) the point corresponding to the one of the pixels (e.g., each pixel is displayed or lit by beams/rays from reflective surfaces of the micro mirrors crossing at a common point on the image display plane). The point on the plane may correspond to an apex of a cone, and the twenty or more micro mirrors can be located within a base of the cone coplanar with the surface of the substrate. The micro mirrors within the base of the cone but excluded from (or not included in or used for) the set of the micro mirrors displaying the pixel are oriented to reflect the ambient light away from point on the plane corresponding to the pixel to provide a dark background for the image.

[0013] The assembly may be configured to display images in more than one image display plane or in two or more levels/layers. In this regard, the array of mirrors may be configured to behave further in response to the receiving of the ambient light to display a second image in a second plane spaced a distance apart from the plane displaying the image. The second image may be provided or "written" with a plurality of pixels (as was the case with the first image). The array of micro mirrors includes,

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for each of the pixels of the second image, a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the second plane corresponding to one of the pixels of the second image. The first image has a first viewing angle and the second image has a second viewing angle offset from the first viewing angle by at least 10 degrees (such as an offset angle in the range of 10 to 45 degrees with offset angles of 20 to 30 degrees being useful in some embodiments).

[0014] In some particular implementations, the substrate is transparent, whereby the image is displayed to be spaced apart the distance from a first side of the substrate and further whereby a second image including a second set of pixels is displayed by the array of micro mirrors to be spaced apart a second distance from a second side of the substrate opposite the first side. In this manner, the array of micro mirrors can be said to be completely functional on the reverse side of the substrate (or film) to present a mirror image or a reverse image (in the image plane) to the viewer on the opposite side of the substrate.

[0015] In the same or other embodiments, the micro mirrors are rectangular (e.g., square) with a smallest side having a length of at least 35 microns such as 50 microns or more while other embodiments use mirrors that are circular with a diameter of at least 35 microns (e.g., 50 microns or larger in diameter). In practice, the plane in which the image is displayed may be above, below, or coinciding with the focal plane for the array of the micro mirrors. Also, the image may be displayed using only (or mostly) white light (and off or dark pixels) or the micro mirrors may be configured to display the image with colors (in addition to white). This may be achieved with at least one of ink, plasmonic resonance, and dielectric material being used to configure the micro mirrors to display the image with the desired colors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Fig. 1 is a top perspective, partial view of a visual display assembly for use as an anti-counterfeiting element or device showing a single micro mirror that would be provided in an array of such micro mirrors;

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[0017] Fig. 2 is a side view (e.g., a functional schematic) of an object (such as currency, a document, a financial card, or the like) including an anti-counterfeiting or authentication (or security) element/device of the present description;

[0018] Fig. 3 is an enlarged view of a subset of the micro mirrors of the security element of Fig. 2 corresponding to micro mirrors in an area of one cone base associated with one cone apex or written pixel in one of the displayed/written images provided by the security element of Fig. 2;

[0019] Fig. 4 is a schematic or graphic side view or diagram of a security element during its use to provide a two-layer or level image;

[0020] Fig. 5 is a side schematic view or diagram of a security element during its use to provide a display that combines a light image and a dark image;

[0021] Fig. 6 is a functional block diagram of a computer or computing device configured to run an array design program to allow an operator to generate a design of an array of micro mirrors for displaying a particular image(s) when provided in a security element;

[0022] Fig. 7 is a flow diagram of an exemplary design method for an array of micro mirrors for use in a security element, such as may be carried out by operation of the system of Fig. 6;

[0023] Figs. 8A and 8B illustrate a micro mirror design GUI that can be displayed on a monitor or display by the design program;

[0024] Figs. 9A-9C are graphs illustrating images that can be displayed on various levels or image display planes by an array of micro mirrors of the present description;

[0025] Fig. 10 is a plot illustrating a ray tracing near a first image display plane or first level/layer for one modeled array of micro mirrors;

[0026] Fig. 11 illustrates a representative GUI or ray tracing menu that allows a user to specify parameters to utilize in performing the ray tracing;

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[0027] Fig. 12 is a plot of a representative ray tracing showing beams/rays reflected from micro mirrors in a mirror plane and converging on a viewer's retina;

[0028] Figs. 13A and 13B illustrate written or displayed images provided by an array of micro mirrors with an angular offset between image display planes or levels/layers of the imagery;

[0029] Figs. 14A and 14B illustrate plots of floating pixels in a space above an array of micro mirrors; and

[0030] Figs. 15A and 15B illustrate plots generated and displayed by a preview program (which may be a subroutine of the design program described herein) for previewing likely or predicted results of a design of an array of micro mirrors.

DETAILED DESCRIPTION

[0031] Briefly, the present description is directed toward visual display assemblies that can be used as anti-counterfeiting or authentication elements or devices such as on currency, coins, documents, products, and so on. Each visual display assembly includes an array of a large number of micro mirrors, and this array can be provided on a surface of nearly any supporting substrate (e.g., a surface of a piece of currency, on a coin, on a surface of a product or its sales/identification label, and so on). Sets (or subsets) of the micro mirrors are used to work in unison to "write" pixels of images in one, two, or more image display planes above the supporting substrate by having each of the micro mirrors in each of the pixel-providing sets direct light striking its first or upper reflective surface to a location of a pixel in one of the image display planes. The sets of pixels may be configured to provide angular offset viewing (e.g., by an offset angle in the range of 15 to 35 degrees or the like with 20 degrees used in some cases between the viewing angles of the written images of each adjacent image display plane) in the different image display planes such that a viewer typically only observes or perceives the written pixels of one image display plane at a time (or at a single viewing angle or perspective) and switching occurs as the viewer changes their viewing angle or rotates the substrate supporting the visual display assembly and its many micro mirrors.

[0032] The visual display assembly (or security element/device) is designed to create a floating image(s) of pixels, and the pixel-providing sets of micro mirrors are chosen to have a large enough

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number to effectively display a great enough quantity of light to allow a viewer to perceive each separate, floating pixel in the written or displayed image. The number of micro mirrors used in each set may vary due to a large number of parameters such as material used to provide the reflective upper surface, size of each micro mirror (e.g., with 35 to 100 micron mirrors used in some implementations and 50 micron mirrors used in one prototype of the present invention), and the like. Each of these micro mirrors in each pixel-providing set is oriented to try to have all of these micro mirrors direct their reflected light to intersect at a point (the written pixel of the displayed image) in an image display plane above the supporting substrate, and each pixel of the written image is either on or off (or providing light or no light) at various viewing angles.

[0033] A basic or underlying idea of the micro mirror-based visual display assembly is to use ambient light and a plane (an upper surface of a supporting substrate) containing many, small mirrors. The ambient light that is reflected off the mirrors is aimed or targeted toward desired points (or pixels) above the plane that contains the mirrors. The image displayed by all the pixel-providing sets of micro mirrors targeting a first image display plane above the supporting substrate may be considered a first layer image. The first layer image can be defined by artwork that has light or dark pixels to be produced in this first layer (or a multi-layer image) or first image display plane. To this end, the mirrors in a pixel-providing set of micro mirrors are carefully selected from the micro mirror array as being within a circle (or cone base) defined by the intersection of the cone defined by an apex angle and a pixel from the desired image display plane/layer (e.g., the first image display plane) that is chosen to coincide with the apex of the cone. Each of these mirrors (which are in the base of the cone) is then aimed or targeted (or "oriented") toward the cone apex (image's pixel) so that the resulting effect is a point source of light floating a height or distance above (or below in some cases) the plane of the supporting surface containing the array of micro mirrors at the location of the pixel.

[0034] Prior to explaining a design or configuration of an entire array of micro mirrors in a visual display assembly, it may be useful to first look at a single one of these mirrors. Figure 1 illustrates a portion of a visual display assembly 100 (or a substrate with a security element or device) according to the present description. As shown, a supporting substrate 110 with a surface 112 is provided that receives and supports a micro mirror 120. For example, the substrate 110 may be a piece of currency,

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a coin, a product label, a document, a credit/debit/bank card, or the like for which it is desired to provide anti-counterfeiting or authentication functionality with the visual display assembly or security element 100. The micro mirror 120 is shown to include a body (or lower layer/surface) 122 that is affixed to or integrally formed with the surface 112 of the substrate 110. The view in Figure 1 is only "partial" as it will be understood that the assembly 100 typically would include many (e.g., hundreds to many thousands) of the micro mirrors 120 (i.e., an array of micro mirrors 120). Each of such micro mirrors 120 is individually oriented or "programmed" as discussed below such that the micro mirrors 120 of the array act together to display one or more floating images made up of a plurality of pixels in one or more image display planes above the substrate surface 112.

[0035] The micro mirror 120 also includes an upper (or exposed) reflective surface 124 facing away from the surface 112 of the supporting substrate 110. This surface 124 is reflective as the micro mirror 120 typically will be formed of a metal or metallic compound or other material chosen for its reflective properties. For example, the micro mirror 120 may be a thin layer of aluminum, silver, gold, or the like provided by deposition upon the surface 112 of the substrate 110. When the image display assembly 100 is in use, ambient light 130 strikes the reflective upper surface 124 of the micro mirror 120 and is reflected as shown at 134 from the upper surface 124. Particularly, the micro mirror's upper surface 124 is to have a normal vector 135 (e.g., as may be defined as output of a design program with X, Y, and Z coordinates), and the incoming ray 130 and the normal vector 135 from the same angle, β, as is formed between the normal vector 135 and the reflected light 134.

[0036] The reflected light 134 is preferably directed or aimed so as to cross an image display plane 140, which is spaced apart a height, H_1, above or away from the substrate surface 112 (and reflective surface 124 which may be substantially coplanar due to the small thickness of the body 122), at a location (X-Y-Z coordinates may define this location relative to the surfaces 112 and 124) coinciding with or defining one of a plurality of written pixels 142 of an image displayed by the assembly 100 in the plane 140. While not shown, a plurality of other micro mirrors configured similar to mirror 120 would also reflect their received ambient light to the point/pixel 142 in the plane 140 (a plurality of reflected light beams from micro mirrors would intersect at the point/pixel 142) so as to provide a point source of light at 142 viewable by a viewer 102.

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[0037] To provide this desired reflection of light 134, the micro mirror 120 is oriented or has its reflective surface 124 oriented in a particular, predefined (e.g., by a visual display assembly configuration computer program or algorithm) manner. Particularly, each micro mirror 120 may be individually oriented by rotating its body 122 (or surface 124) about one or both of first and second rotation axes 150, 152 as shown with arrows 151, 153 during design processes (prior to fabrication). Then, the micro mirror 120 may be formed with these design parameters so that the reflective upper surface 124 (with its known location in the array of micro mirrors by X-Y coordinates of its center) is oriented (at first and second angles) relative to the two axes 150, 152 to have its normal vector 135 aimed or targeted in a particular manner (X-Y-Z coordinates of the normal vector for the mirror 120), e.g., to have ambient light 130 reflected as shown at 134 to cross the image display plane 140 at the location of the pixel 142. As noted above, the size (and shape) of each micro mirror 120 may be varied to practice the invention with some embodiments utilizing square-shaped bodies 122 that have sides with a length, L_{Side}, that is typically greater than about 35 microns (such as 50 microns) and often in the range of 40 to 60 microns while some embodiments may use larger micro mirrors.

[0038] Figure 2 is a side view (e.g., a functional schematic) 200 of an object (such as currency, a document, a financial card, or the like) 210 including an anti-counterfeiting or authentication (or security) element/device 220 of the present description. The object or substrate 210 includes an upper or first surface 212 upon which is provided or formed the security device 220 (which may take the form of the visual display assembly 100 of Figure 1). The security device 220 has an exposed or upper surface 222 that is configured to provide an array of micro mirrors 224, which may be individually oriented to provide reflection of ambient light striking the surface 222 of the security element 220 so as to display one or more floating images that can be observed by a viewer 202 to authenticate the object 210.

[0039] To this end, a first number of the micro mirrors 224 may be configured to provide sets of pixel-providing micro mirrors that reflect ambient light as shown with arrows 230 to "write" or display a first displayed image 242 made up of a plurality of pixels 243 (with each of these pixels 243 associated with one of the sets of pixel-providing micro mirrors 224). A second number of the micro mirrors 224 is configured to provides sets of pixel-providing micro mirrors that reflect ambient light

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as shown with arrows 250 to "write" or display a second displayed image 262 made up of a plurality of pixels 263 (with each of these pixels 263 being associated or written by one of the sets of pixel-providing micro mirrors 224). As discussed with reference to Figure 1, each of the micro mirrors 224 in the same set of pixel-providing micro mirrors 224 used to create/write a particular pixel 243, 263 in one of the images 242, 262 is configured or oriented with its reflective surface oriented (with rotation relative to one and/or two rotation axes) to target or direct a point/location on the plane 240 or 260 coinciding with the pixel 243, 263. This, in most embodiments, coincides with an apex of a cone with each of the pixels 243, 263 in the set of micro mirrors 224 being in the base of the cone (e.g., within the circular area on the surface 222 defined by the cone base). Note, each of these micro mirrors 224, though, is oriented uniquely and differently to provide the reflected light 230, 250 along a normal vector to its reflective surface.

[0040] To the viewer 202, the first displayed image 242 appears to float in the first image display plane 240 that is a height, H_1, above the surface 212 of the object/substrate 210 while the second displayed image 262 appears to float in the second image display plane 260 that is a different (typically greater) height, H_2, above the surface 212. The micro mirrors 224 are oriented so that the pixels 243 of the first image 242 are a viewing angle offset, θ_{Offset}, (e.g., 10 to 30 degrees or the like) from the pixels 263 of the second image 262 so that the viewer 202 typically only views one of the floating images 242, 262 at a time (at a range of viewing angles).

[0041] As discussed above, micro mirrors for each set of pixel-providing micro mirrors are chosen from a set of available micro mirrors located within an area on the security element surface (or substrate surface) that corresponds with a base of the cone with an apex coinciding with the pixel being created by these micro mirrors. Figure 3 is an enlarged view of a subset of the micro mirrors 224 on the surface 222 of the security element 220 of Figure 2, which correspond to micro mirrors 224 in an area of one cone base with diameter, $Diam_{Cone\ Base}$, associated with one cone apex or written pixel 243 or 263 in one of the displayed/written images 242 or 262 provided by the security element 220.

[0042] Figure 3 illustrates all the available micro mirrors 224 in the cone base, but the security element 220 typically is designed so that only a subset of these available mirrors 224 (such as 20 to

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40 or more with 30 shown in use in Figure 3 at 324) are used to write or display a particular pixel. The unused mirrors 224 typically are oriented to reflect received ambient light away from the location of the pixel being written/created by the chosen mirrors 324, which may be considered as providing a mask with the unused mirrors 224. The chosen mirrors 324 (or mirrors in the set of pixel-providing micro mirrors) are shown with shading/patterning that would not be actually present in a security element but that is useful for differentiating these mirrors 324 from the other/unused ones of the mirrors 224.

[0043] As will be explained below, the micro mirrors 324 in the set of pixel-providing micro mirrors are randomly chosen such that the mirrors 324 do not provide an obvious, regular pattern and each pixel's set of micro mirrors 224 likely will have a very different pattern within a cone base or circular area of the surface 222 of the security element 220. Also, each of the micro mirrors 324 in the set used to provide a particular pixel 243 or 263 will be differently oriented so as to have the normal vectors of all the mirrors 324 intersect at the X-Y-Z coordinates of the same pixel 243 or 263 in the appropriate one of the image display planes 240 or 260.

[0044] Significantly, the mirrors 324 are not pointing toward a viewer but, instead, are aimed or targeted toward the intersection point (or pixel coordinates) in the image display plane or layer. The use of sets of micro mirrors to provide or create floating pixels that in combination can write or display an image in one, two, or more layers is effective in providing a displayed image with depth and with high contrast. Further, the image appears to switch from light to dark with rotation of the object/substrate with the security element (or with movement of the viewer's eyes to change their viewing angle or perspective).

[0045] Figure 4 is a schematic or graphic side view or diagram 400 of a security element 410 during its use to provide a two-layer or level image. The security element 410 includes a micro mirror array 412 made up of numerous (e.g., thousands) micro mirrors (e.g., 50 micron diameter mirrored surfaces). As shown, three sets of micro mirrors in the array 412 have been oriented or configured to display pixels 422 in a first plane or at a first level 420 above the security element 410 (or its surface containing the array 412). As shown with arrows 423, light is reflected so that beams from a set of the micro mirrors intersect to create a pixel 422 in the first level 420. These are provided within a

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cone angle, β_{Cone}, Further, as shown with arrows 425, a mask or mask image may defined to block some rays by having the mirrors that would provide this light directed outside of the conical angle, β_{Cone}, region (e.g., the arrows 425 are associated with light that is not actually reflected for viewing with the light 423 but is, instead, directed elsewhere).

[0046] Also, as shown two sets of micro mirrors in the array 412 have been oriented or configured to display pixels 432 in a second plane or at a second level 430 spaced apart from level 420. Arrows 433 represent beams of reflected light that are directed from these sets of mirrors to intersect or cross at the locations of the pixels 432. Also, as shown, the pixels are displayed to the viewer at viewing angles that are offset by an angle (pixel offset angle), γ (such as 10 to 30 degrees or the like). The basic angle direction of the pixels 432 is chosen to offset the image in the plane/level 430 for the viewer (or at the viewer) from the image in the plane/level 420.

[0047] Figure 5 is a schematic or diagram 500 similar to that of Figure 4 but showing an embodiment of a security element 510 with an array of mirrors adapted specifically to provide two light and dark images. The diagram 500 illustrates that the sets of pixel-providing micro mirrors on the security element 510 (or in a mirror planar surface) can be oriented to provide a light image (with bright pixels with a dark background) that when going in reverse provides a dark image with a light background as the viewer rotates the element 510 or otherwise changes their perspective.

[0048] As shown, the security element 510 has a planar mirror surface with an array of micro mirrors adapted to reflect light in directed beams 514 and 518. The beams/rays 514 are directed so as to display/create pixels 522 on a first plane 520 that is more proximate to the mirror plane of security element 510 (with only two pixels 522 shown in each image plane 520 and 530 (in each displayed image) for clarity with it being understood that any number of pixels (1 to more typically many (e.g., a few hundred to several thousand or the like)) may be used to create each image with the size of the mirrors and overall array provided in security element 510 being the only limitations). The beams/rays 518 provided by the other sets of pixel-providing mirrors in element 510 are directed/aimed to cross/intersect on the second image displaying plane 530 (which is spaced apart from the first plane 520 some distance such 0.25 to 1 inch to several inches or more) to display/create pixels 532.

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[0049] To make the images provided by the pixels 522, 532 appear light and dark, the beams 514 and 532 are separated by an angle, ϕ, (e.g., 15 to 30 degrees or more) as may be measured between proximate ones of the beams in each group 514 and 518 (e.g., after the beams cross proximate to the mirror plane of security element 510 such as at or after the first image display plane 520). The angle of image separation, ϕ, and the cone angles at pixels 522, 532 are chosen to give this angular separation. Images of bright and dark zones do not overlap, and images provided by pixels 522 and 532 appear to the viewer to be in the two spaced apart or different planes 520, 530. One image darkens as the other lightens as the view angle changes.

[0050] Figure 6 is a functional block diagram of a computer or computing device 600 configured to run an array design program to allow an operator to generate a design of an array of micro mirrors for displaying a particular image(s) when provided in a security element (e.g., to perform steps of the method of manufacturing a security element with an array of micro mirrors according to the present description). The computer 600 includes a processor(s) 610 that executes code/instructions in computer readable media to run or provide the functionality of the micro mirror array design program 630 as well as those of the ray tracing module(s) 635. The processor 610 also manages operation of input/output (I/O) devices 620 such as a keyboard, a mouse, a touch pad or screen, voice recognition software, and the like configured to allow a user to provide input such as to select design parameters for a particular security element. The I/O devices 620 may include a monitor/display 624 and the design program 630 may be configured to generate one or more graphical user interfaces (GUIs) 628 displayed on the monitor/display device 624 to facilitate a user providing input and to display calculated results (such as the calculated angular orientations of each mirror in the array).

[0051] The processor 610 during the running of the design program 630 may access and manage memory (or data storage device) 640, which may be onboard as shown or offboard but accessible by the processor 610. The output of the design program 630 is stored at 650 in memory 640 and provides a design for an array of micro mirrors for a particular security element to be manufactured. The design 650 is shown at 651 to include a calculated angular orientation for each mirror in the array. This may be defined at 652 with a center location of the mirror (e.g., X-Y coordinates) combined with coordinates of a normal vector (e.g., X-Y-Z coordinates) for the mirror. This information can be used

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in a manufacture (e.g., deposition or other processes) of a security element for an object (such as for currency, coins, product labels, documents, and the like).

[0052] To allow the design program 630 to generate the array design 650, a user typically initially chooses a digital image 660 as a base or starting image for creating an anti-counterfeit or authentication image to be displayed in one or more planes or levels relative to the array of micro mirrors. The user/operator then may use the GUI 628 or other I/O devices 620 to identify one or more images to be displayed on each level of the image displayed by the security element being designed as shown at 662, 663. For example, images in the first plane or level 662 may be foreground images in the base/start image 660 while images 663 in the second (or later) plane or level 663 may be background (or intermediate) images of the base/start image 660. The design program 630 or another program on the computer 600 or available to the processor 610 may then be used to convert the digital base/start image 660 into a text or other file that identifies each pixel in the base/start image as being assigned to a particular one of the levels/planes (e.g., a text file with a plurality of numbers replacing the pixels of the image 660 representing one of the planes/levels of the image to be displayed by the security element being designed using the design program 630).

[0053] At this stage of operations, the design program 630 may function to generate a GUI 628 with a number of data entry boxes/fields prompting the user to accept default design parameter values or to enter/modify such values. The design program 630 may then operate to calculate the array design 650 including the angular orientations of each of the micro mirrors in an array. For example, the user may set or define a cone angle, as shown at 666 in memory 640, for use for generating the pixels of images in each level/plane used to display a security image. The cone angle often will differ for each level such as with larger values assigned to earlier/lower levels/planes (but this is not required), and exemplary cone angles for image pixels may be in the range of 10 to 30 degrees or the like.

[0054] The user may also be asked to provide or select an angular offset between each pair of image levels/planes as shown at 668 in memory 640, and this offset may range from 0 to 30 or more degrees to achieve a desired effect for a displayed image. Other parameters that may be entered or set by the user of the system 600 may include the dots per inch (DPI) 670 that defines the spacing of the pixels in each image display level or plane (the cone apex planes). The user may also be allowed to set the

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number mirrors to be used to create or display each pixel as shown in memory 640 at 680 (with 20 to 40 mirrors likely to be useful in some implementations). Further, the user may define heights of the image display levels or planes as shown at 688 (such as a first plane at 10000 microns, a second plane at 20000 microns, a third plane at 30000 microns or other useful spacings/heights).

[0055] With the parameters defined, the user may instruct the design program 630 to run to first choose, for each pixel in each image to be displayed in the levels/planes, a set of micro mirrors to be used to display or create the pixel. The other pixels may be considered unused pixels or pixels that can be used in a mask, and these pixels may be angularly oriented to direct light outside of the cone angle. The design program 630 may then continue with determining an array design 650 with these sets of pixel-providing mirrors 684 by calculating for each of the micro mirrors of the array its angular orientation 651, which may be provided by the coordinates (e.g., X-Y coordinates or the like) of the center of each mirror and the coordinates (e.g., X-Y-Z coordinates or the like) of the normal vector for the mirror with such center coordinates. This determination of the design 650 is carried out such that the micro mirrors in each set of pixel-providing mirrors is oriented to direct its reflected ambient light (a reflected light stream or beam or ray) onto the same image display plane at the same location (e.g., at a location of a pixel). The ray tracing module 635 may be configured to test the effectiveness of the array design 650 as explained below to ray trace reflected light providing images to a viewer's eye (or expected viewing positions relative to a security element with the array of micro mirrors having angular orientations as called out in the array design 650).

[0056] Figure 7 is a flow diagram of an exemplary design method 700 for an array of micro mirrors for use in a security element, such as may be carried out by operation of the system 600 of Figure 6. The method 700 starts at 705 such as with loading a design program onto a computing device and initiating or running the program. The method 700 continues at 710 with selecting a base or start image such as selecting a file in memory of a computing device providing a digital image of objects that may be useful for providing a multi-layer display for use in authenticating an object (e.g., an image with one or more components that can be presented as foreground images and one or more components that can be presented as background and/or intermediate images or on layers that appear behind the foreground images).

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[0057] In step 720, the method 700 involves a user indicating which portions/components of the base/start image from step 710 should be presented in the image(s) displayed on each of the one, two, or more image display layers for this security element. Hence, step 720 may be thought of as including first deciding how many display layers/planes to use with this array of micro mirrors (and this value can be affirmed/set in later step 730 as one of the design parameters). Step 720 may involve assigning differing colors of a colored base/start image to differing image display planes/levels. In other cases, a component/object in the image may be chosen as a foreground image and one or more of the other components/objects in the image may be selected to be background images to be on different levels/planes. At step 725, the method 700 continues with converting the base image into a file (such as a text document or file with each pixel replaced with 0's and 1's when two levels/planes are used and so on) that indicates for each pixel in the base image which level/plane that pixel is assigned for display by the array of micro mirrors.

[0058] The method 700 continues at 730 with the user choosing/setting design parameters (or accepting default ones such as may be predefined by the design program or as previously saved for other arrays). For example, the spacing of pixels in each image plane may be set (e.g., set the DPI for each image display plane/level), and the user may also set the cone angle and, in some cases, the mirror size. Step 730 may also include setting the height of each image display level/plane (which also sets the spacing between adjacent pairs of the planes/levels).

[0059] The method 700 continues at 740 with selecting or identifying a set of mirrors in the array to use to display each of the pixels in the images chosen in step 720 (with more detail provided for this process provided below). Step 740 may involve determining the number of mirrors that should be used for each pixel (typically a number between 1 and 40 or more that is used throughout the design) based on a cone angle, mirror size, and the DPI of the image (or pixel pitch). In some implementations, a program implementing the method 700 provides the average number of mirrors per pixel after step 730, and the user may determine it is useful to modify the design parameters (repeat step 730) to achieve a better result (e.g., some prototyping indicates that a "sweet spot" may exist around 25 mirrors per pixel with 10 being too few in some cases and 40 being too many in others). Step 740 may also involve defining a cone with an apex coinciding at the pixel location and

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with a cone angle set by the design parameters, and the cone base or area on the mirror plane may be used to define which micro mirrors may be chosen to display or "write" the particular pixel. The design parameters also define how many mirrors among the available ones in this circular or cone base area to use in the set of pixel-providing mirrors. A first mirror is chosen randomly (any useful random selection algorithm may be used and it may have "memory" in that a next run may remember which mirrors in the available set have already been chosen), and then this random process is repeated for the available mirrors until the set includes the number of mirrors needed for a complete set based on the design parameters for this array of micro mirrors.

[0060] At step 750, the method 700 includes for a next one of the pixels in the images, calculating angular orientation of all mirrors in the set of mirrors chosen for displaying that pixel. At 760, it is determined whether there remain additional pixels in the images, and, if yes, the method 700 proceeds with repeating steps 750 and 760 until all the angular orientations for the mirrors in the sets of pixel-providing micro mirrors are determined. If no at step 760, the method 700 continues at 770 with directing all mirrors not in one of these sets (or unused mirrors) so that they do not interfere with image display, e.g., by assigning an angular orientation that is outside the viewing cone for each of the pixels used to display the images on each of the levels/planes.

[0061] At step 780, the method 700 is shown to include a decision step based on the number and/or location of the unused mirrors. The method 700 (or computer program functioning to implement the method 700) may plot the position of all the unused mirrors. If there are too many unused mirrors (e.g., above a predefined maximum unused mirror number) and/or the unused mirrors are too close to each other (e.g., not scattered over the canvas or array of micro mirrors), the method 700 may return to step 730 to change the design parameters and repeat the other steps of the method 700 after step 730. The parameters that may be changed at 730 can include the cone angle (e.g., to have more surface from which to choose mirrors) and the height of the floating images (e.g., the closer the images are floating to the mirror plane the more difficult it can be to find useful mirrors so that higher or lower display/floating levels or planes will decrease the number of unused mirrors). In some cases, the DPI can be changed from the original image and/or the image design may need to be changed to obtain a useful result with method 700.

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[0062] If the number and/or location of the unused mirrors is determined to be satisfactory at 770, the method 700 then may end at 790. The design of the angular array may then be output for use in fabricating a security element with an array of micro mirrors individually oriented to provide one or more images (with a number of displayed pixels) on one or more image display planes/levels.

[0063] As discussed previously, an underlying idea of the security elements of the present description is to use ambient light and a planar surface containing many small mirrors and to aim the ambient light reflected off the mirrors toward a desired point in space above the planar surface that contains the mirrors. This is called the first layer image and is defined by artwork that has light or dark pixels to be produced in a layer or level (or first image display plane). By carefully selecting the mirrors within a circle defined by the intersection of the cone defined by an apex angle and a pixel from the first layer/level as the apex of the cone, the cone apex from various mirrors in the circular base of the cone provides a point source of light floating above the level of the mirror plane at the location of a pixel, containing the mirrors. A computer algorithm (as shown with the program 630 in Figure 6) completes this process on a pixel-by-pixel basis. If the pixel in the first layer/level is a dark pixel (e.g., a pixel not associated with the image or image component/portion from a base/start image chosen for display in the first image display plane), no rays will be aimed toward it.

[0064] In addition, the program has the capability of using a second layer of pixels that acts as a mask for the first layer of pixels so that various portions of the pixel image at level one are "hidden" or visible depending on the viewing angle. The algorithm that generates the first layer of floating pixels looks at the rays aimed to the pixel in the first layer and the continuation of the rays to the second layer. The intersection location in the second layer is calculated and is searched for nearby dark pixels of the second layer/level (mask layer and/or second image display plane). If dark pixels are found in the intersection area on the second layer, the mirror that reflected that ray to the first layer is not used to aim the ray at that pixel to the first layer (e.g., this additional processing can be used to modify or originally select the mirrors to be used to display the pixel of the first image display plane).

[0065] Thus, there is a masking effect of the mask layer as is desired. To form a mask that appears to "float" over the pixels in the first layer (or first image display plane), some pixels of the first layer will have partial cones of pixels depending on the mask geometry defined by the pixels on/off of the

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second layer and on the angle the pixels are viewed (as can be seen with reference to the diagram 400 of Figure 4). As the viewer's eye is moved (or the mirror assembly tilted to the viewer), pixels of the first layer will change brightness and appear or disappear from view in a way that causes the mask to appear to move.

[0066] To insure uniform illumination across pixels, during the aiming process as described above, only one of the available mirrors is used in each pixel's cone of acceptance by the design program, and the mirror is selected at random from the available mirrors in the cone of acceptance. After the direction cosines of the selected mirror are calculated, the mirror is marked by the design program as "no longer available for use by any other pixel." The design program moves on to the next pixel, and the same sequence of events or design steps are repeated until all the pixels are used (or oriented for desired light reflection). At that point in the design algorithm, the entire sequence of pixels is again used to pick up one of the available mirrors for each pixel. After a number of cycles of the pixels, all the mirrors are used depending on the image and mask patterns. If some mirrors cannot be used because of the geometry of the image layer and mask layer, they will be aimed out of the viewing zone.

[0067] The design program allows the user to choose the values of the spacing of image levels from the mirror plane, as well as pixel cone angles, mirror sizes and pixel pitches. These all can be optimized or selected by the user to make (or try to make) the best image to present to the viewer. The inputs to the design program in some embodiments are pixel image files for the first layer image and for the mask for the second image display plane or layer/level. However, there are also capabilities for the program to make its own test input layers. The output of the program is a data file containing mirror locations and the coordinates of the normal vector to each mirror in a format suitable to make the mirrors or to form an array of micro mirrors on a supporting substrate (such as a piece of currency, a coin, a product label, a document, or the like).

[0068] In some embodiments, the design program allows the user to see the input files, ray traces to different levels (e.g., via operation of the ray tracking module 635 shown in Figure 6), and the expected image seen on the retina of a viewer. Tracings can be done using input cones of light on the mirrors to see the affects ambient light distributions on the viewer's retina. As an example of the GUI

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628 of Figure 6 that can be generated by the design program 639, Figure 8 illustrates a micro mirror design GUI 800 that is displayed in one prototype of the design program created and used in prototyping by the inventors.

[0069] The main GUI or menu 800 shows an exemplary set of inputs (design parameters, for example) that can be chosen, input, or modified by the user. These include pixel pitch, level/image display plane values, and cone angles for pixels, mirror size, and selection of test patterns. The right side of the GUI/menu 800 shows some of the details or results of the calculations performed by the design algorithm based on the user's input or selected (or default) design parameters provided on the left side. These include the number of mirrors that are dark (aimed away from pixels of images chosen for display on level or image display plane), numbers of mirrors used, algorithm used, and time required to calculate direction cosines of mirrors.

[0070] The level height parameter can be used to define or set how far above or below the mirror plane, in microns, that the image designated will appear for a mirror array design. The level cone angle degree parameter sets the angle at the floating pixel of the cone in which specific mirrors can be selected. A narrower angle means that there will be fewer potential mirrors for each pixel, and the opposite for a larger angle. The level angle offset parameter defines or sets the angle of offset that you would like the image level to appear, in respect to the Z axis. The "Assign Image (1,2) color (0,1,3,4) to level#" input box allows the user to place the various image colors to the specified levels. The "Border Edge Width Add" input box allows the user to expand or shrink the canvas to allow for movement of the images.

[0071] As noted earlier, the design process begins with inputting or providing an image file for the design program to process to create or calculate the design for the micro mirrors. One significant parameter in such design calculations is the resolution (DPI), and, in some applications, it may be useful to input or use lower resolution files (or digital images). For instance, an image that is 100 DPI is equivalent to having a pixel every 254 microns, and in the GUI 800 in Figure 8 this is the input shown under “image focal points X pitch = 254" (and the same value for Y pitch). Based on this resolution or how many pixels you need floating to represent that specific image along with the mirror size (in the attached menu 800 this is 50 microns), the design program calculates “avg Num Mirrors

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available per pixel," which in this example is 25.7685291. In other words, a little over 25 mirrors that can be used to represent one pixel from the original or base/starting image file.

[0072] Figures 9A-9C illustrate with graphs 910, 920, 930 images that can be displayed on various levels or image display planes by an array of micro mirrors of the present description. Graph 910 of Figure 9A shows a first layer image, with the light or on pixels providing an "X" pattern that would be displayed by a number of sets of pixel-providing mirrors to be floating in a first image display plane. In Figure 9B, graph 920 shows a second layer image, with the light or on pixels providing a rectangular background pattern or object that would be displayed by a number of sets of pixel-providing mirrors so as to be floating in a second image display plane. The graph 930 of Figure 9C shows a partial "X" of light or on pixels displayed with micro mirrors of an array and shows the effect of a mask blocking part of the image.

[0073] Figure 10 is a plot 1000 illustrating a ray tracing of light rays 1015 and dark rays 1017 near a first image display plane or first level/layer 1020 for one modeled array of micro mirrors 1010. As can be seen, the array of micro mirrors 1010 provides converging rays of reflected ambient light meeting or intersecting at a number of pixels 1022 at the floating pixel level or image display plane 1020 (or a first level as discussed above). It can also be seen that dark rays 1017 are directed away from the converging points/pixels 1022 and do not converge at the first level 1020.

[0074] One useful analysis tool of the design program and/or the ray tracing module is that a designer of an array of micro mirrors for a security element is able to evaluate the image as seen by a viewer. To this end, a ray tracing part of the design module (or a separate module as shown in Figure 6) is used to view the image on a simulated retina. Thus, the effectiveness of array design including a mask can be analyzed by putting the viewer's eye in various locations, which is equivalent to tilting the mirror plane, and plotting the ray traced image on the simulated retina. Figure 11 illustrates a representative GUI or ray tracing menu 1100 that allows a user to specify parameters to utilize in performing the ray tracing. Figure 12 illustrates a plot 1200 of a representative ray tracing showing the mirror plane 1210, traced reflected rays/beams 1220, a face plane 1230, location of a viewer's eyeball at 1240, and a corresponding retina at 1245 upon which rays converge indicating display of a

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set or number of pixels of a "written" or displayed image by the mirrors oriented in a desired manner at the plane 1210.

[0075] A number of manufacturing approaches may be used to fabricate an array of micro mirrors for attachment to or upon a surface of a substrate (such as currency, coins, product labels, and so on). In some embodiments, a photo resist process has been implemented by the inventors in creating security elements or devices as taught herein. As discussed earlier, the design program or software generates an output file (as explained in more detail below). To form the micro mirrors according to this output file, a laser system is used to expose the photo resist material, usually on a quartz or lime glass master. The photo resist material is normally at least 25 microns thick. The laser or laser system may expose the material in steps such as in about .5μ steps. The exposure settings correspond to the amount of material that will be washed away and not hardened, and this exposure creates a "Z" axis or height of the feature. The resulting micro mirrors (which may be flat or may be concaved for better focus depending upon design) are made in the photo resist material. The photo resist is generally still light sensitive and will "melt" in white light. In some cases, the photo resist is chrome plated in house before processing. The photo resist is then placed in an electroforming tank. The resist is charged and attracts nickel (or other metallic) particles, and nickel is "grown" on the photo resist as a nickel "shim." This nickel shim can be "turned" as needed from negative to positive and back again for tooling. The nickel shim is then used in the cast and cure process to form the array of micro mirrors oriented as indicated by the output file of the design program or software.

[0076] In other fabrication processes, a UV (ultraviolet light) or energy-cured polymer is used, and the process includes metallizing the mirrors to form an array as taught herein. In other cases, the fabrication process involves stamping or forming the micro mirrors into surfaces such as chrome or aluminum containers.

[0077] In general, the inventors teach a method of fabricating a security or branding element. The method includes providing a substrate and forming an array of micro mirrors on a surface of the substrate. The array of micro mirrors is configured for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate. The image comprises a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of

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the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

[0078] In some embodiments of the fabrication method, the forming the array of micro mirrors step includes casting the micro mirrors with a mirror tool in contact with the surface of the substrate. In these embodiments, the substrate may be a clear, energy-cured polymer, and the mirror tool can be formed of nickel or a polymer.

[0079] In some cases, the step of forming the array of micro mirrors includes metallization of surfaces of the micro mirrors. This may be performed so as to apply a thin layer of aluminum, gold, or silver to form reflective surfaces or form the mirror structures of the array. The metallization may be performed in a vacuum chamber using a deposition system or the like. Further, the forming step may include, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors. In this regard, it may be useful for the surface of the substrate to include or be made up of an embossable coating or layer.

[0080] In performing the fabrication method, the substrate may be (or include or be provided on) a coin, an automobile part, a computer part, a bumper, or a container, and the displayed image provides branding or authentication for the component that includes the array of micro mirrors. In such cases, the array forming step may include stamping the micro mirrors into the surface of the substrate.

[0081] In the same or other embodiments, the step of forming the array of micro mirrors may involve filling in recessed surfaces associated with the micro mirrors with a filler so as to make duplication (e.g., by molding) more difficult if not impossible. The filler may take the form of an ultraviolet (UV) varnish, an e-beam solvent, a water-based varnish, or the like. In some cases, it may be desirable for the filler to have a higher refractive index such as an index of at least 1.55, such that at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image for a viewer.

[0082] From the description and figures, it can be seen that there are numerous advantages and unique features of security elements/devices that include or are formed of arrays of micro mirrors. The individual mirrors can be programmed or oriented in two axes to focus to a specific pixel in any visual

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plane (e.g., in a first image display plane, in a second image display plane, and so on). In this way, the micro mirrors are used to image pixels forming drawings or text that appear to float relative to the planar surface containing the array of micro mirrors. The micro mirrors can be configured or designed to focus above or below the visual plane forming pixels that in combination display images with depth (multi-layered or multi-depth imagery). The program performs a unique design method providing an output file that can be used in fabricating or generating the micro mirrors.

[0083] In practice, the shape of the micro mirrors can be round, square, and rectangular with the reflective surface being flat, concave, or convex to provide desired focusing upon a pixel (or location on one of the image display planes). The size of the mirrors may vary to practice the arrays of micro mirrors such as from about 1000 microns down to one micron with mirrors in the 35 to 70 micron range likely being desirable (with 50 micron square mirrors being used in a prototype/model).

[0084] An array of micro mirrors can be designed to provide a variety of visual effects such as showing images above or below the visual planes and in first, second, third, or more image display planes relative to the mirror-containing planar surface. In other cases, the mirrors are used to provide an effect of light images with dark backgrounds animating to light backgrounds and dark images with a change of perspective. In the same or other cases, an array of micro mirrors can be configured with selective orienting of mirror reflective surfaces to provide a masking effect showing one image receding as it goes across another image. In many cases, the micro mirrors generate more than one level of imagery to the viewer (two or more). Particularly, the micro mirrors can generate one image made up of a set of pixels at one level above the focal plane while also (or separately) generating an image below the focal plane. In the same or other cases, the micro mirrors may be configured to generate an image at the focal plane. In these embodiments, the images are displayed/written either with bright pixels (light) or dark pixels (the absence of light or reflected light from the viewer). Images created by the micro mirrors can provide an animation effect, and, in the same or other embodiments, the images created by the micro mirrors may provide a 3D effect.

[0085] The array of micro mirrors can be used in (or provided as part of) a currency thread, which may be about 10 to 50 microns thick. The array of micro mirrors or security element can be used as a foil stamp that may be about 10 to 100 microns thick. The array may be formed by stamping the

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micro mirrors into any metallic surface, such as a surface of a coin, or by placing the micro mirrors on glass, ceramic, or plastic substrates, which may be clear so as to create a unique visual display or imaging effect that allows a viewer to see images in display planes on two sides of the substrate supporting the array of micro mirrors (or transparent film including such mirrors). In these and other ways, an array of micro mirrors may be successfully used in any high security application including, but not limited to, passports and other high security documents including currency.

[0086] In some embodiments, the displayed or written image is colored (e.g., is not simply black and white). In one embodiment, a color display is created by forming the mirrors of the array with plasmonic resonance for color while other fabrication processes use tinting of the reflective mirrors with ink. In other embodiments, diffractive material is added to the reflective surface of the mirrors or diffraction grating may be used to create color with the micro mirrors. In some embodiments, dielectrics are used to provide color with the array of micro mirrors. In still other colored display embodiments, a protective cover layer may be applied to the mirrors that is transparent (to-translucent), and then coloring may be provided by printing on this cover layer with translucent color squares (or other mirror shape-matching coloring filters) aligned over the proper micro mirrors to achieve a desired colored image in one or more of the image display planes or levels/layers.

[0087] Figures 13A and 13B illustrate plots 1310 and 1320 provided by the design program of images chosen for display on first and second image display planes or levels, respectively, and these are the two images that would be written or displayed by micro mirrors of an array. In Figure 13A, a user has input an image with a colored or plain background with a circular boarder enclosing a leaf, and the circular boarder and the outline of the leaf have been chosen for display or writing on a first level or first image display plane (at a first height such as 10000 microns away from the planar surface containing the mirrors). The offset angle may be set at 0 degrees (or some other value), and Figure 13A represents an approximation of what a viewer would see when viewing the security element with this design of an array of micro mirrors. Particularly, a plurality of bright or "on" pixels showing the circular boundary and the outer edges/boundary of the leaf.

[0088] Figure 13B shows the first layer imagery 1310, but it also shows with plot 1320 that as the viewer rotates the mirror plane or changes their perspective (e.g., from a 0 degree viewing angle to

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the offset angle that may be 20 degrees or the like) the original images 1315 are replaced with the new images 1325 at the second level or second image display plane (which may be at 20000 microns or some other height such that the two levels/image display planes are spaced apart some desired distance). As shown, the designer/program user has indicated that the background of the input image, the inner portion of the circle, and the inner portion of the leaf should be written or have their associated pixels "on" in the second layer while the portions chosen for image 1315 of the first layer are "off" or dark. In this manner, the image sees a transition between displaying imagery with light and then with dark pixels as their perspective or viewing angel changes to view the images in the two spaced apart levels/layers or image display planes.

[0089] Figures 14A and 14B illustrate plots 1410 and 1420 that show the results of programming or orienting an array of micro mirrors to display an object or image 1415 (here an eagle or hawk). The plot 1410 of Figure 14A may be considered a top view as the intersections of normal vectors from the micro mirrors are shown relative to X and Y axes while the plot 1420 of Figure 14B may be considered a side view as the same intersections are shown relative to the X and Z axes. Figure 14A is useful for showing a representation of what a viewer would perceive when looking in an orthogonal direction to the plane containing the mirrors, e.g., the viewer perceives the outline of an eagle (which may be displayed or written with bright or dark pixels). The intersections act to display "pixels" that, as can be seen at 1415, work in combination to display an object/subimage (as may be chosen by a user of the design program from an input image file for display in a particular level or image display plane). Figure 14B shows that the pixels (or normal vector intersections) are generally planar or provided in a plane coinciding with a preset/defined level or image display plane relative to the planar surface containing the micro mirrors (e.g., a plane spaced apart a predefine distance from the array of micro mirrors), and this acts to provide a floating image 1415 or an image with depth or 3D effects.

[0090] As discussed above, the design program or algorithm functions to create an output file that may be used in manufacturing an array of micro mirrors adapted to display one or more floating images above (or below) the planar surface containing the array. Table 1 below provides exemplary data that may be provided in such an output file (with only a small number of mirrors being shown for ease of explanation but with it understood that similar data would be provided for each mirror in

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the array). The X and Y columns of Table 1 show mirror positions (in microns), e.g., in the second row a mirror is located in the array at 35 microns on the X axis and at 0 microns on the Y axis. In the table, next to each mirror location in the array, the DX, DY, and DZ columns provide the coordinates of the normal vectors for each of the mirrors. In this way, each mirror has a defined position in the array and a precise direction its reflective surface is pointing in space.

[0091] In creating the exemplary data in Table 1, the following assumptions were made for the design of the array of micro mirrors: (1) units are microns; (2) the array is configured to have flat mirrors with tilted reflective surfaces; (3) the mirrors were square in shape with 35 micron sides; (4) the array was also assumed to be square in shape with 27,930 micron sides; (5) the number of mirrors was calculated to be 798 along the X and Y axes such that the total number of mirrors was 636,804; and (6) the maximum mirror tilt angle was requested to be 30 degrees (e.g., due to vendor/manufacturer limitations so may be set at 20 degrees).

Table 1

X	Y	DX	DY	DZ
0.00	0.00	-0.061672	0.021122	0.997873
35.00	0.00	-0.020315	0.050724	0.998506
70.00	0.00	-0.063424	0.008449	0.997951
105.00	0.00	-0.064293	0.008449	0.997895
140.00	0.00	-0.056737	0.016904	0.998246
175.00	0.00	-0.053402	0.000000	0.998573
210.00	0.00	-0.058482	0.012677	0.998208
245.00	0.00	-0.025586	0.008464	0.999637
280.00	0.00	-0.051801	0.000000	0.998657
315.00	0.00	-0.061093	0.012675	0.998052
350.00	0.00	-0.061967	0.004225	0.998069
385.00	0.00	-0.058619	0.016902	0.998137
420.00	0.00	-0.046852	0.000000	0.998902
455.00	0.00	-0.018142	0.004233	0.999826
490.00	0.00	-0.061225	0.021122	0.997900
525.00	0.00	-0.062100	0.016898	0.997927
560.00	0.00	-0.062979	0.000000	0.998015
595.00	0.00	-0.063848	0.004225	0.997951

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X	Y	DX	DY	DZ
0.00	0.00	-0.061672	0.021122	0.997873
35.00	0.00	-0.020315	0.050724	0.998506
70.00	0.00	-0.063424	0.008449	0.997951
105.00	0.00	-0.064293	0.008449	0.997895
140.00	0.00	-0.056737	0.016904	0.998246
175.00	0.00	-0.053402	0.000000	0.998573
210.00	0.00	-0.058482	0.012677	0.998208
245.00	0.00	-0.025586	0.008464	0.999637
280.00	0.00	-0.051801	0.000000	0.998657
315.00	0.00	-0.061093	0.012675	0.998052
350.00	0.00	-0.061967	0.004225	0.998069
385.00	0.00	-0.058619	0.016902	0.998137
420.00	0.00	-0.046852	0.000000	0.998902
455.00	0.00	-0.018142	0.004233	0.999826
490.00	0.00	-0.061225	0.021122	0.997900
525.00	0.00	-0.062100	0.016898	0.997927
560.00	0.00	-0.062979	0.000000	0.998015
595.00	0.00	-0.063848	0.004225	0.997951

[0092] Figures 15A and 15B illustrate plots generated and displayed by a preview program (which may be a subroutine of the design program described herein) for previewing likely or predicted results of a design of an array of micro mirrors. Specifically, Figure 15A illustrates a plot 1510 of a 3D image that may be displayed with a selected image and a particular design of an array of micro mirrors. The plot 1510 illustrates a foreground or first layer image 1514 (e.g., a bird such as a flying eagle) relative to a background or second layer image 1518 (e.g., a colored frame with stars) relative to each other and X and Y coordinates. The plot 1510 previews what a viewer looking directly at or downward at the security device may see via the array of micro mirrors. Figure 15B illustrates a plot 1520 illustrating the foreground image 1514 and background image 1518 not only relative to the X and Y axes but also relative to the Z axis (e.g., the depth that would be provided by the array of micro mirror design).

[0093] The preview program providing the plots 1510 and 1520 takes as input the output file of the design program, with all the mirror positions and normal vector coordinates. The preview program calculates the intersection of the reflected rays (e.g., rays coming straight down and bouncing out of

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the mirrors to the viewer) with the plane where the image is supposed to (or is designed to) float. With the plots 1510 and 1520 provided by the preview program, the operator or designer can verify the combination of foreground and background images 1514, 1518 provides a desired 3D image or representation as shown in Figures 15A and 15B. In this example, an eagle 1514 is floating in a first image plane at +30,000 microns above the mirror plane while the frame 1518 (with stars) is floating in a pushed back second image plane at -30,000 microns (or the two image planes are spaced apart 60,000 microns for the viewer providing a desirable 3D effect). Stated differently, the preview program takes the normal vectors corresponding to the eagle's mirrors and plots the intersection to the plane at 30,000 microns (and does a similar processing for the frame/background image's mirrors and the plane at -30,000 microns).

[0094] Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter claimed.

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WE CLAIM:

1. A method of fabricating a security element, comprising:

assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane;

with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane;

for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; and

generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors.

2. The method of claim 1, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.

3. The method of claim 1 wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.

4. The method of claim 3, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.

5. The method of claim 1, wherein the angular orientations are calculated based on heights of the first and second image display.

6. The method of claim 1, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.

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7. A method of fabricating a security element, comprising:

with a processor of a computing device, executing code to provide an array design module configured to select a set of micro mirrors in an array of the micro mirrors to display pixels of a first object in a first image display plane and to display pixels of a second object in a second image display plane spaced apart from the first image display plane;

for each of the pixels, determining, with the array design module, an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; and

generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors,

wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.

8. The method of claim 7, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.

9. The method of claim 7, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.

10. The method of claim 7, wherein the angular orientations are calculated based on heights of the first and second image display.

11. The method of claim 7, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.

12. A method of fabricating a security element useful on paper and coin currency and on product labels, comprising:

with a processor of a computing device, executing code to provide an array design module configured to define an array of micro mirrors to be formed on a surface of a substrate; and

generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors,

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wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate,

wherein the image comprises a plurality of pixels, and

wherein the array of micro mirrors includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

13. The method of claim 12, wherein a voxel is created at each of the point on the plane via intersection of two or more beams of the reflected ambient light, and wherein each of the created voxels produces an effect of a point source of light floating above the surface of the substrate in the plane.

14. The method of claim 12, wherein each of the different sets concurrently reflect the ambient light to concurrently generate the plurality of pixels.

15. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by casting the micro mirrors with a mirror tool in contact with the surface of the substrate,

16. The method of claim 15, wherein the substrate provided in the providing step comprises a clear, energy-cured polymer.

17. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by metallization of surfaces of the micro mirrors, wherein the metallization applies a layer of aluminum, gold, or silver to form reflective surfaces.

18. The method of claim 17, wherein the forming the array of micro mirrors includes, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors and wherein the surface of the substrate includes an embossable coating or layer.

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19. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by filling in recessed surfaces associated with the micro mirrors with a filler comprising at least one of an ultraviolet (UV) varnish, an e-beam solvent, and a water-based varnish.

20. The method of claim 19, wherein the filler has a refractive index of at least 1.55, whereby at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image.

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ABSTRACT OF THE DISCLOSURE

A visual display assembly useful as an authentication or anti-counterfeiting element. The assembly includes a substrate and, on a surface of the substrate, an array of micro mirrors receiving ambient light. Each mirror includes a reflective surface to reflect the ambient light to display an image that appears to float in a plane, which is spaced a distance apart from the surface of the substrate. The image includes a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels. Each of the sets of the micro mirrors includes a plurality of the micro mirrors, and the reflected ambient light each set of micro mirrors intersects to illuminate or write a pixel of an image.

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First Named Inventor/Applicant Name:	MARK A. RAYMOND
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METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Patent Application No. 16/203,128, filed November 28, 2018, which is a divisional of U.S. Patent Application No. 15/162,113, filed May 23, 2016, that claims the benefit of U.S. Provisional Application No. 62/262,767, filed December 3, 2015, which are all incorporated herein by reference in their entireties.

BACKGROUND

1. Field of the Description.

[0002] The present invention relates, in general, to anti-counterfeiting devices for currency and brand authentication, and, more particularly, to currency and brand authentication elements, and methods of designing and manufacturing such authentication elements, that are configured to provide a multi-planar image that is viewable without special eyewear and that is difficult, if not nearly impossible, to replicate or copy.

2. Relevant Background.

[0003] Anti-counterfeiting efforts often involve use of an anti-counterfeiting device or element that is made up of an array of lenses and an image printed onto the back of the lens array or onto an underlying substrate or surface (e.g., a sheet of paper or plastic). The anti-counterfeiting element may be used to display an image that is chosen to be unique and be an indicator that the item carrying the anti-counterfeiting element is not a counterfeit. The anti-counterfeiting market is rapidly growing worldwide with anti-counterfeiting elements placed on a wide range of items such as upon currency (e.g., on a surface of a paper bill to help prevent copying) and on labels for retail products (e.g., labels on clothing showing authenticity).

[0004] In this regard, moiré patterns have been used for years in anti-counterfeiting elements with arrays of round lenses and with arrays of hexagonal lenses (or round and hexagonal lens arrays). Typically, the printed images provided in an ink layer under these lens arrays are small, fine images

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relative to the size of the lenses. A moiré pattern is provided in the printed images in the form of a secondary and visually evident superimposed pattern that is created when two identical patterns on a surface are overlaid while being displaced or rotated a small amount from each other.

[0005] In such moiré pattern-based anti-counterfeiting elements, some of the images may be printed in a frequency slightly more or less frequent than the one-to-one dimension of the lenses in two axes, and some of the images may be printed slightly differently relative to each other. While helpful to reduce counterfeiting, use of moiré patterns with round lens arrays has not been wholly satisfactory for the anti-counterfeiting market. One reason is that the effects that can be achieved with moiré patterns are limited, and the effect is often relatively easy to reverse engineer, which limits its usefulness as an anti-counterfeiting element. For example, printing the underlying image is becoming easier to accomplish due to high resolution lasers and setters and other printing advances. Typically, for an element, the micro-lenses are printed using an emboss and fill technology, which limits the printing to one color due to the fact that the process tends to be self-contaminating after one color and also due to the fact that the process is difficult to control from a relative color-to-color pitch in the emboss-and-fill printing process.

[0006] In other cases, holograms and lens features are used for security devices in currency, brand authentication and brand protection as well as on high security documents. Holograms are becoming increasingly less secure, in part, due to the rise in technology, programming, and general availability of programs that allow one to easily create holograms. In many applications, the cheaper dot matrix holograms are "good enough" to simulate many of the effects of the more expensive elaborate holograms used in anti-counterfeiting elements. While lens features done properly can be more secure than hologram elements, there is a need for new technology to combat the currency and product counterfeiting. Ideally, new technology would have attributes that are not possible with holography or micro-lenses.

[0007] Hence, there remains a need for advancements in the design and fabrication of assemblies or elements that display imagery useful for anti-counterfeiting and/or product/document authentication. For example, such improvements may allow new anti-counterfeiting devices or elements to be produced for use with currency, labels, credit/debit cards, and other items, and these anti-

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counterfeiting devices preferably would be much more difficult if not nearly impossible to duplicate or copy. Further, there is a growing demand for such anti-counterfeiting devices to provide a surprising or "wow factor" with their displayed imagery such as images that float above and/or below a focal plane (e.g., more true 3D displays) rather than merely laterally reflecting back light such as with a sequence of mirrors or mirrored surface or using reproducible holograms.

SUMMARY

[0008] Briefly, the inventors recognized that an anti-counterfeiting or security device can be provided that is configured to "write" images with light in one, two, or more spatial planes above and below the surface of an array of micro mirrors. Each of the micro mirrors is oriented (or "programmed") to act with a number of other such micro mirrors (e.g., a "set of pixel-providing micro mirrors") as one pixel in the written image(s) as the set of micro mirrors each directs its reflected light to a particular location in the image(s) display plane(s) (e.g., an apex of a cone with each of the micro mirrors in the set of pixel-providing micro mirrors being within the base of the cone) that when viewed with a number of other such pixels (each provided by a different set of pixel-providing micro mirrors) makes up a written image in one or more spaced apart image display planes.

[0009] In other words, text, imagery, and so forth can be written with ambient light by focusing the micro-mirrors to different spatial planes above the plane of the security device (which is typically provided on a surface of a document (e.g., currency) or product being authenticated with the security device). Conversely, the technology can then "reverse" to the viewer by having the "bright" pixels go to "dark" and the backgrounds reverse from "light' to "dark" with a change of perspective (e.g., occurring when the viewer changes their viewing angle or rotates the document/product containing the security device).

[0010] Also, since the technology is made of mirrors (made from thin aluminum, silver or gold depositions on an upper surface of the document/product on which the security element is provided (e.g., any supporting substrate)), the anti-counterfeiting or security device will work from two sides in a film process (e.g., when the supporting substrate is transparent). This type of two-sided or two-view image cannot be done with holography or other presently available anti-counterfeiting technologies. The technology can be embossed into films, metallized, and then processed into

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currency threads, foil stamps, labels and packaging. It can also be directly stamped onto coins or other metallic surfaces (e.g., provided on nearly any supporting substrate). Color can also be added to the displayed or "written" image(s) by using a reflective ink printing method or with the use of dielectric nanostructures (e.g., with plasmonic resonance and/or other techniques).

[0011] More particularly, a visual display assembly is provided that is useful as a security element on paper and coin currency, product labels, and other objects. The assembly includes a substrate (which may be part of the object upon which the security element is provided such as a piece of currency or a product label). The assembly also includes, on a surface of the substrate, an array of micro mirrors receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate. The image includes or is "written" with a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

[0012] In some embodiments, each of the sets of the micro mirrors includes at least twenty of the micro mirrors (e.g. a number in the range of 20 to 40 such as about 30 mirrors). To provide a "bright" or light pixel, the reflected ambient light from the twenty or more micro mirrors intersects or crosses at (or passes near to) the point corresponding to the one of the pixels (e.g., each pixel is displayed or lit by beams/rays from reflective surfaces of the micro mirrors crossing at a common point on the image display plane). The point on the plane may correspond to an apex of a cone, and the twenty or more micro mirrors can be located within a base of the cone coplanar with the surface of the substrate. The micro mirrors within the base of the cone but excluded from (or not included in or used for) the set of the micro mirrors displaying the pixel are oriented to reflect the ambient light away from point on the plane corresponding to the pixel to provide a dark background for the image.

[0013] The assembly may be configured to display images in more than one image display plane or in two or more levels/layers. In this regard, the array of mirrors may be configured to behave further in response to the receiving of the ambient light to display a second image in a second plane spaced a distance apart from the plane displaying the image. The second image may be provided or "written" with a plurality of pixels (as was the case with the first image). The array of micro mirrors includes,

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for each of the pixels of the second image, a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the second plane corresponding to one of the pixels of the second image. The first image has a first viewing angle and the second image has a second viewing angle offset from the first viewing angle by at least 10 degrees (such as an offset angle in the range of 10 to 45 degrees with offset angles of 20 to 30 degrees being useful in some embodiments).

[0014] In some particular implementations, the substrate is transparent, whereby the image is displayed to be spaced apart the distance from a first side of the substrate and further whereby a second image including a second set of pixels is displayed by the array of micro mirrors to be spaced apart a second distance from a second side of the substrate opposite the first side. In this manner, the array of micro mirrors can be said to be completely functional on the reverse side of the substrate (or film) to present a mirror image or a reverse image (in the image plane) to the viewer on the opposite side of the substrate.

[0015] In the same or other embodiments, the micro mirrors are rectangular (e.g., square) with a smallest side having a length of at least 35 microns such as 50 microns or more while other embodiments use mirrors that are circular with a diameter of at least 35 microns (e.g., 50 microns or larger in diameter). In practice, the plane in which the image is displayed may be above, below, or coinciding with the focal plane for the array of the micro mirrors. Also, the image may be displayed using only (or mostly) white light (and off or dark pixels) or the micro mirrors may be configured to display the image with colors (in addition to white). This may be achieved with at least one of ink, plasmonic resonance, and dielectric material being used to configure the micro mirrors to display the image with the desired colors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Fig. 1 is a top perspective, partial view of a visual display assembly for use as an anti-counterfeiting element or device showing a single micro mirror that would be provided in an array of such micro mirrors;

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[0017] Fig. 2 is a side view (e.g., a functional schematic) of an object (such as currency, a document, a financial card, or the like) including an anti-counterfeiting or authentication (or security) element/device of the present description;

[0018] Fig. 3 is an enlarged view of a subset of the micro mirrors of the security element of Fig. 2 corresponding to micro mirrors in an area of one cone base associated with one cone apex or written pixel in one of the displayed/written images provided by the security element of Fig. 2;

[0019] Fig. 4 is a schematic or graphic side view or diagram of a security element during its use to provide a two-layer or level image;

[0020] Fig. 5 is a side schematic view or diagram of a security element during its use to provide a display that combines a light image and a dark image;

[0021] Fig. 6 is a functional block diagram of a computer or computing device configured to run an array design program to allow an operator to generate a design of an array of micro mirrors for displaying a particular image(s) when provided in a security element;

[0022] Fig. 7 is a flow diagram of an exemplary design method for an array of micro mirrors for use in a security element, such as may be carried out by operation of the system of Fig. 6;

[0023] Figs. 8A and 8B illustrate a micro mirror design GUI that can be displayed on a monitor or display by the design program;

[0024] Figs. 9A-9C are graphs illustrating images that can be displayed on various levels or image display planes by an array of micro mirrors of the present description;

[0025] Fig. 10 is a plot illustrating a ray tracing near a first image display plane or first level/layer for one modeled array of micro mirrors;

[0026] Fig. 11 illustrates a representative GUI or ray tracing menu that allows a user to specify parameters to utilize in performing the ray tracing;

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[0027] Fig. 12 is a plot of a representative ray tracing showing beams/rays reflected from micro mirrors in a mirror plane and converging on a viewer's retina;

[0028] Figs. 13A and 13B illustrate written or displayed images provided by an array of micro mirrors with an angular offset between image display planes or levels/layers of the imagery;

[0029] Figs. 14A and 14B illustrate plots of floating pixels in a space above an array of micro mirrors; and

[0030] Figs. 15A and 15B illustrate plots generated and displayed by a preview program (which may be a subroutine of the design program described herein) for previewing likely or predicted results of a design of an array of micro mirrors.

DETAILED DESCRIPTION

[0031] Briefly, the present description is directed toward visual display assemblies that can be used as anti-counterfeiting or authentication elements or devices such as on currency, coins, documents, products, and so on. Each visual display assembly includes an array of a large number of micro mirrors, and this array can be provided on a surface of nearly any supporting substrate (e.g., a surface of a piece of currency, on a coin, on a surface of a product or its sales/identification label, and so on). Sets (or subsets) of the micro mirrors are used to work in unison to "write" pixels of images in one, two, or more image display planes above the supporting substrate by having each of the micro mirrors in each of the pixel-providing sets direct light striking its first or upper reflective surface to a location of a pixel in one of the image display planes. The sets of pixels may be configured to provide angular offset viewing (e.g., by an offset angle in the range of 15 to 35 degrees or the like with 20 degrees used in some cases between the viewing angles of the written images of each adjacent image display plane) in the different image display planes such that a viewer typically only observes or perceives the written pixels of one image display plane at a time (or at a single viewing angle or perspective) and switching occurs as the viewer changes their viewing angle or rotates the substrate supporting the visual display assembly and its many micro mirrors.

[0032] The visual display assembly (or security element/device) is designed to create a floating image(s) of pixels, and the pixel-providing sets of micro mirrors are chosen to have a large enough

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number to effectively display a great enough quantity of light to allow a viewer to perceive each separate, floating pixel in the written or displayed image. The number of micro mirrors used in each set may vary due to a large number of parameters such as material used to provide the reflective upper surface, size of each micro mirror (e.g., with 35 to 100 micron mirrors used in some implementations and 50 micron mirrors used in one prototype of the present invention), and the like. Each of these micro mirrors in each pixel-providing set is oriented to try to have all of these micro mirrors direct their reflected light to intersect at a point (the written pixel of the displayed image) in an image display plane above the supporting substrate, and each pixel of the written image is either on or off (or providing light or no light) at various viewing angles.

[0033] A basic or underlying idea of the micro mirror-based visual display assembly is to use ambient light and a plane (an upper surface of a supporting substrate) containing many, small mirrors. The ambient light that is reflected off the mirrors is aimed or targeted toward desired points (or pixels) above the plane that contains the mirrors. The image displayed by all the pixel-providing sets of micro mirrors targeting a first image display plane above the supporting substrate may be considered a first layer image. The first layer image can be defined by artwork that has light or dark pixels to be produced in this first layer (or a multi-layer image) or first image display plane. To this end, the mirrors in a pixel-providing set of micro mirrors are carefully selected from the micro mirror array as being within a circle (or cone base) defined by the intersection of the cone defined by an apex angle and a pixel from the desired image display plane/layer (e.g., the first image display plane) that is chosen to coincide with the apex of the cone. Each of these mirrors (which are in the base of the cone) is then aimed or targeted (or "oriented") toward the cone apex (image's pixel) so that the resulting effect is a point source of light floating a height or distance above (or below in some cases) the plane of the supporting surface containing the array of micro mirrors at the location of the pixel.

[0034] Prior to explaining a design or configuration of an entire array of micro mirrors in a visual display assembly, it may be useful to first look at a single one of these mirrors. Figure 1 illustrates a portion of a visual display assembly 100 (or a substrate with a security element or device) according to the present description. As shown, a supporting substrate 110 with a surface 112 is provided that receives and supports a micro mirror 120. For example, the substrate 110 may be a piece of currency,

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a coin, a product label, a document, a credit/debit/bank card, or the like for which it is desired to provide anti-counterfeiting or authentication functionality with the visual display assembly or security element 100. The micro mirror 120 is shown to include a body (or lower layer/surface) 122 that is affixed to or integrally formed with the surface 112 of the substrate 110. The view in Figure 1 is only "partial" as it will be understood that the assembly 100 typically would include many (e.g., hundreds to many thousands) of the micro mirrors 120 (i.e., an array of micro mirrors 120). Each of such micro mirrors 120 is individually oriented or "programmed" as discussed below such that the micro mirrors 120 of the array act together to display one or more floating images made up of a plurality of pixels in one or more image display planes above the substrate surface 112.

[0035] The micro mirror 120 also includes an upper (or exposed) reflective surface 124 facing away from the surface 112 of the supporting substrate 110. This surface 124 is reflective as the micro mirror 120 typically will be formed of a metal or metallic compound or other material chosen for its reflective properties. For example, the micro mirror 120 may be a thin layer of aluminum, silver, gold, or the like provided by deposition upon the surface 112 of the substrate 110. When the image display assembly 100 is in use, ambient light 130 strikes the reflective upper surface 124 of the micro mirror 120 and is reflected as shown at 134 from the upper surface 124. Particularly, the micro mirror's upper surface 124 is to have a normal vector 135 (e.g., as may be defined as output of a design program with X, Y, and Z coordinates), and the incoming ray 130 and the normal vector 135 from the same angle, β, as is formed between the normal vector 135 and the reflected light 134.

[0036] The reflected light 134 is preferably directed or aimed so as to cross an image display plane 140, which is spaced apart a height, H_1, above or away from the substrate surface 112 (and reflective surface 124 which may be substantially coplanar due to the small thickness of the body 122), at a location (X-Y-Z coordinates may define this location relative to the surfaces 112 and 124) coinciding with or defining one of a plurality of written pixels 142 of an image displayed by the assembly 100 in the plane 140. While not shown, a plurality of other micro mirrors configured similar to mirror 120 would also reflect their received ambient light to the point/pixel 142 in the plane 140 (a plurality of reflected light beams from micro mirrors would intersect at the point/pixel 142) so as to provide a point source of light at 142 viewable by a viewer 102.

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[0037] To provide this desired reflection of light 134, the micro mirror 120 is oriented or has its reflective surface 124 oriented in a particular, predefined (e.g., by a visual display assembly configuration computer program or algorithm) manner. Particularly, each micro mirror 120 may be individually oriented by rotating its body 122 (or surface 124) about one or both of first and second rotation axes 150, 152 as shown with arrows 151, 153 during design processes (prior to fabrication). Then, the micro mirror 120 may be formed with these design parameters so that the reflective upper surface 124 (with its known location in the array of micro mirrors by X-Y coordinates of its center) is oriented (at first and second angles) relative to the two axes 150, 152 to have its normal vector 135 aimed or targeted in a particular manner (X-Y-Z coordinates of the normal vector for the mirror 120), e.g., to have ambient light 130 reflected as shown at 134 to cross the image display plane 140 at the location of the pixel 142. As noted above, the size (and shape) of each micro mirror 120 may be varied to practice the invention with some embodiments utilizing square-shaped bodies 122 that have sides with a length, L_{Side}, that is typically greater than about 35 microns (such as 50 microns) and often in the range of 40 to 60 microns while some embodiments may use larger micro mirrors.

[0038] Figure 2 is a side view (e.g., a functional schematic) 200 of an object (such as currency, a document, a financial card, or the like) 210 including an anti-counterfeiting or authentication (or security) element/device 220 of the present description. The object or substrate 210 includes an upper or first surface 212 upon which is provided or formed the security device 220 (which may take the form of the visual display assembly 100 of Figure 1). The security device 220 has an exposed or upper surface 222 that is configured to provide an array of micro mirrors 224, which may be individually oriented to provide reflection of ambient light striking the surface 222 of the security element 220 so as to display one or more floating images that can be observed by a viewer 202 to authenticate the object 210.

[0039] To this end, a first number of the micro mirrors 224 may be configured to provide sets of pixel-providing micro mirrors that reflect ambient light as shown with arrows 230 to "write" or display a first displayed image 242 made up of a plurality of pixels 243 (with each of these pixels 243 associated with one of the sets of pixel-providing micro mirrors 224). A second number of the micro mirrors 224 is configured to provides sets of pixel-providing micro mirrors that reflect ambient light

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as shown with arrows 250 to "write" or display a second displayed image 262 made up of a plurality of pixels 263 (with each of these pixels 263 being associated or written by one of the sets of pixel-providing micro mirrors 224). As discussed with reference to Figure 1, each of the micro mirrors 224 in the same set of pixel-providing micro mirrors 224 used to create/write a particular pixel 243, 263 in one of the images 242, 262 is configured or oriented with its reflective surface oriented (with rotation relative to one and/or two rotation axes) to target or direct a point/location on the plane 240 or 260 coinciding with the pixel 243, 263. This, in most embodiments, coincides with an apex of a cone with each of the pixels 243, 263 in the set of micro mirrors 224 being in the base of the cone (e.g., within the circular area on the surface 222 defined by the cone base). Note, each of these micro mirrors 224, though, is oriented uniquely and differently to provide the reflected light 230, 250 along a normal vector to its reflective surface.

[0040] To the viewer 202, the first displayed image 242 appears to float in the first image display plane 240 that is a height, H_1, above the surface 212 of the object/substrate 210 while the second displayed image 262 appears to float in the second image display plane 260 that is a different (typically greater) height, H_2, above the surface 212. The micro mirrors 224 are oriented so that the pixels 243 of the first image 242 are a viewing angle offset, θ_{Offset}, (e.g., 10 to 30 degrees or the like) from the pixels 263 of the second image 262 so that the viewer 202 typically only views one of the floating images 242, 262 at a time (at a range of viewing angles).

[0041] As discussed above, micro mirrors for each set of pixel-providing micro mirrors are chosen from a set of available micro mirrors located within an area on the security element surface (or substrate surface) that corresponds with a base of the cone with an apex coinciding with the pixel being created by these micro mirrors. Figure 3 is an enlarged view of a subset of the micro mirrors 224 on the surface 222 of the security element 220 of Figure 2, which correspond to micro mirrors 224 in an area of one cone base with diameter, $Diam_{Cone\ Base}$, associated with one cone apex or written pixel 243 or 263 in one of the displayed/written images 242 or 262 provided by the security element 220.

[0042] Figure 3 illustrates all the available micro mirrors 224 in the cone base, but the security element 220 typically is designed so that only a subset of these available mirrors 224 (such as 20 to

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40 or more with 30 shown in use in Figure 3 at 324) are used to write or display a particular pixel. The unused mirrors 224 typically are oriented to reflect received ambient light away from the location of the pixel being written/created by the chosen mirrors 324, which may be considered as providing a mask with the unused mirrors 224. The chosen mirrors 324 (or mirrors in the set of pixel-providing micro mirrors) are shown with shading/patterning that would not be actually present in a security element but that is useful for differentiating these mirrors 324 from the other/unused ones of the mirrors 224.

[0043] As will be explained below, the micro mirrors 324 in the set of pixel-providing micro mirrors are randomly chosen such that the mirrors 324 do not provide an obvious, regular pattern and each pixel's set of micro mirrors 224 likely will have a very different pattern within a cone base or circular area of the surface 222 of the security element 220. Also, each of the micro mirrors 324 in the set used to provide a particular pixel 243 or 263 will be differently oriented so as to have the normal vectors of all the mirrors 324 intersect at the X-Y-Z coordinates of the same pixel 243 or 263 in the appropriate one of the image display planes 240 or 260.

[0044] Significantly, the mirrors 324 are not pointing toward a viewer but, instead, are aimed or targeted toward the intersection point (or pixel coordinates) in the image display plane or layer. The use of sets of micro mirrors to provide or create floating pixels that in combination can write or display an image in one, two, or more layers is effective in providing a displayed image with depth and with high contrast. Further, the image appears to switch from light to dark with rotation of the object/substrate with the security element (or with movement of the viewer's eyes to change their viewing angle or perspective).

[0045] Figure 4 is a schematic or graphic side view or diagram 400 of a security element 410 during its use to provide a two-layer or level image. The security element 410 includes a micro mirror array 412 made up of numerous (e.g., thousands) micro mirrors (e.g., 50 micron diameter mirrored surfaces). As shown, three sets of micro mirrors in the array 412 have been oriented or configured to display pixels 422 in a first plane or at a first level 420 above the security element 410 (or its surface containing the array 412). As shown with arrows 423, light is reflected so that beams from a set of the micro mirrors intersect to create a pixel 422 in the first level 420. These are provided within a

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cone angle, β_{Cone}, Further, as shown with arrows 425, a mask or mask image may defined to block some rays by having the mirrors that would provide this light directed outside of the conical angle, β_{Cone}, region (e.g., the arrows 425 are associated with light that is not actually reflected for viewing with the light 423 but is, instead, directed elsewhere).

[0046] Also, as shown two sets of micro mirrors in the array 412 have been oriented or configured to display pixels 432 in a second plane or at a second level 430 spaced apart from level 420. Arrows 433 represent beams of reflected light that are directed from these sets of mirrors to intersect or cross at the locations of the pixels 432. Also, as shown, the pixels are displayed to the viewer at viewing angles that are offset by an angle (pixel offset angle), γ (such as 10 to 30 degrees or the like). The basic angle direction of the pixels 432 is chosen to offset the image in the plane/level 430 for the viewer (or at the viewer) from the image in the plane/level 420.

[0047] Figure 5 is a schematic or diagram 500 similar to that of Figure 4 but showing an embodiment of a security element 510 with an array of mirrors adapted specifically to provide two light and dark images. The diagram 500 illustrates that the sets of pixel-providing micro mirrors on the security element 510 (or in a mirror planar surface) can be oriented to provide a light image (with bright pixels with a dark background) that when going in reverse provides a dark image with a light background as the viewer rotates the element 510 or otherwise changes their perspective.

[0048] As shown, the security element 510 has a planar mirror surface with an array of micro mirrors adapted to reflect light in directed beams 514 and 518. The beams/rays 514 are directed so as to display/create pixels 522 on a first plane 520 that is more proximate to the mirror plane of security element 510 (with only two pixels 522 shown in each image plane 520 and 530 (in each displayed image) for clarity with it being understood that any number of pixels (1 to more typically many (e.g., a few hundred to several thousand or the like)) may be used to create each image with the size of the mirrors and overall array provided in security element 510 being the only limitations). The beams/rays 518 provided by the other sets of pixel-providing mirrors in element 510 are directed/aimed to cross/intersect on the second image displaying plane 530 (which is spaced apart from the first plane 520 some distance such 0.25 to 1 inch to several inches or more) to display/create pixels 532.

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[0049] To make the images provided by the pixels 522, 532 appear light and dark, the beams 514 and 532 are separated by an angle, ϕ, (e.g., 15 to 30 degrees or more) as may be measured between proximate ones of the beams in each group 514 and 518 (e.g., after the beams cross proximate to the mirror plane of security element 510 such as at or after the first image display plane 520). The angle of image separation, ϕ, and the cone angles at pixels 522, 532 are chosen to give this angular separation. Images of bright and dark zones do not overlap, and images provided by pixels 522 and 532 appear to the viewer to be in the two spaced apart or different planes 520, 530. One image darkens as the other lightens as the view angle changes.

[0050] Figure 6 is a functional block diagram of a computer or computing device 600 configured to run an array design program to allow an operator to generate a design of an array of micro mirrors for displaying a particular image(s) when provided in a security element (e.g., to perform steps of the method of manufacturing a security element with an array of micro mirrors according to the present description). The computer 600 includes a processor(s) 610 that executes code/instructions in computer readable media to run or provide the functionality of the micro mirror array design program 630 as well as those of the ray tracing module(s) 635. The processor 610 also manages operation of input/output (I/O) devices 620 such as a keyboard, a mouse, a touch pad or screen, voice recognition software, and the like configured to allow a user to provide input such as to select design parameters for a particular security element. The I/O devices 620 may include a monitor/display 624 and the design program 630 may be configured to generate one or more graphical user interfaces (GUIs) 628 displayed on the monitor/display device 624 to facilitate a user providing input and to display calculated results (such as the calculated angular orientations of each mirror in the array).

[0051] The processor 610 during the running of the design program 630 may access and manage memory (or data storage device) 640, which may be onboard as shown or offboard but accessible by the processor 610. The output of the design program 630 is stored at 650 in memory 640 and provides a design for an array of micro mirrors for a particular security element to be manufactured. The design 650 is shown at 651 to include a calculated angular orientation for each mirror in the array. This may be defined at 652 with a center location of the mirror (e.g., X-Y coordinates) combined with coordinates of a normal vector (e.g., X-Y-Z coordinates) for the mirror. This information can be used

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in a manufacture (e.g., deposition or other processes) of a security element for an object (such as for currency, coins, product labels, documents, and the like).

[0052] To allow the design program 630 to generate the array design 650, a user typically initially chooses a digital image 660 as a base or starting image for creating an anti-counterfeit or authentication image to be displayed in one or more planes or levels relative to the array of micro mirrors. The user/operator then may use the GUI 628 or other I/O devices 620 to identify one or more images to be displayed on each level of the image displayed by the security element being designed as shown at 662, 663. For example, images in the first plane or level 662 may be foreground images in the base/start image 660 while images 663 in the second (or later) plane or level 663 may be background (or intermediate) images of the base/start image 660. The design program 630 or another program on the computer 600 or available to the processor 610 may then be used to convert the digital base/start image 660 into a text or other file that identifies each pixel in the base/start image as being assigned to a particular one of the levels/planes (e.g., a text file with a plurality of numbers replacing the pixels of the image 660 representing one of the planes/levels of the image to be displayed by the security element being designed using the design program 630).

[0053] At this stage of operations, the design program 630 may function to generate a GUI 628 with a number of data entry boxes/fields prompting the user to accept default design parameter values or to enter/modify such values. The design program 630 may then operate to calculate the array design 650 including the angular orientations of each of the micro mirrors in an array. For example, the user may set or define a cone angle, as shown at 666 in memory 640, for use for generating the pixels of images in each level/plane used to display a security image. The cone angle often will differ for each level such as with larger values assigned to earlier/lower levels/planes (but this is not required), and exemplary cone angles for image pixels may be in the range of 10 to 30 degrees or the like.

[0054] The user may also be asked to provide or select an angular offset between each pair of image levels/planes as shown at 668 in memory 640, and this offset may range from 0 to 30 or more degrees to achieve a desired effect for a displayed image. Other parameters that may be entered or set by the user of the system 600 may include the dots per inch (DPI) 670 that defines the spacing of the pixels in each image display level or plane (the cone apex planes). The user may also be allowed to set the

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number mirrors to be used to create or display each pixel as shown in memory 640 at 680 (with 20 to 40 mirrors likely to be useful in some implementations). Further, the user may define heights of the image display levels or planes as shown at 688 (such as a first plane at 10000 microns, a second plane at 20000 microns, a third plane at 30000 microns or other useful spacings/heights).

[0055] With the parameters defined, the user may instruct the design program 630 to run to first choose, for each pixel in each image to be displayed in the levels/planes, a set of micro mirrors to be used to display or create the pixel. The other pixels may be considered unused pixels or pixels that can be used in a mask, and these pixels may be angularly oriented to direct light outside of the cone angle. The design program 630 may then continue with determining an array design 650 with these sets of pixel-providing mirrors 684 by calculating for each of the micro mirrors of the array its angular orientation 651, which may be provided by the coordinates (e.g., X-Y coordinates or the like) of the center of each mirror and the coordinates (e.g., X-Y-Z coordinates or the like) of the normal vector for the mirror with such center coordinates. This determination of the design 650 is carried out such that the micro mirrors in each set of pixel-providing mirrors is oriented to direct its reflected ambient light (a reflected light stream or beam or ray) onto the same image display plane at the same location (e.g., at a location of a pixel). The ray tracing module 635 may be configured to test the effectiveness of the array design 650 as explained below to ray trace reflected light providing images to a viewer's eye (or expected viewing positions relative to a security element with the array of micro mirrors having angular orientations as called out in the array design 650).

[0056] Figure 7 is a flow diagram of an exemplary design method 700 for an array of micro mirrors for use in a security element, such as may be carried out by operation of the system 600 of Figure 6. The method 700 starts at 705 such as with loading a design program onto a computing device and initiating or running the program. The method 700 continues at 710 with selecting a base or start image such as selecting a file in memory of a computing device providing a digital image of objects that may be useful for providing a multi-layer display for use in authenticating an object (e.g., an image with one or more components that can be presented as foreground images and one or more components that can be presented as background and/or intermediate images or on layers that appear behind the foreground images).

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[0057] In step 720, the method 700 involves a user indicating which portions/components of the base/start image from step 710 should be presented in the image(s) displayed on each of the one, two, or more image display layers for this security element. Hence, step 720 may be thought of as including first deciding how many display layers/planes to use with this array of micro mirrors (and this value can be affirmed/set in later step 730 as one of the design parameters). Step 720 may involve assigning differing colors of a colored base/start image to differing image display planes/levels. In other cases, a component/object in the image may be chosen as a foreground image and one or more of the other components/objects in the image may be selected to be background images to be on different levels/planes. At step 725, the method 700 continues with converting the base image into a file (such as a text document or file with each pixel replaced with 0's and 1's when two levels/planes are used and so on) that indicates for each pixel in the base image which level/plane that pixel is assigned for display by the array of micro mirrors.

[0058] The method 700 continues at 730 with the user choosing/setting design parameters (or accepting default ones such as may be predefined by the design program or as previously saved for other arrays). For example, the spacing of pixels in each image plane may be set (e.g., set the DPI for each image display plane/level), and the user may also set the cone angle and, in some cases, the mirror size. Step 730 may also include setting the height of each image display level/plane (which also sets the spacing between adjacent pairs of the planes/levels).

[0059] The method 700 continues at 740 with selecting or identifying a set of mirrors in the array to use to display each of the pixels in the images chosen in step 720 (with more detail provided for this process provided below). Step 740 may involve determining the number of mirrors that should be used for each pixel (typically a number between 1 and 40 or more that is used throughout the design) based on a cone angle, mirror size, and the DPI of the image (or pixel pitch). In some implementations, a program implementing the method 700 provides the average number of mirrors per pixel after step 730, and the user may determine it is useful to modify the design parameters (repeat step 730) to achieve a better result (e.g., some prototyping indicates that a "sweet spot" may exist around 25 mirrors per pixel with 10 being too few in some cases and 40 being too many in others). Step 740 may also involve defining a cone with an apex coinciding at the pixel location and

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with a cone angle set by the design parameters, and the cone base or area on the mirror plane may be used to define which micro mirrors may be chosen to display or "write" the particular pixel. The design parameters also define how many mirrors among the available ones in this circular or cone base area to use in the set of pixel-providing mirrors. A first mirror is chosen randomly (any useful random selection algorithm may be used and it may have "memory" in that a next run may remember which mirrors in the available set have already been chosen), and then this random process is repeated for the available mirrors until the set includes the number of mirrors needed for a complete set based on the design parameters for this array of micro mirrors.

[0060] At step 750, the method 700 includes for a next one of the pixels in the images, calculating angular orientation of all mirrors in the set of mirrors chosen for displaying that pixel. At 760, it is determined whether there remain additional pixels in the images, and, if yes, the method 700 proceeds with repeating steps 750 and 760 until all the angular orientations for the mirrors in the sets of pixel-providing micro mirrors are determined. If no at step 760, the method 700 continues at 770 with directing all mirrors not in one of these sets (or unused mirrors) so that they do not interfere with image display, e.g., by assigning an angular orientation that is outside the viewing cone for each of the pixels used to display the images on each of the levels/planes.

[0061] At step 780, the method 700 is shown to include a decision step based on the number and/or location of the unused mirrors. The method 700 (or computer program functioning to implement the method 700) may plot the position of all the unused mirrors. If there are too many unused mirrors (e.g., above a predefined maximum unused mirror number) and/or the unused mirrors are too close to each other (e.g., not scattered over the canvas or array of micro mirrors), the method 700 may return to step 730 to change the design parameters and repeat the other steps of the method 700 after step 730. The parameters that may be changed at 730 can include the cone angle (e.g., to have more surface from which to choose mirrors) and the height of the floating images (e.g., the closer the images are floating to the mirror plane the more difficult it can be to find useful mirrors so that higher or lower display/floating levels or planes will decrease the number of unused mirrors). In some cases, the DPI can be changed from the original image and/or the image design may need to be changed to obtain a useful result with method 700.

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[0062] If the number and/or location of the unused mirrors is determined to be satisfactory at 770, the method 700 then may end at 790. The design of the angular array may then be output for use in fabricating a security element with an array of micro mirrors individually oriented to provide one or more images (with a number of displayed pixels) on one or more image display planes/levels.

[0063] As discussed previously, an underlying idea of the security elements of the present description is to use ambient light and a planar surface containing many small mirrors and to aim the ambient light reflected off the mirrors toward a desired point in space above the planar surface that contains the mirrors. This is called the first layer image and is defined by artwork that has light or dark pixels to be produced in a layer or level (or first image display plane). By carefully selecting the mirrors within a circle defined by the intersection of the cone defined by an apex angle and a pixel from the first layer/level as the apex of the cone, the cone apex from various mirrors in the circular base of the cone provides a point source of light floating above the level of the mirror plane at the location of a pixel, containing the mirrors. A computer algorithm (as shown with the program 630 in Figure 6) completes this process on a pixel-by-pixel basis. If the pixel in the first layer/level is a dark pixel (e.g., a pixel not associated with the image or image component/portion from a base/start image chosen for display in the first image display plane), no rays will be aimed toward it.

[0064] In addition, the program has the capability of using a second layer of pixels that acts as a mask for the first layer of pixels so that various portions of the pixel image at level one are "hidden" or visible depending on the viewing angle. The algorithm that generates the first layer of floating pixels looks at the rays aimed to the pixel in the first layer and the continuation of the rays to the second layer. The intersection location in the second layer is calculated and is searched for nearby dark pixels of the second layer/level (mask layer and/or second image display plane). If dark pixels are found in the intersection area on the second layer, the mirror that reflected that ray to the first layer is not used to aim the ray at that pixel to the first layer (e.g., this additional processing can be used to modify or originally select the mirrors to be used to display the pixel of the first image display plane).

[0065] Thus, there is a masking effect of the mask layer as is desired. To form a mask that appears to "float" over the pixels in the first layer (or first image display plane), some pixels of the first layer will have partial cones of pixels depending on the mask geometry defined by the pixels on/off of the

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second layer and on the angle the pixels are viewed (as can be seen with reference to the diagram 400 of Figure 4). As the viewer's eye is moved (or the mirror assembly tilted to the viewer), pixels of the first layer will change brightness and appear or disappear from view in a way that causes the mask to appear to move.

[0066] To insure uniform illumination across pixels, during the aiming process as described above, only one of the available mirrors is used in each pixel's cone of acceptance by the design program, and the mirror is selected at random from the available mirrors in the cone of acceptance. After the direction cosines of the selected mirror are calculated, the mirror is marked by the design program as "no longer available for use by any other pixel." The design program moves on to the next pixel, and the same sequence of events or design steps are repeated until all the pixels are used (or oriented for desired light reflection). At that point in the design algorithm, the entire sequence of pixels is again used to pick up one of the available mirrors for each pixel. After a number of cycles of the pixels, all the mirrors are used depending on the image and mask patterns. If some mirrors cannot be used because of the geometry of the image layer and mask layer, they will be aimed out of the viewing zone.

[0067] The design program allows the user to choose the values of the spacing of image levels from the mirror plane, as well as pixel cone angles, mirror sizes and pixel pitches. These all can be optimized or selected by the user to make (or try to make) the best image to present to the viewer. The inputs to the design program in some embodiments are pixel image files for the first layer image and for the mask for the second image display plane or layer/level. However, there are also capabilities for the program to make its own test input layers. The output of the program is a data file containing mirror locations and the coordinates of the normal vector to each mirror in a format suitable to make the mirrors or to form an array of micro mirrors on a supporting substrate (such as a piece of currency, a coin, a product label, a document, or the like).

[0068] In some embodiments, the design program allows the user to see the input files, ray traces to different levels (e.g., via operation of the ray tracking module 635 shown in Figure 6), and the expected image seen on the retina of a viewer. Tracings can be done using input cones of light on the mirrors to see the affects ambient light distributions on the viewer's retina. As an example of the GUI

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628 of Figure 6 that can be generated by the design program 639, Figure 8 illustrates a micro mirror design GUI 800 that is displayed in one prototype of the design program created and used in prototyping by the inventors.

[0069] The main GUI or menu 800 shows an exemplary set of inputs (design parameters, for example) that can be chosen, input, or modified by the user. These include pixel pitch, level/image display plane values, and cone angles for pixels, mirror size, and selection of test patterns. The right side of the GUI/menu 800 shows some of the details or results of the calculations performed by the design algorithm based on the user's input or selected (or default) design parameters provided on the left side. These include the number of mirrors that are dark (aimed away from pixels of images chosen for display on level or image display plane), numbers of mirrors used, algorithm used, and time required to calculate direction cosines of mirrors.

[0070] The level height parameter can be used to define or set how far above or below the mirror plane, in microns, that the image designated will appear for a mirror array design. The level cone angle degree parameter sets the angle at the floating pixel of the cone in which specific mirrors can be selected. A narrower angle means that there will be fewer potential mirrors for each pixel, and the opposite for a larger angle. The level angle offset parameter defines or sets the angle of offset that you would like the image level to appear, in respect to the Z axis. The "Assign Image (1,2) color (0,1,3,4) to level#" input box allows the user to place the various image colors to the specified levels. The "Border Edge Width Add" input box allows the user to expand or shrink the canvas to allow for movement of the images.

[0071] As noted earlier, the design process begins with inputting or providing an image file for the design program to process to create or calculate the design for the micro mirrors. One significant parameter in such design calculations is the resolution (DPI), and, in some applications, it may be useful to input or use lower resolution files (or digital images). For instance, an image that is 100 DPI is equivalent to having a pixel every 254 microns, and in the GUI 800 in Figure 8 this is the input shown under “image focal points X pitch = 254" (and the same value for Y pitch). Based on this resolution or how many pixels you need floating to represent that specific image along with the mirror size (in the attached menu 800 this is 50 microns), the design program calculates “avg Num Mirrors

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available per pixel," which in this example is 25.7685291. In other words, a little over 25 mirrors that can be used to represent one pixel from the original or base/starting image file.

[0072] Figures 9A-9C illustrate with graphs 910, 920, 930 images that can be displayed on various levels or image display planes by an array of micro mirrors of the present description. Graph 910 of Figure 9A shows a first layer image, with the light or on pixels providing an "X" pattern that would be displayed by a number of sets of pixel-providing mirrors to be floating in a first image display plane. In Figure 9B, graph 920 shows a second layer image, with the light or on pixels providing a rectangular background pattern or object that would be displayed by a number of sets of pixel-providing mirrors so as to be floating in a second image display plane. The graph 930 of Figure 9C shows a partial "X" of light or on pixels displayed with micro mirrors of an array and shows the effect of a mask blocking part of the image.

[0073] Figure 10 is a plot 1000 illustrating a ray tracing of light rays 1015 and dark rays 1017 near a first image display plane or first level/layer 1020 for one modeled array of micro mirrors 1010. As can be seen, the array of micro mirrors 1010 provides converging rays of reflected ambient light meeting or intersecting at a number of pixels 1022 at the floating pixel level or image display plane 1020 (or a first level as discussed above). It can also be seen that dark rays 1017 are directed away from the converging points/pixels 1022 and do not converge at the first level 1020.

[0074] One useful analysis tool of the design program and/or the ray tracing module is that a designer of an array of micro mirrors for a security element is able to evaluate the image as seen by a viewer. To this end, a ray tracing part of the design module (or a separate module as shown in Figure 6) is used to view the image on a simulated retina. Thus, the effectiveness of array design including a mask can be analyzed by putting the viewer's eye in various locations, which is equivalent to tilting the mirror plane, and plotting the ray traced image on the simulated retina. Figure 11 illustrates a representative GUI or ray tracing menu 1100 that allows a user to specify parameters to utilize in performing the ray tracing. Figure 12 illustrates a plot 1200 of a representative ray tracing showing the mirror plane 1210, traced reflected rays/beams 1220, a face plane 1230, location of a viewer's eyeball at 1240, and a corresponding retina at 1245 upon which rays converge indicating display of a

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set or number of pixels of a "written" or displayed image by the mirrors oriented in a desired manner at the plane 1210.

[0075] A number of manufacturing approaches may be used to fabricate an array of micro mirrors for attachment to or upon a surface of a substrate (such as currency, coins, product labels, and so on). In some embodiments, a photo resist process has been implemented by the inventors in creating security elements or devices as taught herein. As discussed earlier, the design program or software generates an output file (as explained in more detail below). To form the micro mirrors according to this output file, a laser system is used to expose the photo resist material, usually on a quartz or lime glass master. The photo resist material is normally at least 25 microns thick. The laser or laser system may expose the material in steps such as in about .5μ steps. The exposure settings correspond to the amount of material that will be washed away and not hardened, and this exposure creates a "Z" axis or height of the feature. The resulting micro mirrors (which may be flat or may be concaved for better focus depending upon design) are made in the photo resist material. The photo resist is generally still light sensitive and will "melt" in white light. In some cases, the photo resist is chrome plated in house before processing. The photo resist is then placed in an electroforming tank. The resist is charged and attracts nickel (or other metallic) particles, and nickel is "grown" on the photo resist as a nickel "shim." This nickel shim can be "turned" as needed from negative to positive and back again for tooling. The nickel shim is then used in the cast and cure process to form the array of micro mirrors oriented as indicated by the output file of the design program or software.

[0076] In other fabrication processes, a UV (ultraviolet light) or energy-cured polymer is used, and the process includes metallizing the mirrors to form an array as taught herein. In other cases, the fabrication process involves stamping or forming the micro mirrors into surfaces such as chrome or aluminum containers.

[0077] In general, the inventors teach a method of fabricating a security or branding element. The method includes providing a substrate and forming an array of micro mirrors on a surface of the substrate. The array of micro mirrors is configured for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate. The image comprises a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of

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the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

[0078] In some embodiments of the fabrication method, the forming the array of micro mirrors step includes casting the micro mirrors with a mirror tool in contact with the surface of the substrate. In these embodiments, the substrate may be a clear, energy-cured polymer, and the mirror tool can be formed of nickel or a polymer.

[0079] In some cases, the step of forming the array of micro mirrors includes metallization of surfaces of the micro mirrors. This may be performed so as to apply a thin layer of aluminum, gold, or silver to form reflective surfaces or form the mirror structures of the array. The metallization may be performed in a vacuum chamber using a deposition system or the like. Further, the forming step may include, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors. In this regard, it may be useful for the surface of the substrate to include or be made up of an embossable coating or layer.

[0080] In performing the fabrication method, the substrate may be (or include or be provided on) a coin, an automobile part, a computer part, a bumper, or a container, and the displayed image provides branding or authentication for the component that includes the array of micro mirrors. In such cases, the array forming step may include stamping the micro mirrors into the surface of the substrate.

[0081] In the same or other embodiments, the step of forming the array of micro mirrors may involve filling in recessed surfaces associated with the micro mirrors with a filler so as to make duplication (e.g., by molding) more difficult if not impossible. The filler may take the form of an ultraviolet (UV) varnish, an e-beam solvent, a water-based varnish, or the like. In some cases, it may be desirable for the filler to have a higher refractive index such as an index of at least 1.55, such that at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image for a viewer.

[0082] From the description and figures, it can be seen that there are numerous advantages and unique features of security elements/devices that include or are formed of arrays of micro mirrors. The individual mirrors can be programmed or oriented in two axes to focus to a specific pixel in any visual

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plane (e.g., in a first image display plane, in a second image display plane, and so on). In this way, the micro mirrors are used to image pixels forming drawings or text that appear to float relative to the planar surface containing the array of micro mirrors. The micro mirrors can be configured or designed to focus above or below the visual plane forming pixels that in combination display images with depth (multi-layered or multi-depth imagery). The program performs a unique design method providing an output file that can be used in fabricating or generating the micro mirrors.

[0083] In practice, the shape of the micro mirrors can be round, square, and rectangular with the reflective surface being flat, concave, or convex to provide desired focusing upon a pixel (or location on one of the image display planes). The size of the mirrors may vary to practice the arrays of micro mirrors such as from about 1000 microns down to one micron with mirrors in the 35 to 70 micron range likely being desirable (with 50 micron square mirrors being used in a prototype/model).

[0084] An array of micro mirrors can be designed to provide a variety of visual effects such as showing images above or below the visual planes and in first, second, third, or more image display planes relative to the mirror-containing planar surface. In other cases, the mirrors are used to provide an effect of light images with dark backgrounds animating to light backgrounds and dark images with a change of perspective. In the same or other cases, an array of micro mirrors can be configured with selective orienting of mirror reflective surfaces to provide a masking effect showing one image receding as it goes across another image. In many cases, the micro mirrors generate more than one level of imagery to the viewer (two or more). Particularly, the micro mirrors can generate one image made up of a set of pixels at one level above the focal plane while also (or separately) generating an image below the focal plane. In the same or other cases, the micro mirrors may be configured to generate an image at the focal plane. In these embodiments, the images are displayed/written either with bright pixels (light) or dark pixels (the absence of light or reflected light from the viewer). Images created by the micro mirrors can provide an animation effect, and, in the same or other embodiments, the images created by the micro mirrors may provide a 3D effect.

[0085] The array of micro mirrors can be used in (or provided as part of) a currency thread, which may be about 10 to 50 microns thick. The array of micro mirrors or security element can be used as a foil stamp that may be about 10 to 100 microns thick. The array may be formed by stamping the

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micro mirrors into any metallic surface, such as a surface of a coin, or by placing the micro mirrors on glass, ceramic, or plastic substrates, which may be clear so as to create a unique visual display or imaging effect that allows a viewer to see images in display planes on two sides of the substrate supporting the array of micro mirrors (or transparent film including such mirrors). In these and other ways, an array of micro mirrors may be successfully used in any high security application including, but not limited to, passports and other high security documents including currency.

[0086] In some embodiments, the displayed or written image is colored (e.g., is not simply black and white). In one embodiment, a color display is created by forming the mirrors of the array with plasmonic resonance for color while other fabrication processes use tinting of the reflective mirrors with ink. In other embodiments, diffractive material is added to the reflective surface of the mirrors or diffraction grating may be used to create color with the micro mirrors. In some embodiments, dielectrics are used to provide color with the array of micro mirrors. In still other colored display embodiments, a protective cover layer may be applied to the mirrors that is transparent (to-translucent), and then coloring may be provided by printing on this cover layer with translucent color squares (or other mirror shape-matching coloring filters) aligned over the proper micro mirrors to achieve a desired colored image in one or more of the image display planes or levels/layers.

[0087] Figures 13A and 13B illustrate plots 1310 and 1320 provided by the design program of images chosen for display on first and second image display planes or levels, respectively, and these are the two images that would be written or displayed by micro mirrors of an array. In Figure 13A, a user has input an image with a colored or plain background with a circular boarder enclosing a leaf, and the circular boarder and the outline of the leaf have been chosen for display or writing on a first level or first image display plane (at a first height such as 10000 microns away from the planar surface containing the mirrors). The offset angle may be set at 0 degrees (or some other value), and Figure 13A represents an approximation of what a viewer would see when viewing the security element with this design of an array of micro mirrors. Particularly, a plurality of bright or "on" pixels showing the circular boundary and the outer edges/boundary of the leaf.

[0088] Figure 13B shows the first layer imagery 1310, but it also shows with plot 1320 that as the viewer rotates the mirror plane or changes their perspective (e.g., from a 0 degree viewing angle to

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the offset angle that may be 20 degrees or the like) the original images 1315 are replaced with the new images 1325 at the second level or second image display plane (which may be at 20000 microns or some other height such that the two levels/image display planes are spaced apart some desired distance). As shown, the designer/program user has indicated that the background of the input image, the inner portion of the circle, and the inner portion of the leaf should be written or have their associated pixels "on" in the second layer while the portions chosen for image 1315 of the first layer are "off" or dark. In this manner, the image sees a transition between displaying imagery with light and then with dark pixels as their perspective or viewing angel changes to view the images in the two spaced apart levels/layers or image display planes.

[0089] Figures 14A and 14B illustrate plots 1410 and 1420 that show the results of programming or orienting an array of micro mirrors to display an object or image 1415 (here an eagle or hawk). The plot 1410 of Figure 14A may be considered a top view as the intersections of normal vectors from the micro mirrors are shown relative to X and Y axes while the plot 1420 of Figure 14B may be considered a side view as the same intersections are shown relative to the X and Z axes. Figure 14A is useful for showing a representation of what a viewer would perceive when looking in an orthogonal direction to the plane containing the mirrors, e.g., the viewer perceives the outline of an eagle (which may be displayed or written with bright or dark pixels). The intersections act to display "pixels" that, as can be seen at 1415, work in combination to display an object/subimage (as may be chosen by a user of the design program from an input image file for display in a particular level or image display plane). Figure 14B shows that the pixels (or normal vector intersections) are generally planar or provided in a plane coinciding with a preset/defined level or image display plane relative to the planar surface containing the micro mirrors (e.g., a plane spaced apart a predefine distance from the array of micro mirrors), and this acts to provide a floating image 1415 or an image with depth or 3D effects.

[0090] As discussed above, the design program or algorithm functions to create an output file that may be used in manufacturing an array of micro mirrors adapted to display one or more floating images above (or below) the planar surface containing the array. Table 1 below provides exemplary data that may be provided in such an output file (with only a small number of mirrors being shown for ease of explanation but with it understood that similar data would be provided for each mirror in

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the array). The X and Y columns of Table 1 show mirror positions (in microns), e.g., in the second row a mirror is located in the array at 35 microns on the X axis and at 0 microns on the Y axis. In the table, next to each mirror location in the array, the DX, DY, and DZ columns provide the coordinates of the normal vectors for each of the mirrors. In this way, each mirror has a defined position in the array and a precise direction its reflective surface is pointing in space.

[0091] In creating the exemplary data in Table 1, the following assumptions were made for the design of the array of micro mirrors: (1) units are microns; (2) the array is configured to have flat mirrors with tilted reflective surfaces; (3) the mirrors were square in shape with 35 micron sides; (4) the array was also assumed to be square in shape with 27,930 micron sides; (5) the number of mirrors was calculated to be 798 along the X and Y axes such that the total number of mirrors was 636,804; and (6) the maximum mirror tilt angle was requested to be 30 degrees (e.g., due to vendor/manufacturer limitations so may be set at 20 degrees).

Table 1

X	Y	DX	DY	DZ
0.00	0.00	-0.061672	0.021122	0.997873
35.00	0.00	-0.020315	0.050724	0.998506
70.00	0.00	-0.063424	0.008449	0.997951
105.00	0.00	-0.064293	0.008449	0.997895
140.00	0.00	-0.056737	0.016904	0.998246
175.00	0.00	-0.053402	0.000000	0.998573
210.00	0.00	-0.058482	0.012677	0.998208
245.00	0.00	-0.025586	0.008464	0.999637
280.00	0.00	-0.051801	0.000000	0.998657
315.00	0.00	-0.061093	0.012675	0.998052
350.00	0.00	-0.061967	0.004225	0.998069
385.00	0.00	-0.058619	0.016902	0.998137
420.00	0.00	-0.046852	0.000000	0.998902
455.00	0.00	-0.018142	0.004233	0.999826
490.00	0.00	-0.061225	0.021122	0.997900
525.00	0.00	-0.062100	0.016898	0.997927
560.00	0.00	-0.062979	0.000000	0.998015
595.00	0.00	-0.063848	0.004225	0.997951

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[0092] Figures 15A and 15B illustrate plots generated and displayed by a preview program (which may be a subroutine of the design program described herein) for previewing likely or predicted results of a design of an array of micro mirrors. Specifically, Figure 15A illustrates a plot 1510 of a 3D image that may be displayed with a selected image and a particular design of an array of micro mirrors. The plot 1510 illustrates a foreground or first layer image 1514 (e.g., a bird such as a flying eagle) relative to a background or second layer image 1518 (e.g., a colored frame with stars) relative to each other and X and Y coordinates. The plot 1510 previews what a viewer looking directly at or downward at the security device may see via the array of micro mirrors. Figure 15B illustrates a plot 1520 illustrating the foreground image 1514 and background image 1518 not only relative to the X and Y axes but also relative to the Z axis (e.g., the depth that would be provided by the array of micro mirror design).

[0093] The preview program providing the plots 1510 and 1520 takes as input the output file of the design program, with all the mirror positions and normal vector coordinates. The preview program calculates the intersection of the reflected rays (e.g., rays coming straight down and bouncing out of the mirrors to the viewer) with the plane where the image is supposed to (or is designed to) float. With the plots 1510 and 1520 provided by the preview program, the operator or designer can verify the combination of foreground and background images 1514, 1518 provides a desired 3D image or representation as shown in Figures 15A and 15B. In this example, an eagle 1514 is floating in a first image plane at +30,000 microns above the mirror plane while the frame 1518 (with stars) is floating in a pushed back second image plane at -30,000 microns (or the two image planes are spaced apart 60,000 microns for the viewer providing a desirable 3D effect). Stated differently, the preview program takes the normal vectors corresponding to the eagle's mirrors and plots the intersection to the plane at 30,000 microns (and does a similar processing for the frame/background image's mirrors and the plane at -30,000 microns).

[0094] Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter claimed.

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WE CLAIM:

1. A method of fabricating a security element, comprising:

assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane;

with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane;

for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; and

generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors.

2. The method of claim 1, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.

3. The method of claim 1 wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.

4. The method of claim 3, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.

5. The method of claim 1, wherein the angular orientations are calculated based on heights of the first and second image display.

6. The method of claim 1, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.

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7. A method of fabricating a security element, comprising:

with a processor of a computing device, executing code to provide an array design module configured to select a set of micro mirrors in an array of the micro mirrors to display pixels of a first object in a first image display plane and to display pixels of a second object in a second image display plane spaced apart from the first image display plane;

for each of the pixels, determining, with the array design module, an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; and

generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors,

wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.

8. The method of claim 7, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.

9. The method of claim 7, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.

10. The method of claim 7, wherein the angular orientations are calculated based on heights of the first and second image display.

11. The method of claim 7, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.

12. A method of fabricating a security element useful on paper and coin currency and on product labels, comprising:

with a processor of a computing device, executing code to provide an array design module configured to define an array of micro mirrors to be formed on a surface of a substrate; and

generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors,

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wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate,

wherein the image comprises a plurality of pixels, and

wherein the array of micro mirrors includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

13. The method of claim 12, wherein a voxel is created at each of the point on the plane via intersection of two or more beams of the reflected ambient light, and wherein each of the created voxels produces an effect of a point source of light floating above the surface of the substrate in the plane.

14. The method of claim 12, wherein each of the different sets concurrently reflect the ambient light to concurrently generate the plurality of pixels.

15. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by casting the micro mirrors with a mirror tool in contact with the surface of the substrate,

16. The method of claim 15, wherein the substrate provided in the providing step comprises a clear, energy-cured polymer.

17. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by metallization of surfaces of the micro mirrors, wherein the metallization applies a layer of aluminum, gold, or silver to form reflective surfaces.

18. The method of claim 17, wherein the forming the array of micro mirrors includes, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors and wherein the surface of the substrate includes an embossable coating or layer.

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19. The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by filling in recessed surfaces associated with the micro mirrors with a filler comprising at least one of an ultraviolet (UV) varnish, an e-beam solvent, and a water-based varnish.

20. The method of claim 19, wherein the filler has a refractive index of at least 1.55, whereby at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image.

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ABSTRACT OF THE DISCLOSURE

A visual display assembly useful as an authentication or anti-counterfeiting element. The assembly includes a substrate and, on a surface of the substrate, an array of micro mirrors receiving ambient light. Each mirror includes a reflective surface to reflect the ambient light to display an image that appears to float in a plane, which is spaced a distance apart from the surface of the substrate. The image includes a plurality of pixels, and the array of micro mirrors includes for each of the pixels a set of the micro mirrors each having a reflective surface oriented to reflect the ambient light toward a point on the plane corresponding to one of the pixels. Each of the sets of the micro mirrors includes a plurality of the micro mirrors, and the reflected ambient light each set of micro mirrors intersects to illuminate or write a pixel of an image.

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/152,623

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE($)	FEE($)		RATE($)	FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 240 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	830		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
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The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/152,623	01/19/2021		830	79897.01436	20	3

CONFIRMATION NO. 9833

UPDATED FILING RECEIPT

166539
Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004

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Date Mailed: 03/01/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Inventor(s)

MARK A. RAYMOND, LITTLETON, CO;
HECTOR ANDRES PORRAS SOTO, LITTLETON, CO;
HOWARD G. LANGE, SAN DIEGO, CA;

Applicant(s)

LUMENCO, LLC, Englewood, CO;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 16/203,128 11/28/2018 PAT 10901191
which is a DIV of 15/162,113 05/23/2016 PAT 10189294 *
which claims benefit of 62/262,767 12/03/2015
(*)Data provided by applicant is not consistent with PTO records.

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

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The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/152,623**

Projected Publication Date: 06/10/2021

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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(Not for submission under 37 CFR 1.99)

Application Number	17152623
Filing Date	2021-01-19
First Named Inventor	Mark A. Raymond
Art Unit	
Examiner Name	
Attorney Docket Number	79897.01436

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	2	6288842	B1	2001-09-11	FLORCZAK, JEFFREY M.	
	3	7261417	B2	2007-08-28	GYOUNG, CHO ET AL	
	4	9176266	B2	2015-11-03	GIESECKE & DEVRIENT GMBH	
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	Attorney Docket Number	79897.01436

	2	20100231860	A1	2010-09-16	SATOSHI, MAEKAWA	
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	10	20080258456	A1	2008-10-23	RAHM, ET AL	
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	Art Unit	
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	3	2013056825	WO	A1	2013-04-25	GIESECKE & DEVRIENT GMBH		
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	7	2760677	EP	B1	2016-01-13	MAYER, ET AL		
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	Art Unit	
	Examiner Name	
	Attorney Docket Number	79897.01436

	1	International Search Report for International Application No. PCT/US2016/061845 dated March 16, 2017	
	2	International Search Report for International Application No. PCT/US2018/028241, dated August 16, 2018	
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	Application Number	17152623
	Filing Date	2021-01-19
	First Named Inventor	Mark A. Raymond
	Art Unit	
	Examiner Name	
	Attorney Docket Number	79897.01436

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Signature	/Kent A. Lembke/	Date (YYYY-MM-DD)	2021-04-15
Name/Print	Kent A. Lembke	Registration Number	44866

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(19) Weltorganisation für geistiges Eigentum
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(71) Anmelder *(für alle Bestimmungsstaaten mit Ausnahme von US)*: **GIESECKE & DEVRIENT GMBH** [DE/DE]; Prinzregentenstrasse 159, 81677 München (DE).

(72) Erfinder; und
(75) Erfinder/Anmelder *(nur für US)*: **FUHSE, Christian** [DE/DE]; Bahnhofstraße 22, 83624 Otterfing (DE). **KAULE, Wittich** [DE/DE]; Lindacher Weg 13, 82275 Emmering (DE).

(74) Gemeinsamer Vertreter: **GIESECKE & DEVRIENT GMBH**; Patent- und Linzenzabteilung, Prinzregentenstrasse 159, 81677 München (DE).

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Erklärungen gemäß Regel 4.17:

[Fortsetzung auf der nächsten Seite]

(54) **Title**: REPRESENTATION ELEMENT COMPRISING OPTICAL ELEMENTS ARRANGED ON A SUBSTRATE, FOR PRODUCING AN IMAGE COMPOSED OF LIGHT SPOTS AND SUSPENDED ABOVE OR BELOW THE SUBSTRATE

(54) **Bezeichnung** : DARSTELLUNGSELEMENT MIT AUF EINEM SUBSTRAT ANGEORDNETEN OPTISCHEN ELEMENTEN ZUR ERZEUGUNG EINES OBERHALB ODER UNTERHALB DES SUBSTRATS SCHWEBENDEN, AUS LICHTFLECKEN ZUSAMMENGESETZEN BILDES

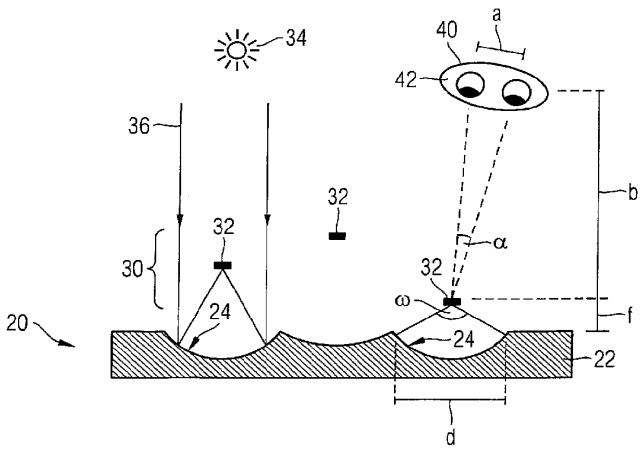


Fig. 2

(57) **Abstract**: The invention relates to a representation element (20) comprising a substrate (22) having a surface region containing a plurality of optical elements (24). According to the invention, the representation element (20) is designed to produce, when illuminated (34), a light spot image (30) consisting of a plurality of light spots (32) that appear to the observer (40) to be suspended above or below the surface region, and are arranged in the form of a pre-determined pattern. Said optical elements are formed by refractive and/or reflective optical elements (24) and at least one refractive and/or reflective optical element is associated with each light spot (32) of the light spot image, contributing to the production of the light spot (32) associated therewith when the representation element (20) is illuminated (34).

(57) **Zusammenfassung**:

[Fortsetzung auf der nächsten Seite]

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— *vor Ablauf der für Änderungen der Ansprüche geltenden Frist; Veröffentlichung wird wiederholt, falls Änderungen eingehen (Regel 48 Absatz 2 Buchstabe h)*

Die Erfindung betrifft ein Darstellungselement (20) mit einem Substrat (22) mit einem Flächenbereich, in dem eine Mehrzahl optischer Elemente (24) angeordnet ist. Erfindungsgemäß ist das Darstellungselement (20) ausgelegt und bestimmt, bei Beleuchtung (34) ein Lichtfleckenbild (30) aus einer Mehrzahl von Lichtflecken (32) zu erzeugen, die für einen Betrachter (40) oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind, wobei die optischen Elemente durch refraktive und/oder reflektive optische Elemente (24) gebildet sind und jedem Lichtfleck (32) des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element (24) zugeordnet ist, welches bei Beleuchtung (34) des Darstellungselements (20) zur Erzeugung des ihm zugeordneten Lichtflecks (32) beiträgt.

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Die Erfindung betrifft ein Darstellungselement mit einem Substrat mit einem Flächenbereich, in dem eine Mehrzahl optischer Elemente angeordnet ist. Die Erfindung betrifft ferner ein Verfahren zur Herstellung eines derartigen Darstellungselements und einen Datenträger mit einem solchen Darstellungselement.

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Dabei sind mehrere Techniken bekannt, mit denen bei beidäugiger Betrachtung flacher Bilder ein dreidimensionaler Bildeindruck erzeugt werden kann. Bei Anaglyphenbildern sind etwa zwei stereoskopische Halbbilder einander überlagert. Bei Betrachtung mit einem Hilfsmittel, wie einer Rot-Grün-Brille oder einer Polarisationsbrille werden die beiden Halbbilder für die beiden Augen getrennt.

Eine andere Technik verwendet Linsen- oder Spiegelrasterbilder, die aus einem Mehrschichtaufbau mit Motivschicht und von der Motivschicht beabstandeter Linsen- bzw. Spiegelschicht bestehen. Ein Beispiel dieser Technik

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sind die 3D-Moiré-Magnifier, wie sie in der Druckschrift WO 2009/000530 A2 beschrieben sind.

Ein weiterer Ansatz, wie er etwa in der Druckschrift WO 90/08338 A1 beschrieben ist, besteht darin, das Motiv als flaches Relief ausbilden, wobei sich die Oberfläche des Motivs nachgeahmt und/oder gestückelt in der Oberfläche des Bildes wiederfindet.

Schließlich werden für Sicherheitselemente seit längerem Hologramme, holographische Stereogramme und hologrammartige Gitterbilder eingesetzt, um einen dreidimensionalen Bildeindruck zu erzeugen. Bei dieser Technik spielt Lichtbeugung und Interferenz an den holographischen Strukturen und Beugungsgittern eine entscheidende Rolle.

Davon ausgehend davon liegt der Erfindung die Aufgabe zugrunde, ein Darstellungselement der eingangs genannten Art zu schaffen, das ein attraktives visuelles Erscheinungsbild aufweist. Für Sicherheitsanwendungen soll das Darstellungselement zudem eine hohe Fälschungssicherheit aufweisen und darüber hinaus auch für Laien einfach auf Echtheit zu prüfen sein.

Diese Aufgabe wird durch das Darstellungselement mit den Merkmalen des Hauptanspruchs gelöst. Ein Verfahren zur Herstellung eines derartigen Darstellungselements, ein mit einem solchen Darstellungselement ausgestatteter Datenträger und eine mit einem solchen Darstellungselement ausgestattete Anzeigeeinrichtung sind in den nebengeordneten Ansprüchen angegeben. Weiterbildungen der Erfindung sind Gegenstand der Unteransprüche.

Gemäß der Erfindung enthält ein gattungemäßes Darstellungselement ein Substrat mit einem Flächenbereich, in dem eine Mehrzahl optischer Elemen-

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te angeordnet ist. Das Darstellungselement ist dabei ausgelegt und bestimmt, bei Beleuchtung ein Lichtfleckenbild aus einer Mehrzahl von Lichtflecken zu erzeugen, die für einen Betrachter oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind. Dazu sind die genannten optischen Elemente durch refraktive und/oder reflektive optische Elemente gebildet, wobei jedem Lichtfleck des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element zugeordnet ist, welches bei Beleuchtung des Darstellungselements zur Erzeugung des ihm zugeordneten Lichtflecks beiträgt.

Die Erfindung beruht somit auf dem Gedanken, ein dreidimensionales Motiv vorzugeben, das aus über oder unter dem Darstellungselement schwebenden Lichtflecken besteht. Um die Lichtflecke bei Beleuchtung zu erzeugen, weist das Darstellungselement nebeneinander liegende oder verschachtelte Teile von Spiegeln, Linsen oder Prismen auf, die so ausgelegt sind, dass sie in einem Bildraum bei geeigneter Beleuchtung schwebende Lichtreflexe erzeugen, die zusammengenommen das vorgegebene dreidimensionale Motiv darstellen. Die schwebenden Lichtreflexe sind im physikalischen Sinne reelle Bilder oder virtuelle Bilder der beleuchtenden Lichtquellen, wie nachfolgend genauer erläutert. Der visuelle Eindruck ist dabei besonders gut, wenn das Darstellungselement mit parallelem Licht, beispielsweise einer weit entfernten Lichtquelle, beleuchtet wird.

Das durch die Beleuchtung entstehende dreidimensionale Lichtfleckenbild bietet dem Betrachter einen ungewöhnlichen und visuell ansprechenden dreidimensionalen Bildeindruck, der dem Darstellungselement einen hohen Aufmerksamkeits- und Wiedererkennungswert verleiht. Das Vorliegen oder Nichtvorliegen des Effekts ist für jeden Benutzer leicht festzustellen, das

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Darstellungselement also einfach verifizierbar. Dennoch ist die Spiegel- bzw. Linsenanordnung aufgrund des erforderlichen Know-how und der benötigen Technologie für einen potentiellen Fälscher nur schwer nachzustellen.

Nachfolgend werden die refraktiven und/oder reflektiven optischen Elemente der kürzeren Benennung halber meist nur als "optische Elemente" bezeichnet. Es versteht sich jedoch, dass damit im Rahmen der Erfindung stets refraktive und/oder reflektive optische Elemente gemeint sind. Die optischen Elemente können entweder rein refraktiv sein, wie etwa eine Linse oder ein Mikroprisma, rein reflektiv, wie etwa ein Spiegel oder ein Mikrospiegel, oder sowohl refraktiv als auch reflektiv, wie etwa eine mit einer semitransparenten Beschichtung versehene Linse oder ein mit einer semitransparenten Beschichtung versehenes Mikroprisma. In jedem Fall spielen Beugungs- und Interferenzeffekte bei den erfindungsgemäßen refraktiven und/oder reflektiven optischen Elementen keine Rolle und können stets vernachlässigt werden.

In einer bevorzugten Ausgestaltung sind die optischen Elemente und die Schwebehöhen der Lichtflecke so ausgelegt, dass für die Lichtflecke und die zugeordneten optischen Elemente jeweils die Bedingung $f/d < 5$ gilt, wobei f die Schwebehöhe eines Lichtflecks oberhalb oder unterhalb des Flächenbereichs bezeichnet und d den Durchmesser der zu diesem Lichtfleck beitragenden optischen Elemente angibt. Dadurch ist sichergestellt, dass die Lichtflecke bei normalem Betrachtungsabstand von etwa 30 cm für beide Augen des Betrachters innerhalb der Öffnung des zugehörigen optischen Elements liegen.

Gemäß einer vorteilhaften Erfindungsvariante schweben die Lichtflecken des Lichtfleckenbilds in mehreren verschiedenen Schwebehöhen oberhalb

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oder unterhalb des Flächenbereichs, um ein dreidimensionales Motiv zu bilden. Nach einer alternativen, ebenfalls vorteilhaften Erfindungsvariante schweben die Lichtflecken des Lichtfleckenbilds bereichsweise alle in derselben Schwebehöhe oberhalb oder unterhalb des Flächenbereichs, um ein Kulissenmotiv zu bilden. Mit Vorteil kann in dem Lichtfleckenbild auch ein dreidimensionales Motiv mit einem zweidimensionalen Motiv kombiniert sein, da dann auch bei schlechten Lichtverhältnissen noch ein Lichtfleckenbild erkennbar und damit eine Echtheitsprüfung möglich ist.

Die optischen Elemente umfassen zweckmäßig gewölbte Spiegel, insbesondere Hohlspiegel (konkav gewölbte Spiegel) oder Wölbspiegel (konvex gewölbte Spiegel). Die gewölbten Spiegel können sphärisch, elliptisch, rotationssymmetrisch asphärisch, nichtrotationssymmetrisch asphärisch oder rinnenförmig ausgebildet sein, wobei im letzteren Fall die Rinnen geradlinig oder krummlinig verlaufen können. Elliptische Spiegel weisen in x- und y-Richtung eine unterschiedliche Spiegelkrümmung auf, bei asphärischen Spiegeln weicht die Spiegelfläche von einer Kugelform ab. Asphärische Spiegel können rotationssymmetrisch oder im allgemeinsten Fall auch nichtrotationssymmetrisch sein. Gradlinige rinnenförmige Spiegel können als Sonderfall elliptischer Spiegel angesehen werden, bei denen der Krümmungsradius in einer Raumrichtung unendlich groß ist. Um eine geringe Strukturhöhe zu verwirklichen, können die gewölbten Spiegel auch zumindest teilweise durch Fresnelspiegel gebildet sein.

Alternativ oder zusätzlich können die optischen Elemente auch Linsen umfassen, insbesondere sphärische, elliptische, rotationssymmetrisch asphärische, nichtrotationssymmetrisch asphärische oder zylindrische Linsen. Elliptische Linsen weisen in x- und y-Richtung eine unterschiedliche Krümmung auf, bei asphärischen Linsen weicht die lichtbrechende Linsenfläche von ei-

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ner Kugelform ab. Asphärische Linsen können rotationssymmetrisch oder im allgemeinsten Fall auch nichtrotationssymmetrisch sein. Zylindrische Linsen können als Sonderfall elliptischer Linsen angesehen werden, bei denen der Krümmungsradius in einer Raumrichtung unendlich groß ist. Auch die Linsen können zumindest teilweise durch Fresnellinsen gebildet sein, um zu einer geringeren Strukturhöhe zu gelangen.

In einer vorteilhaften Erfindungsvariante ist jedem Lichtfleck des Lichtfleckenbilds genau ein optisches Element zugeordnet.

Nach einer alternativen, ebenfalls vorteilhaften Erfindungsvariante ist jedem Lichtfleck des Lichtfleckenbilds nicht nur ein optisches Element, sondern eine Mehrzahl von optischen Elementen zuordnet. Zuordnung bedeutet dabei, dass das optische Element bei Beleuchtung durch Spiegelung (Reflexion) und/oder Lichtbrechung (Refraktion) zur Erzeugung dieses Lichtflecks beiträgt. Die optischen Elemente sind bevorzugt beabstandet auf dem Flächenbereich verteilt. Durch die entstehenden Zwischenräume zwischen den einzelnen optischen Elementen können dann mehrere Gruppen von optischen Elementen, die jeweils verschiedenen Lichtflecken zugeordnet sind, im selben Flächenbereich ineinander verschachtelt angeordnet sein. Auf diese Weise kann eine besonders hohe räumliche Auflösung im Lichtfleckenbild erreicht werden, wie weiter unten genauer erläutert.

Als weiterer Vorteil der Zuordnung einer Mehrzahl von optischen Elementen zu einem Lichtfleck hat sich herausgestellt, dass aufgrund der dann möglichen geringeren Abmessungen der einzelnen optischen Elemente Elemente mit ebenen Begrenzungsflächen eingesetzt werden können, die einfacher zu berechnen und herzustellen sind als ein einziges gekrümmtes, optisches Element gleicher optischer Wirkung.

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Um ein Lichtfleckenbild zu erzeugen, in dem die Lichtflecken unterschiedliche Helligkeiten aufweisen, ist vorteilhaft jedem Lichtfleck des Lichtfleckenbilds eine solche Anzahl von optischen Elementen zugeordnet, die der Helligkeit des Lichtflecks innerhalb des von den Lichtflecken gebildeten Motivs entspricht. Sind die optischen Elemente unterschiedlich groß, kann auch jedem Lichtfleck eine solche Gesamtfläche von optischen Elementen zugeordnet werden, die der Helligkeit des Lichtflecks innerhalb des von den Lichtflecken gebildeten Motivs entspricht.

Besonders bevorzugt sind die optischen Elemente durch ebene Mikrospiegel oder durch kleine Mikroprismen gebildet.

Das vorbestimmte Motiv kann auch ein Wechselbild sein, das aus unterschiedlichen Betrachtungsrichtungen unterschiedliche Bilder zeigt. Ein konkretes Beispiel für die Erzeugung eines solchen Wechselbilds ist weiter unten beschrieben. Es versteht sich, dass der Begriff "Wechselbilder" auch solche Bilder umfasst, bei denen nur Bildteile dem Wechsel unterworfen sind.

Bei Wechselbildern ändern sich Bilder oder Bildpartien bei Änderung der Betrachtungsrichtung, insbesondere beim Kippen des Bildes; weswegen solche Bilder auch Kippbilder genannt werden. Der Wechsel kann beim waagrechten oder senkrechten Kippen erfolgen, oder beim Kippen in einer Richtung, die zwischen waagrecht und senkrecht liegt.

Wenn der Wechsel beim Bildinhalt abrupt erfolgt, spricht man von Flipbildern. Erfolgt der Wechsel über Zwischenstufen spricht man von Morphing-Bildern.

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Weiterhin können auch 2D-3D-Bilder als Lichtfleckenbild ausgebildet werden. Dabei hat man neben 3-dimensional wirkenden Partien (die vor oder hinter der Ebene des Darstellungselements zu sehen sind oder die Ebene des Darstellungselements zu durchdringen scheinen) auch 2-dimensional wirkende Partien in oder nahe der Ebene des Darstellungselements (in der Höhenstufe 0 oder nahe der Höhenstufe 0)

Bei einem 2D-3D-Bild können 2D-und 3D-Partien nebeneinander liegen und/oder bei Änderung der Betrachtungsrichtung wechselweise am gleichen Ort erscheinen. Bei einem solchen 2D-3D-Wechselbild kann z.B. ein zweidimensionaler Bildinhalt (z.B. eine Schrift oder ein Logo) richtungsabhängig in ein 3D-Bild ein- und ausgeblendet werden.

In einer vorteilhaften Erfindungsvariante ist das von der Darstellungsanordnung erzeugte vorbestimmte Motiv ein durch die Lichtflecken gebildeter vollplastischer Körper.

Gemäß einer Weiterbildung der Erfindung kann der Flächenbereich, in dem die Mehrzahl optischer Elemente angeordnet ist, auch gekrümmt sein, beispielsweise zylindrisch oder sphärisch gekrümmt.

Bei einer weiteren Erfindungsvariante erzeugt eine Teilmenge der optischen Elemente eine versteckte Bildinformation, die ohne Hilfsmittel nicht erkennbar ist. Die versteckte Bildinformation steht dabei im Gegensatz zu der durch das oben beschriebene Lichtfleckenbild gebildeten offenen Bildinformation, die bei normaler Beleuchtung ohne weitere Hilfsmittel mit bloßem Auge erkennbar ist. Die versteckte Bildinformation ist dagegen bei normaler Beleuchtung nicht ohne weiteres mit bloßem Auge erkennbar, sondern wird

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beispielsweise nur bei gerichteter Beleuchtung mit Laserlicht sichtbar oder benötigt einen besonderen Auffangschirm.

In einer vorteilhaften Variante der Erfindung umfassen die optischen Elemente eine periodische Anordnung von Mikrospiegeln, die jeweils einen Abstand zum nächsten Nachbarn von 2 mm oder weniger, insbesondere von 1 mm oder weniger aufweisen. Ein Betrachter erkennt dann nicht mehr die Spiegelbilder der Spiegel, sondern sieht pro Spiegel nur einen Lichtpunkt, dessen Form von der Ausleuchtung der Umgebung abhängt. Kippt der Betrachter das Darstellungselement, so wandern die Lichtpunkte der Spiegel etwas zur Seite, und zwar je nach Auslegung der Spiegel als Hohl- oder Wölbspiegel so, als ob die Lichtpunkte vor oder vorzugsweise hinter der Ebene des Darstellungselements liegen würden. Durch die periodische Anordnung der Mikrospiegel sieht der Betrachter somit ein regelmäßiges Gitter von Lichtpunkten, die sich beim Kippen des Darstellungselements vorzugsweise so zu bewegen scheinen, als würden sie sich in einer weiter hinten liegenden Ebene befinden. Das Lichtpunkt-Gitter kann daher den Hintergrund für ein weiteres Motiv bilden, beispielsweise für den in der ebenfalls anhängigen deutschen Patentanmeldung DE 10 2009 056 934.0 beschriebenen Wölbeffekt, oder für eine Sägezahndarstellung mit kinematischen Effekt, wie etwa die Hologrammstrukturen der Druckschrift EP 0 868 313 B1 (dortiger Absatz [0034] bzw. Fig. 8 mit reflektierenden Sägezahnstrukturen).

Um die optischen Elemente einerseits vor Verschmutzung und Abrieb zu schützen und um anderseits eine unbefugte Nachstellung durch Abprägen der Oberflächenstruktur wirksam zu verhindern, werden die optischen Elemente vorteilhaft in eine Umgebungsschicht oder einen Umgebungsschichtverbund, insbesondere in eine Schutzschicht eingebettet. Eine solche Einbettung verändert in der Regel die Schwebehöhe der Lichtflecken, da ein Bre-

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chungsindexunterschied zwischen Einbettungsmaterial und Luft bzw. Einbettungsmaterial und Linsenmaterial den optischen Strahlengang verändert. Eine solche Änderung des optischen Strahlengangs kann jedoch ohne weiteres bei der Auslegung der optischen Elemente entsprechend berücksichtigt werden, so dass nach der Einbettung die gewünschten Schwebehöhen verwirklicht werden.

In einer vorteilhaften Gestaltung sind die optischen Elemente als Prägestrukturen in einer Prägelackschicht ausgebildet. Ist das Darstellungselement zumindest teilweise reflektierend ausgebildet, so sind die Prägestrukturen vorzugsweise mit einer reflexionserhöhenden Beschichtung versehen. Als reflexionserhöhende Beschichtung kommt insbesondere eine vollflächige oder gerasterte Metallisierung, eine hochbrechende Beschichtung, ein Dünnschichtelement mit Farbkippeffekt oder eine cholesterische Flüssigkristallschicht in Betracht.

Die Strukturhöhen der Prägestrukturen liegen vorzugsweise unterhalb von 100 µm, bevorzugt unterhalb von 20 µm, besonders bevorzugt unterhalb von 5 µm.

Die erfindungsgemäßen Darstellungselemente können mit anderen Sicherheitsmerkmalen kombiniert werden, beispielsweise mit diffraktiven Strukturen, mit Hologrammstrukturen in allen Ausführungsvarianten, metallisiert oder nicht metallisiert, mit Subwellenlängenstrukturen, metallisiert oder nicht metallisiert, mit Subwellenlängengittern, mit Schichtsystemen, die beim Kippen einen Farbwechsel zeigen, semitransparent oder opak, mit diffraktiven optischen Elementen, mit refraktiven optischen Elementen, wie etwa Prismenstrahlformern, mit speziellen Lochformen, mit Sicherheitsmerkmalen mit gezielt eingestellter elektrischer Leitfähigkeit, mit eingearbei-

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teten Stoffen mit magnetischer Codierung, mit Stoffen mit phosphoreszierender, fluoreszierender oder lumineszierender Wirkung, mit Sicherheitsmerkmalen auf Grundlage von Flüssigkristallen, mit Mattstrukturen, mit zusätzlichen Mikrospiegelelementen, mit Elementen mit Jalousie-Effekt oder mit Sägezahnstrukturen. Weitere Sicherheitsmerkmale, mit denen die erfindungsgemäßen Darstellungselemente kombiniert werden können, sind in der Druckschrift WO 2005/052650 A2 auf Seiten 71 bis 73 angegeben; diese werden insoweit in die vorliegende Beschreibung aufgenommen.

Die Erfindung enthält auch ein Verfahren zum Herstellen eines refraktiven Darstellungselements der beschriebenen Art, welches ausgelegt und bestimmt ist, bei Beleuchtung ein Lichtfleckenbild aus einer Mehrzahl von Lichtflecken zu erzeugen, die für einen Betrachter oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind. Bei dem Verfahren wird ein Substrat bereitgestellt und wird in einem Flächenbereich des Substrats eine Mehrzahl refraktiver und/oder reflektiver optischer Elemente angeordnet, wobei jedem Lichtfleck des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element zugeordnet wird, welches bei Beleuchtung des Darstellungselements zur Erzeugung des ihm zugeordneten Lichtflecks beiträgt.

Gemäß einer vorteilhaften Verfahrensvariante wird

- ein gewünschtes dreidimensionales Motiv mit Bildpunkten Pj und Höhenwerten Zj über einer xy-Ebene vorgegeben, wobei die Bildpunkte den bei Beleuchtung entstehenden Lichtflecken entsprechen,
- wird für jeden Bildpunkt P_j eine Helligkeit I_j zwischen 0% und 100% festgelegt,

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- werden den Bildpunkten P_j Öffnungskegel zugeordnet, die ein Öffnungsverhältnis > 0,2 aufweisen,
- wird für jeden Bildpunkt Pj durch einen Schnitt des von dem Bildpunkt ausgehenden Öffnungskegels mit der xy-Ebene ein Einzugsbereich Ej bestimmt,
- wird die xy-Ebene in eine Anzahl von Grobfeldern und die Grobfelder jeweils in eine Anzahl von Feinfeldern aufgeteilt,
- werden für jeden Bildpunkt P_j auf Grundlage des festgelegten Höhenwerts Z_j und des festgelegten Helligkeitswerts I_j eine Anzahl an zu füllenden Feinfeldern bestimmt,
- werden die für den Bildpunkt P_j bestimmten, zu füllenden Feinfelder im Wesentlichen gleichmäßig auf die Grobfelder im Einzugsbereich E_j des Bildpunkts P_j verteilt, und
- werden die zu füllenden Feinfelder mit refraktiven und/oder reflektiven optischen Elementen belegt, die bei Beleuchtung des Darstellungselements zur Erzeugung des dem Bildpunkt P_j entsprechenden Lichtflecks beitragen.

Gemäß einer weiteren vorteilhaften Verfahrensvariante wird ein vollplastischer Körper durch schwebende Lichtpunkte dargestellt. Dabei wird vorzugsweise von einen Datensatz ausgegangen, der die Oberfläche des darzustellenden Körpers durch Punkte im Raum, Eckpunkte von Polygonen, Normalenvektoren und Absorptionsverhalten (Farbe, Helligkeit) beschreibt.

Solche Datensätze, geeignete Datenformate und Bearbeitungsverfahren sind dem Fachmann grundsätzlich bekannt, Beispiele sind etwa VRML (Virtual Reality Modeling Language), STL (Surface Tesselation Language; Standard Triangulation Language) oder 3D-CAD (3D- Computer Aided Design).

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Datensätze, die die Oberfläche eines Körpers beschreiben, können beispielsweise beim computerunterstützten technischen Zeichnen erzeugt werden oder durch 3D-Laser-Scanning echter dreidimensionaler Körper. Bei letzterem Verfahren werden beim Abtasten eines Körpers mit Laserstrahlen Punkte im Raum erfasst, die den Körper beschreiben. Diese Punkte können beispielsweise im sogenannten Point-Cloud-Format im Computer gespeichert werden.

Um ein 3D-Lchtflecken-Bild eines vollplastischen Körpers zu erzeugen, muss ein solcher Datensatz bearbeitet werden, wie im Folgenden anhand der Schritte a) bis c) beispielhaft beschrieben:

a) Beleuchtungskonzeption

Um die Körperoberfläche sichtbar zu machen sind Hell-Dunkel-Kontraste erforderlich. Am natürlichsten wirkt ein Körper, wenn man diese Hell-Dunkel-Kontraste mittels einer Beleuchtungskonzeption erzeugt. Dazu denkt man sich eine oder mehrere Lichtquellen außerhalb des Körpers angebracht und ermittelt mittels des Lambertschen Cosinus-Gesetzes, des Reflexions-Gesetzes oder anderer geeigneter physikalischer Gesetze aus den Richtungen der fiktiven Lichtquellen, der Oberflächennormalen und dem Absorptionsverhalten die Oberflächenhelligkeit an allen relevanten Punkten des Körpers.

b) Lichtpunkterzeugung

Wie weiter oben beschrieben werden jedem relevanten Körperpunkt Einzugsbereiche in einer Anordnung von Mikrospiegeln oder Mikroprismen zugeordnet. Innerhalb des Einzugsbereichs werden gewisse Flächenbereiche mit Mikrospiegeln oder Mikroprismen in der oben beschriebenen Weise so belegt, dass der Körperpunkt in der gewünschten Helligkeit leuchtet.

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c) Verdeckungsberechnung

Schließlich hat ein vollplastischer Körper aus einer Betrachtungsrichtung gesehen eine Vorder- und eine Rückseite, so dass manche Körperpartien verdeckt und unsichtbar sind. Daher ist für jedes Mikroelement (bzw. Mikrospiegel oder Mikroprisma) darauf zu achten, dass es nur dem Punkt der Körperoberfläche zugeordnet wird, der ihm auf der Verbindungsgeraden Mikroelement-Körperpunkt am nächsten oder entferntest liegt, je nachdem von welcher Seite das Lichtfleckenbild betrachtet werden soll. Diesen Punkt der Körperoberfläche bestimmt man durch Verfahren der Verdeckungsberechnung, wie sie aus 3D-CAD an sich bekannt sind, wie etwa Ray-Tracing oder Z-Buffer-Verfahren. Bezieht man auch eigentlich verdeckte Punkte in das Lichtfleckenbild ein, so erscheint der Körper durchsichtig, was in Ausnahmefällen allerdings ebenfalls gewünscht sein kann.

Die Erfindung enthält schließlich auch einen Datenträger mit einem Darstellungselement der beschriebenen Art, wobei das Darstellungselement insbesondere als ein reflektierendes Sicherheitselement in einem opaken Bereich des Datenträgers, oder als zumindest teilweise durchsichtiges Sicherheitselement in oder über einem transparenten Fensterbereich oder einer durchgehenden Öffnung des Datenträgers angeordnet sein kann. Bei dem Datenträger kann es sich insbesondere um ein Wertdokument, wie eine Banknote, insbesondere eine Papierbanknote, eine Polymerbanknote oder eine Folienverbundbanknote handeln, aber auch um eine Ausweiskarte, wie etwa eine Kreditkarte, eine Bankkarte, eine Barzahlungskarte, eine Berechtigungskarte, einen Personalausweis oder eine Passpersonalisierungsseite handeln.

Die Erfindung enthält weiter eine Anzeigeeinrichtung mit einer Steuereinrichtung und einem Darstellungselement der oben beschriebenen Art, wobei

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die räumliche Ausrichtung der optischen Elemente des Darstellungselements durch die Steuereinrichtung einstellbar ist. Auf diese Weise kann das Darstellungselement je nach Ansteuerung unterschiedliche Lichtfleckenbilder zeigen. Die Änderung der räumlichen Ausrichtung der optischen Elemente kann dabei sehr rasch erfolgen, so dass für den Betrachter der Eindruck einer fortlaufenden Bildfolge entsteht. Die Anzeigeeinrichtung kann somit als 3D-Display für unterschiedlichste Anwendungen eingesetzt werden.

Schließlich enthält die Erfindung ein Verfahren zum Herstellen eines Volumenhologramms, bei dem in einer Aufzeichnungsplatte, beispielsweise einer Photopolymerplatte, als Referenzwelle ungestreute Laserstrahlung und als Objektwelle die von einem Darstellungselement der oben beschriebenen Art reflektierte oder abgelenkte Laserstrahlung zur Interferenz gebracht werden. Dabei wird bei Darstellungselementen mit reflektiven optischen Elementen, wie etwa Mikrospiegeln, die reflektierte Laserstrahlung als Objektwelle genutzt, während bei Darstellungselementen mit refraktiven optischen Elementen, wie etwa Mikroprismen, die abgelenkte Laserstrahlung als Objektwelle genutzt wird.

Weitere Ausführungsbeispiele sowie Vorteile der Erfindung werden nachfolgend anhand der Figuren erläutert, bei deren Darstellung auf eine maßstabs- und proportionsgetreue Wiedergabe verzichtet wurde, um die Anschaulichkeit zu erhöhen.

Es zeigen:

Fig. 1 eine schematische Darstellung einer Banknote mit einem erfindungsgemäßen Sicherheitselement,

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Fig. 2 schematisch ein erster Ausführungsbeispiel der Erfindung mit Hohlspiegeln als reflektive optische Elemente,

Fig. 3 ein anderes Ausführungsbeispiel der Erfindung mit Wölbspiegeln als reflektive optische Elemente,

Fig. 4 ein vorgegebenes Lichtflecken-Motiv in Form einer dreidimensionalen Lichtpyramide,

Fig. 5 in (a) einen Wölbspiegel und in (b) der durch einen Fresnel-Spiegel ersetzte Wölbspiegel von (a),

Fig. 6 eine Aufsicht auf eine Mehrzahl von gewölbten Spiegeln, in (a) mit Spiegeln mit quadratischer Grundfläche und in (b) mit rinnenförmig ausgebildeten Spiegeln verschiedener Orientierung,

Fig. 7 ein weiteres Ausführungsbeispiel der Erfindung, bei dem die refraktiven optischen Elemente durch Linsen gebildet sind,

Fig. 8 in (a) bis (d) vier Ausführungsbeispiele, bei denen ein gekrümmter Hohlspiegel in Mikrooptikelemente mit quadratischer Grundfläche und ebener Spiegelfläche zerlegt ist,

Fig. 9 die Belegung einer schachbrettartigen Anordnung nach Fig. 8(b) mit Mikrospiegeln, wobei (a) einen Zwischenschritt mit nur einer Mikrospiegelgruppe und (b) die vollständige Bele-

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gung mit zwei Mikrospiegelgruppen für zwei nahe benachbarte Lichtflecken zeigt,

Fig. 10 veranschaulicht die Berechnung der ebenen Spiegelflächen der Mikrospiegel der Figuren 8 und 9,

Fig. 11 veranschaulicht die Berechnung von Mikroprismen, die bei der Zerlegung einer Sammellinse entstehen,

Fig. 12 zeigt schematisch ein Sicherheitselement mit eingebetteten Mikrospiegeln, und

Fig. 13 zeigt in (a) bis (c) drei Ausgestaltungen, in denen ein erfindungsgemäßes Lichtfleckenbild als Master für ein Volumenhologramm dient.

Die Erfindung wird nun am Beispiel von Sicherheitselementen für Banknoten erläutert. Figur 1 zeigt dazu eine schematische Darstellung einer Banknote 10, die mit einem erfindungsgemäßen Sicherheitselement 12 versehen ist. Das Sicherheitselement 12 kann als reflektierendes Sicherheitselement ausgebildet sein, das in einem opaken Bereich der Banknote 10 vorliegt, oder kann als Durchsichtssicherheitselement ausgebildet sein, das beispielsweise über einem transparenten Fensterbereich der Banknoten 10 angeordnet ist.

Bei Beleuchtung, beispielsweise durch Sonnenlicht oder eine Deckenlampe, erzeugt das Sicherheitselement 12 für einen Betrachter ein dreidimensionales Lichtfleckenbild aus einer Mehrzahl von Lichtflecken, die für einen Betrachter jeweils oberhalb oder unterhalb der Ebene des Sicherheitselements 12 zu schweben scheinen. Verschiedene Lichtflecken weisen dabei unterschiedli-

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che Schwebehöhen auf, so dass die Lichtflecken zusammen ein dreidimensionales Motiv, beispielsweise eine aus der Banknote herausragende Lichtpyramide, bilden.

Diese durch die Beleuchtung entstehenden und aus der Banknote vor- oder zurückspringenden Lichtfleckenbilder bieten dem Betrachter einen ungewöhnlichen, visuell ansprechenden dreidimensionalen Bildeindruck, der auch für Laien leicht zu prüfen und zu memorieren ist.

Zur Erläuterung des Erfindungsprinzips zeigt Fig. 2 ein erstes Ausführungsbeispiel eines Sicherheitselements 20, bei dem das dreidimensionale Motiv 30 vereinfacht durch drei Bildpunkte 32 dargestellt ist. Das Sicherheitselement 20 enthält ein Substrat 22, das in einem Flächenbereich eine Mehrzahl von kleinen Hohlspiegeln 24 enthält. Da in der Figur vereinfacht nur drei Bildpunkte 32 des Motivs dargestellt sind, sind entsprechend auch nur drei Hohlspiegel 24 gezeigt. Es versteht sich jedoch, dass ein Sicherheitselement 20 in der Praxis typischerweise eine große Zahl, beispielsweise einige Zehn, einige Hundert oder sogar mehrere Tausend refraktiver und/oder reflektiver optischer Elemente 24 aufweisen wird. Konkrete Beispiele für Sicherheitselemente mit einer großen Zahl an optischen Elementen sind weiter unten beschrieben.

Zurückkommend auf die Darstellung der Fig. 2 ist die Brennweite f der in der Ebene des Substrats 22 angeordneten Hohlspiegel 24 jeweils so gewählt, dass die Hohlspiegel 24 bei Beleuchtung mit einer weit entfernten Lichtquelle 34 die vorgegebenen Bildpunkte als Lichtflecken 32 erzeugen. Genauer gesagt stellen die Lichtflecken 32 reelle Bilder der Lichtquelle dar, wie im linken Bildteil der Fig. 2 durch den geometrischen Strahlengang 36 angedeutet.

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Ein dreidimensionaler Bildeindruck, also die Wahrnehmung des Betrachters 40, dass die Lichtflecken 32 in einer bestimmten Höhe über der Fläche des Substrats 22 schweben, entsteht erst durch beidäugiges Sehen. Dazu muss durch die Auslegung der Hohlspiegelanordnung sichergestellt sein, dass die reellen Bilder 32 der Lichtquelle 34 jeweils für beide Augen 42 innerhalb der Öffnung des maßgeblichen optischen Systems, hier also eines Holspiegels 24, liegen.

Wie im rechten Bildteil von Fig. 2 illustriert, liegt ein Lichtfleck 32 genau dann für beide Augen 42 innerhalb der Öffnung des Hohlspiegels 24, wenn vom Lichtfleck 32 aus gesehen der Öffnungswinkel ω des Hohlspiegels 24 größer ist als der Betrachtungswinkel α des Betrachters 40. Der Öffnungswinkel ω ist dabei durch das Verhältnis von Spiegeldurchmesser d und Brennweite f gegeben, $\omega = d/f$ und der Betrachtungswinkel α durch das Verhältnis von Augenabstand a und Betrachtungsabstand b, also $\alpha = a/b$. Für einen typischen Augenabstand $a \approx 6{,}5$ cm und einen typischen Betrachtungsabstand $b \approx 30$ cm erhält man so die Bedingung

$$f/d < b/a \approx 5,$$

also die Bedingung, dass das Verhältnis der Schwebehöhe f eines Lichtflecks 32 zum Durchmesser des den Lichtfleck erzeugenden Hohlspiegels 24 kleiner als etwa 5 sein muss. Beträgt der Durchmesser der Hohlspiegel 24, wie im Ausführungsbeispiel der Fig. 2, beispielsweise d = 0,5 mm, so lassen sich Schwebehöhen bis zu 2,5 mm mit dreidimensionalem Bildeindruck realisieren.

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Die refraktiven und/oder reflektiven optischen Elemente können Abmessungen von einigen 100 µm oder sogar einigen Millimeter aufweisen, können aber auch deutlich kleiner ausgebildet sein. Beispielsweise kann ein Hohlspiegel in eine Vielzahl von Mikrospiegeln zerlegt und diese über einen bestimmten Flächenbereich des Substrats 22 verteilt sein, wie weiter unten näher erläutert. In jedem Fall liegt die Abmessung eines erfindungsgemäß eingesetzten optischen Elements jedoch deutlich oberhalb der Lichtwellenlänge, so dass Beugungs- und Interferenzeffekte vernachlässigt werden können. Insbesondere liegt die Abmessung der optischen Elemente daher vorteilhaft oberhalb von 2 µm, vorzugsweise sogar oberhalb von 5 µm.

Die Lichtflecken 32 des vorgegeben Motivs 30 können für den Betrachter 40 nicht nur oberhalb, sondern auch unterhalb der Oberfläche 22 des Substrats schweben. Mit Bezug auf Fig. 3 sind dazu in einem Flächenbereich des Substrats 22 eine Mehrzahl kleiner Wölbspiegel 26 angeordnet, deren Brennweiten so gewählt sind, dass die Wölbspiegel 26 bei Beleuchtung mit einer weit entfernten Lichtquelle 34 die vorgegebenen Bildpunkte als Lichtflecken 32 erzeugen. Genauer gesagt stellen die Lichtflecken 32 in diesem Fall virtuelle Bilder der Lichtquelle 34 dar, die für den Betrachter unterhalb der Oberfläche des Substrats zu schweben scheinen, wie im rechten Bildteil der Fig. 3 durch den geometrischen Strahlengang 38 angedeutet.

Hohl- und Wölbspiegel können auch beide im selben Sicherheitselement vorgesehen sein, wenn Teile des Motivs vorspringen, andere Teile hinter die Substratoberfläche zurücktreten sollen. Zur Illustration zeigt Fig. 4 ein vorgegebenes Motiv in Form einer dreidimensionalen Lichtpyramide 50 aus einer Mehrzahl von Lichtflecken 52, die in verschiedenen Schwebehöhen über bzw. unterhalb der Oberfläche des Substrats 22 schweben.

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Im Ausführungsbeispiel der Fig. 4 sind alle gewölbten Spiegel mit einem Durchmesser von 0,5 mm ausgeführt. Die Brennweite f wird bei Hohlspiegeln positiv angegeben (Schwebehöhe über der Substratoberfläche), bei Wölbspiegeln negativ (Schwebehöhe unter der Substratoberfläche). Mit dieser Konvention weist der Lichtfleck 52-1 der Pyramidespitze eine Schwebehöhe von f = + 2 mm auf, während die Lichtflecke 52-2 und 52-3 der Pyramidenkanten in einer Höhe f = + 1,2 mm bzw. f = + 0,4 mm schweben. Die Lichtflecke 52-1 bis 52-3 mit ihren positiven Schwebehöhen werden durch Hohlspiegel erzeugt, wie grundsätzlich bereits bei Fig. 2 erläutert.

In der Pyramide 50 weiter nach außen gehend weisen die Lichtflecken 52-4 und 52-5 eine Schwebehöhe von f = - 0,4 mm bzw. f = - 1,2 mm auf, schweben für den Betrachter also unterhalb der Substratoberfläche 22. Die Pyramidenbasis ist schließlich aus Lichtflecken 52-6 gebildet, die eine Schwebehöhe von f = - 2 mm aufweisen und damit 4 mm unterhalb der Pyramidenspitze 52-1 liegen.

Für alle Lichtflecken 52 ist die Bedingung $|f|/d < 5$ erfüllt, so dass die Pyramide 50 für den Betrachter bei normalem Betrachtungsabstand echt dreidimensional erscheint und die Substratebene von unten nach oben zu durchstoßen scheint.

Die Schwebehöhe der Lichtflecken wird durch den Krümmungsradius der gewölbten Spiegel bestimmt, wie in Fig. 5(a) beispielhaft für einen Wölbspiegel 60 gezeigt. Bei einem Durchmesser d und einem Krümmungsradius r hat der Wölbspiegel 60 eine Brennweite von $f = r/2$. Beispielsweise ist bei einem Spiegeldurchmesser d = 0,5 mm für eine Brennweite bzw. Schwebehöhe von f = 2 mm ein Krümmungsradius von r = 4 mm erforderlich. Die

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Strukturhöhe des Wölbspiegels ergibt sich in diesem Fall über die Beziehung $h*(2r-h) = (d/2)^2$ zu $h = 7{,}8$ µm.

Je nach gewünschter Schwebehöhe können dabei Spiegelstrukturen entstehen, deren Höhe h für eine gewünschte Anwendung zu groß ist, beispielsweise weil eine maximal zulässige Prägehöhe oder Prägetiefe in einer geprägten Schicht überschritten wird. In diesem Fall kann der Wölbspiegel 60 der Fig. 5(a) durch einen entsprechenden Fresnel-Spiegel 62 ersetzt werden, der eine wesentlich geringere Strukturhöhe h_f aufweist, wie in Fig. 5(b) gezeigt. Die Zonenbreiten z der Fresnel-Zonen 64 können dabei beliebig gewählt werden, solange sie groß gegen die Lichtwellenlänge sind, insbesondere solange $z > 2$ µm ist. Ansonsten spielt die Breite z der Fresnel-Zonen 64 für die optische Wirksamkeit des Fresnel-Spiegels 62 keine Rolle.

Haben die gewölbten Spiegel eines Sicherheitselements mehrere verschiedene Brennweiten, weisen die Lichtflecken des Lichtfleckenbilds also mehrere verschiedene Schwebehöhen oberhalb und/oder unterhalb der Substratoberfläche auf, so entsteht ein echt dreidimensionales Motiv. In manchen Gestaltungen kann es sich jedoch auch anbieten, alle gewölbten Spiegel mit derselben Brennweite auszubilden, so dass alle Lichtflecken des Lichtfleckenbilds dieselbe Schwebehöhe aufweisen. Auf diese Weise entstehe ein Kulissenmotiv, das in einer bestimmten Höhe oberhalb oder unterhalb der Substratoberfläche schwebt.

Die gewölbten Spiegel müssen nicht sphärisch gekrümmt sein. Als erfindungsgemäße optische Elemente können beispielsweise auch elliptische Hohl- oder Wölbspiegel eingesetzt werden, die in x- und y-Richtung eine unterschiedliche Spiegelkrümmung aufweisen. Da die Brennweite f eines gewölbten Spiegels nach dem oben Gesagten proportional zum Krüm-

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mungsradius r ist, verändert sich beim Drehen eines elliptisch gewölbten Spiegels die Schwebehöhe f des zugehörigen Lichtflecks für den Betrachter.

Enthält ein vorgegebenes Motiv zumindest teilweise elliptische Hohl- oder Wölbspiegel, so erheben sich die Lichtflecken in den Brennebenen der jeweiligen Partien beim Drehen der Anordnung vor dem Hintergrund bzw. senken sich in den Hintergrund ab. Dieser Effekt tritt besonders auffällig hervor, wenn die beim Drehen aufsteigenden bzw. absinkenden Lichtflecken mit sich bei Drehen nicht verändernden Lichtflecken kombiniert werden, die für das Auge einen ruhenden Bezugspunkt darstellen.

Mit Bezug auf die Aufsicht der Fig. 6(a) kann die Mehrzahl an gewölbten Spiegeln 70 beispielsweise mit rechteckiger oder quadratischer Grundfläche in einem Flächenbereich 72 des Sicherheitselements angeordnet sein.

Für einen dreidimensionalen Bildeindruck für einen Betrachter genügt bereits eine seitliche Parallaxe, also eine Parallaxe entlang der Verbindungslinie der beiden Augen 42 des Betrachters 40. Die gewölbten Spiegel 74, 76, 78 können daher auch rinnenförmig ausgebildet sein, wie der Aufsicht der Fig. 6(b) gezeigt. Rinnenförmige gewölbte Spiegel weisen nur in einer Richtung, nämlich senkrecht zur Rinne, eine von Null verschiedene Krümmung auf, während die Krümmung in Rinnenrichtung verschwindet.

Mit einem aus rinnenförmigen gewölbten Spiegeln 74, 76, 78 aufgebauten Bild lassen sich ebenfalls attraktive visuelle Effekte verwirklichen. Die Lichtflecke erscheinen dabei bei geeignetem Betrachtungswinkel über oder unter der Substratoberfläche schwebend in Form von in der Luft hängenden leuchtenden Strichen.

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Wegen der nebeneinander liegenden Augen ergibt sich bei einem 3D-Rinnenbild bei senkrecht zur Verbindungslinie der Augen 42 verlaufenden Rinnen 74 die stärkste räumliche Wirkung. Jedoch haben auch schräg verlaufende Rinnen 76 einen senkrechten Anteil und erzeugen damit ebenfalls ein Lichtfleckenbild mit dreidimensionaler Wirkung.

Wenn man ein Bild mit schräg in der Bildebene liegenden Rinnen 76 so dreht (80), dass die Rinnen senkrecht stehen, verstärkt sich die dreidimensionale Wirkung. Dreht der Betrachter die Rinnen 76 dagegen in die Waagrechte, so reduziert sich der dreidimensionale Eindruck. Bei einem Sicherheitselement, das wie in Fig. 6(b) gezeigt, Teilbereiche mit verschiedener Orientierung der Rinnen 74, 76, 78 enthält, erheben sich die Lichtflecken der jeweiligen Teilbereiche beim Drehen (80) der Anordnung vor dem Hintergrund bzw. senken sich in den Hintergrund ab.

Unter rinnenförmigen gewölbten Spiegeln sind dabei sowohl rinnenförmige Hohlspiegel als auch rinnenförmige Wölbspiegel zu verstehen. Rinnenförmige Hohlspiegel erzeugen Lichtflecke, die über der Substratoberfläche schweben, während rinnenförmige Wölbspiegel Lichtflecke erzeugen, die unterhalb der Substratoberfläche schweben.

Weiter müssen die rinnenförmigen gewölbten Spiegel nicht gradlinig verlaufen, wie in Fig. 6(b) gezeigt, sondern sie können auch krummlinig angelegt sein. Auch durch eine solche Gestaltung lassen sich attraktive visuelle Effekte verwirklichen.

Bei einer weiteren, in Fig. 7 illustrierten Erfindungsvariante sind die optischen Elemente anstelle von reflektierenden Spiegeln durch lichtbrechende (refraktive) Linsen gebildet. Das refraktive Sicherheitselement 90 stellt in

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diesem Fall ein Durchsichtssicherheitselement dar, das vom Betrachter 40 in Durchsicht gegen eine idealerweise weit entfernte Lichtquelle 95 auf Echtheit geprüft wird.

Als Linsen kommen sowohl Sammellinsen 92 als auch Zerstreuungslinsen 96 in Betracht, wobei, vom Betrachter 40 aus gesehen, die konvexen Sammellinsen 92 als reelle Bilder über dem Sicherheitselement 90 schwebende Lichtflecken 94 erzeugen, und die konkaven Zerstreuungslinsen 96 als virtuelle Bilder unterhalb des Sicherheitselements 90 schwebende Lichtflecken 98 erzeugen.

Die Linsen können insbesondere sphärisch, elliptisch oder zylindrisch sein. Zylinderlinsen ergeben strichartige Lichtflecke, bei elliptischen Linsen ändert sich die Schwebehöhe der Lichtflecken beim Drehen des Sicherheitselements, wie oben für elliptische Spiegel bereits beschrieben. Für die in Fig. 7 dargestellten plankonvexen bzw. plankonkaven Linsen 92, 96 gilt für den Durchmesser d, den Krümmungsradius r, die Brennweite f und die Linsenhöhe h bei einem Brechungsindex des Linsenmaterials von n = 1,5 für an Luft grenzende Linsen:

$$f = 2*r \text{ und}$$

$$h*(2r-h) = (d/2)^2$$

Bei gegebenem Linsendurchmesser d und gegebener gewünschter Schwebehöhe f können damit der Krümmungsradius r und Strukturhöhe h der Linse bestimmt werden. Ist die Strukturhöhe einer Linse für eine gewünschte Anwendung zu groß, können die Linsen auch durch entsprechende Fresnellinsen ersetzt werden, wie im Zusammenhang mit Fig. 5 für Fresnel-Spiegel beschrieben. Auch hier ist darauf zu achten, dass die Zonenbreiten der Fres-

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nel-Zonen groß gegen die Lichtwellenlänge sind, ansonsten aber beliebig gewählt werden können.

Bei den bisher beschriebenen Ausführungsbeispielen ist jedem Lichtfleck des Lichtfleckenbilds genau ein optisches Element zugeordnet, das bei Beleuchtung diesen Lichtfleck erzeugt, nämlich ein Hohlspiegel 24 (Fig. 2), ein Wölbspiegel 26 (Fig. 3), eine Sammellinse 92 oder eine Zerstreuungslinse 96 (Fig. 7). Die im Lichtfleckenbild erreichbare Auflösung, also der minimale Abstand zweier Lichtflecken im Lichtfleckenbild, ist bei einer solchen Gestaltung jedoch auf den Durchmesser d der gewölbten Spiegel oder Linsen beschränkt. Dieser Durchmesser ist wiederum über die oben genannte Bedingung für einen dreidimensionalen Bildeindruck $f/d < 5$ an die Schwebehöhe der Lichtflecken gekoppelt. Eine hohe Auflösung im Lichtfleckenbild ist somit nur für geringe Schwebehöhen und damit einer geringen dreidimensionalen Wirkung erreichbar.

Um dennoch eine höhere Auflösung im erzeugten Lichtfleckenbild bei unverändert großer Schwebehöhe zu erhalten, werden die in den bisherigen Ausführungsbeispielen verwendeten großen Spiegel oder Linsen jeweils durch eine Mehrzahl von kleineren Mikrospiegeln oder Mikroprismen ersetzt, die zusammen im Wesentlichen dieselbe optische Wirkung wie das ursprüngliche optische Element haben. Der einfacheren Benennung halber werden Mikrospiegel und Mikroprismen nachfolgend gemeinsam als Mikrooptikelemente bezeichnet.

Jedem Lichtfleck des Lichtfleckenbilds ist dann eine Mehrzahl von optischen Elementen in Form von Mikrooptikelementen zuordnet. Die höhere Auflösung im Lichtfleckenbild wird dabei dadurch erreicht, dass die Mikrooptikelemente nicht lückenlos nebeneinander, sondern im Abstand auf dem Flä-

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chenbereich verteilt werden. Die Zwischenräume der optischen Elemente eines Lichtflecks können dann mit optischen Elementen belegt werden, die anderen Lichtflecken zugeordnet sind. Auf diese Weise können mehrere Gruppen von Mikrooptikelementen, die jeweils verschiedenen Lichtflecken zugeordnet sind, im selben Flächenbereich ineinander verschachtelt angeordnet werden.

Der minimale Abstand zweier Lichtflecken im Lichtfleckenbild ist dann nicht mehr durch die Abmessung der ursprünglichen großen Spiegel oder Linsen gegeben, sondern durch die viel kleineren Abmessungen der Mikrooptikelemente, in die die ursprünglichen Spiegel oder Linsen zerlegt sind.

Zudem können bei der Zerlegung eines gewölbten Spiegels oder einer gekrümmten Linse in eine Mehrzahl von Mikrooptikelemente die im Prinzip zunächst ebenfalls gekrümmten Oberflächen der Mikrooptikelemente wegen ihrer geringen Größe in der Regel durch ebene Flächen ersetzt werden. Diese Ersetzung bleibt insbesondere wenn die Abmessungen der Mikrooptikelemente kleiner als das Auflösungsvermögen der Betrachtungssituation sind, ohne nachteilige Auswirkungen auf das erzeugte Lichtfleckbild. Als Vorteil ergibt sich, dass Mikrooptikelemente mit ebenen Oberflächen einfacher zu berechnen und herzustellen sind. Unter diesem Gesichtspunkt kann es sich sogar dann empfehlen, gewölbte Spiegel oder Linsen in kleine Mikrooptikelemente mit ebenen Oberflächen zu zerlegen, wenn keine Verschachtelung mehrerer Gruppen von Mikrooptikelementen gewünscht oder notwendig ist.

Zur Illustration zeigt Fig. 8 in (a) bis (d) vier Ausführungsbeispiele, bei denen ein gekrümmter Hohlspiegel in Mikrooptikelemente 100 mit quadratischer Grundfläche und ebener Spiegelfläche zerlegt ist. Bei dem Ausführungsbeispiel der Fig. 8(a) ist ein Hohlspiegel zur Erzeugung eines Licht-

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flecks durch eine Anordnung aus n x n Mikrospiegeln 100 ersetzt, die ohne Abstand in der Fläche des Sicherheitselements nebeneinander angeordnet sind. Die Mikrospiegeln 100 weisen beispielsweise eine Abmessung von 50 µm x 50 µm auf und können mit ebener Spiegelfläche ausgebildet werden, ohne die Abbildungsqualität zu beeinträchtigen. Die Anzahl n x n der Mikrospiegel beträgt beispielsweise 10 x 10, so dass die Mikrospiegel eine Gesamtfläche von 0,5 mm x 0,5 mm einnehmen. Die Berechnung der Orientierung der ebenen Spiegelflächen ist weiter unten mit Bezug auf Fig. 10 erläutert. Wie für den Fachmann ersichtlich, ist die Berechnung und Herstellung der ebenen Mikrospiegel 100 wesentlich einfacher als die Berechnung und Herstellung eines gekrümmten Hohlspiegels gleicher optischer Wirkung.

Das Ausführungsbeispiel der Fig. 8(b) zeigt eine Gestaltung, bei der ein gekrümmter Hohlspiegel zunächst wie bei Fig. 8(a) durch eine Mehrzahl von Mikrospiegeln 102 mit ebener Spiegelfläche ersetzt ist. Die Mikrospiegel 102 sind allerdings schachbrettartig im Flächenbereich des Sicherheitselements angeordnet, so dass jede zweite Spiegelposition frei bleibt. Diese zunächst unbelegten und in der Figur weiß dargestellten Felder 104 können dann mit Mikrospiegeln belegt werden, die einem anderen Lichtfleck zugeordnet sind.

Die Auflösung des Lichtfleckenbilds kann durch eine solche Verschachtelung von Mikrospiegel-Gruppen deutlich erhöht werden: Sollen beispielsweise zwei Lichtflecken, die in 5 mm Höhe schweben, nur 0,2 mm nebeneinander liegen, so werden dazu gewölbte Spiegel oder Linsen mit einer Brennweite f = 5 mm benötigt. Wie oben beschrieben, müssen der Durchmesser und die Brennweite der optischen Elemente für eine dreidimensionale Wirkung der Bedingung $f/d < 5$ genügen, woraus sich bei den gemachten Vorgaben ein Optikdurchmesser $d > 1$ mm ergibt. Nebeneinander liegende gewölbte Spiegel oder Linsen müssten also mehr als 1 mm beabstandet sein,

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so dass sich die geforderte Auflösung von 0,2 mm auf diese Weise nicht erreichen lässt.

Wird dagegen eine Zerlegung wie in Fig. 8(b) verwendet, bei der nur jedes zweite Feld mit 50 µm x 50 µm großen Mikrospiegeln 102 zur Erzeugung des ersten Lichtflecks genutzt wird, können die dazwischen liegenden Felder 104 mit Mikrospiegeln belegt werden, die einen zweiten, 0,2 mm daneben liegenden Lichtfleck erzeugen. Die Bedingung $f/d < 5$ fordert einen Optikdurchmesser von mehr als 1 mm, was beispielsweise durch eine schachbrettartige Anordnung von 12 x 12 Mikrospiegeln 102 mit 12 x 12 freien Feldern 104 und damit $d = 2*12*50\ \mu m = 1{,}2$ mm erreicht werden kann. Der minimale Abstand des von der Mikrospiegelgruppe 102 erzeugten Lichtflecks und des zweiten Lichtflecks, der von den in den Feldern 104 angeordneten Mikrospiegeln erzeugt wird, beträgt nunmehr 50 µm, so dass die geforderte Auflösung von 0,2 mm ohne weiteres erreicht werden kann.

Die Belegung einer schachbrettartigen Anordnung nach Fig. 8(b) mit Mikrospiegeln ist in Fig. 9 in einer Schnittdarstellung nochmals illustriert.
Mit Bezug auf Fig. 9(a) wird jedes zweite Feld mit 50 µm x 50 µm großen Mikrospiegeln 102 zur Erzeugung des ersten Lichtflecks 110 belegt. Die Mikrospiegel 102 bilden eine Gruppe von Mikrospiegeln, die alle demselben Lichtfleck 110 zuordnet sind und diesen bei Beleuchtung gemeinsam erzeugen.

Die zwischen den Mikrospiegeln 102 liegenden Felder 104 stehen für die Belegung mit Mikrospiegeln, die anderen Lichtflecken zugeordnet sind, zur Verfügung. Im Extremfall können die Felder 104 mit Mikrospiegeln 106 belegt werden, die der Erzeugung eines Lichtflecks 112 dienen, der nur einen

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Mikrospiegeldurchmesser d_m, im Ausführungsbeispiel also 50 µm, von dem ersten Lichtfleck 110 entfernt ist, wie in Fig. 9(b) illustriert.

Wie aus Fig. 9 ersichtlich, ist der Optikdurchmesser d der Mikrospiegelgruppen 102, 106 bei der alternierenden Spiegelanordnung durch $d = 2*n*d_m$ gegeben, wobei n die Anzahl der Mikrospiegel einer Gruppe in einer Raumrichtung darstellt. Durch geeignete Wahl von n kann daher der Optikdurchmesser d trotz der hohen Auflösung d_m stets groß genug gemacht werden, um die Bedingung $f/d < 5$ zu erfüllen.

Zurückkommend auf die Darstellung der Fig. 8 versteht sich, dass die Belegung des Flächenbereichs des Sicherheitselements je nach der gewünschten Anzahl der zu verschachtelnden Gruppen von Mikrooptikelementen gewählt werden kann. Beispielsweise kann auch nur jedes vierte Feld mit Mikrospiegeln 102 belegt werden, die einem bestimmten Lichtfleck zugeordnet sind, wie in Fig. 8(c) illustriert. Die in der Figur weiß dargestellten, zunächst noch freien Felder 104 können dann mit Mikrospiegeln belegt werden, die bis zu drei anderen Lichtflecken zugeordnet sind. In einer weiteren Gestaltung ist jedes neunte Feld mit den einem bestimmten Lichtfleck zugeordneten Mikrospiegeln 102 belegt, wie in Fig. 8(d) gezeigt. Die in der Figur weiß dargestellten, zunächst noch freien Felder 104 können dann mit Mikrospiegeln belegt werden, die bis zu acht anderen Lichtflecken zugeordnet sind.

Die Berechnung der ebenen Spiegelflächen der Mikrospiegel ist in Fig. 10 veranschaulicht. Gezeigt sind im Querschnitt einige der Mikrospiegel 102 und der dazwischen liegenden, freien Felder 104 einer Gestaltung nach den Figuren 8(b) und 9(a).

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Für die Berechnung bezeichnet (x_0,y_0, z_0) die Position des zu erzeugenden Lichtflecks 110 mit $z_0 > 0$, (x,y,0) die Position des zu berechnenden Spiegelelements. $\vec{n}$ ist der Normalenvektor des Spiegels an der Position (x,y,0), $\vec{k}$ der Richtungsvektor des einfallenden Lichtstrahls und $\vec{p}$ der Richtungsvektor des reflektierten Lichtstrahls.

Zu bestimmten ist jeweils die Lage des Spiegelflächen, also der Normalenvektor $\vec{n}$ so, dass das aus einer vorgegebenen Richtung $\vec{k}$ einfallende Licht für alle dem Lichtfleck 110 zugeordneten Mikrospiegel 102 auf den Brennpunkt (x_0,y_0, z_0) reflektiert wird. Dies gelingt erfindungsgemäß durch

$$\vec{n} = \frac{\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}}{\left|\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}\right|} \quad , \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 \end{pmatrix} \quad , \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + {z_0}^2}$$

Befindet sich die Lichtquelle 120 an der Position (x_L,y_L, z_L), so ist

$$\frac{\vec{k}}{|\vec{k}|} = \frac{\begin{pmatrix} x_L - x \\ y_L - y \\ z_L \end{pmatrix}}{\sqrt{(x_L - x)^2 + (y_L - y)^2 + {z_L}^2}}$$

Wird die Mikrospiegelgruppe 102 auf senkrechten Lichteinfall ausgelegt, so ist $\frac{\vec{k}}{|\vec{k}|} = \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix}$,

so dass sich der Normalenvektor $\vec{n}$ zu

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$$\vec{n} = \frac{\frac{\vec{p}_n}{|\vec{p}_n|} - \frac{\vec{k}}{|\vec{k}|}}{\left|\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}\right|} = \frac{\begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 + \sqrt{\ } \end{pmatrix}}{\sqrt{(x_0 - x)^2 + (y_0 - y)^2 + (z_0 + \sqrt{\ })^2}} \quad ,$$

ergibt, wobei die Abkürzung $\sqrt{\ } = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + z_0{}^2}$ verwendet wurde.

In analoger Weise kann der Normalenvektor $\vec{n}$ für Mikrospiegel berechnet werden, deren Brennpunkt (x_0,y_0, z_0) mit $z_0 < 0$ unterhalb der Ebene des Sicherheitselements liegt. Dazu geht man erfindungsgemäß von der Beziehung

$$\vec{n} = -\frac{\frac{\vec{p}}{|\vec{p}|} + \frac{\vec{k}}{|\vec{k}|}}{\left|\frac{\vec{p}}{|\vec{p}|} + \frac{\vec{k}}{|\vec{k}|}\right|}$$

aus, die weitere Berechnung erfolgt wie bei Hohlspiegeln.

Gekrümmte Linsen lassen sich bei der Zerlegung in Mikrooptikelemente durch kleine Mikroprismen nachstellen, die, wenn die Größe der Mikroprismen unterhalb des Auflösungsvermögens der Betrachtungssituation liegt, mit gleicher optischer Wirkung einsetzbar, aber einfacher zu berechnen und herzustellen sind.

In Fig. 11 sind zur Illustration bei einer schachbrettartigen Zerlegung wie in Fig. 8(b) einige Mikroprismen 122 im Querschnitt gezeigt. Analog zum Vorgehen bei den Mikrospiegeln 102 kann auch für die Mikroprismen 122 der Normalenvektor $\vec{n}$ so berechnet werden, dass das von der Lichtquelle 120 einfallende Licht jeweils zur gewünschten Position des Lichtflecks 110 ge-

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brochen wird. Die in Fig. 11 freibleibenden Felder 124 können mit Mikroprismen belegt werden, die einem anderen Lichtfleck zugeordnet sind.

Bei allen beschriebenen Varianten könnten die refraktiven und/oder reflektiven optischen Elemente auch in ein Umgebungsmaterial einbettet bzw. mit einer Schutzschicht versehen sein. Durch eine solche Einbettung werden die optischen Elemente einerseits vor Verschmutzung und Abrieb geschützt und anderseits wird eine unbefugte Nachstellung durch Abprägen der Oberflächenstruktur wirksam verhindert.

Die Einbettung ist in Fig. 12 für ein Sicherheitselement 130 mit Mikrospiegeln 132 schematisch gezeigt. Durch die Einbettung der Mikrospiegel 132 in die transparente Schutzschicht 134 und den resultierenden Sprung des Brechungsindex an der Oberfläche 136 der Schutzschicht 134 ändert sich die Position der erzeugten Lichtflecke 140 gegenüber der Lichtfleckposition 142 bei einer nicht eingebetteten Mikrospiegelanordnung. Genauer gesagt, ändert sich bei einer Einbettung der Mikrospiegel 132 in eine Schutzschicht mit Brechungsindex n die Schwebehöhe eines von den Mikrospiegeln 132 erzeugten Lichtflecks 140 etwa um den Faktor 1/n. Übliche Schutzlackschichten 134 haben eine Brechzahl von etwa n = 1,5, so dass sich die Schwebehöhen der Lichtflecken gegenüber den für eine offene Anwendung berechneten Schwebehöhen um etwa 2/3 verringern. Diese Änderung wird selbstverständlich in der Regel bereits bei der Auslegung der Mikrospiegelanordnung berücksichtigt so dass nach der Einbettung die gewünschten Schwebehöhen erreicht werden.

Bei eingebetteten Prismen oder Linsen kann der Brechzahlunterschied zwischen Prismen- bzw. Linsenmaterial und Einbettungsmaterial bei der Berechnung der Lichtstrahlablenkung entsprechend berücksichtigt werden.

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Um ein visuell ansprechendes dreidimensionales Lichtfleckenbild zu erzeugen, sollen die Lichtflecken unterschiedliche Helligkeiten aufweisen können. Dabei kann auch erwünscht sein, dass ein Lichtfleck, also ein im Raum schwebender Punkt eines Motivs aus unterschiedlichen Richtungen unterschiedlich hell erscheint. Derartige unterschiedliche Helligkeiten von Lichtflecken können im Rahmen der Erfindung auf verschiedene Arten erzeugt werden. Beispielsweise können dazu die optischen Elemente, die einem Lichtfleck zugeordnet sind, je nach dem gewünschten Bruchteil der Maximalhelligkeit abgedunkelt werden.

Gegenwärtig ist allerdings bevorzugt, die Helligkeit eines Lichtflecks nach Zerlegung in Mikrooptikelemente über den Flächenanteil, der mit Mikrooptikelementen belegt ist, oder über die Anzahl der Felder, die pro Raumwinkel für einen Lichtfleck zuständig sind, einzustellen. Dadurch ergeben sich Bildbereiche, die keine auf einen Lichtfleck gerichteten Spiegel oder Prismen enthalten und die dunkel gehalten werden müssen.

Derartige Bildbereiche können beispielsweise auf eine der folgenden Arten erzeugt werden. Bei einer ersten Variante werden die dunkleren Partien im spiegelnden Lichtfleckenbild mit Lichtfallen versehen, etwa mit Subwellenlängenstrukturen, wie etwa Mottenaugenstrukturen, oder mit trichterförmigen, reflektierenden Strukturen mit steilen Flanken, bei denen einfallendes Licht wenig oder gar nicht zurück reflektiert wird. Wegen der steilen Flanken sind derartige Lichtfallen allerdings nicht einfach herzustellen. Daher bietet es sich an, die dunklen Partien im spiegelnden Lichtfleckenbild mit Spiegeln auszustatten, die so orientiert sind, dass sich darin Raumbereiche spiegeln, die keine Lichtquellen enthalten. Die Spiegel können dazu beispielsweise auf den Körper des Betrachters gerichtet sein.

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Bei Durchsichtssicherheitselementen werden die dunklen Partien vorzugsweise mit Prismen ausgestattet, die Lichtstrahlen aus Richtungen zum Auge des Betrachters lenken, in denen sich keine Lichtquellen befinden, beispielsweise vom Fußboden.

Der Flächenbereich, in dem die optischen Elemente angeordnet sind, muss nicht eben, sondern kann in beliebiger Weise gekrümmt sein. Dies gelingt besonders einfach, wenn die optischen Elemente durch kleine Mikrooptikelemente gebildet sind. Da ohnehin für jedes Mikrooptikelement ein Normalenvektor berechnet wird (Figuren 10, 11), kann die lokale Position und Orientierung der Oberfläche des Sicherheitselements ohne großen Zusatzaufwand berücksichtigt werden, wie nachfolgend am Beispiel einer Mikrospiegelanordnung erläutert:

Bezeichnet wie oben (x_0,y_0, z_0) die Position des gewünschten Lichtflecks, (x,y,z) die Position eines Mikrospiegels im Raum, wobei diese Position die gekrümmte Oberfläche des Sicherheitselements beinhaltet, bezeichnet weiter $\vec{n}$ den Normalenvektor des Mikrospiegels an der Position (x,y,z), $\vec{k}$ den Richtungsvektor des einfallenden Lichtstrahls und $\vec{p}$ den Richtungsvektor vom Mikrospiegel zum Lichtfleck, so ist erfindungsgemäß

$$\vec{n} = \pm \frac{\frac{\vec{p}}{|\vec{p}|} \mp \frac{\vec{k}}{|\vec{k}|}}{\left| \frac{\vec{p}}{|\vec{p}|} \mp \frac{\vec{k}}{|\vec{k}|} \right|} \quad , \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 - z \end{pmatrix} \quad , \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + (z_0 - z)^2}$$

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wobei das obere Vorzeichen für $z_0 > 0$, also ein über der Substratebene schwebendes, reelles Bild, und das untere Vorzeichen für $z_0 < 0$, also ein unterhalb der Substratebene schwebendes, virtuelles Bild gilt.

Bei einer Weiterbildung der Erfindung kann das Sicherheitselement bei Beleuchtung auch ein Lichtflecken-Wechselbild erzeugen, bei dem für den Betrachter aus unterschiedlichen Richtungen unterschiedliche Bilder sichtbar werden. Dazu kann beispielsweise für ein spiegelndes Sicherheitselement wie folgt vorgegangen werden, die Vorgehensweise für ein Durchsichtssicherheitselement ist analog:

Das Sicherheitselement soll bei seitlichem Kippen einen Bildwechsel von einem Lichtfleckenbild A zu einem Lichtfleckenbild B zeigen. Zunächst werden für beide Lichtfleckenbilder die benötigten optischen Elemente bestimmt, die die Lichtfleckenbilder bei Beleuchtung erzeugen. Dabei wird, wie im Zusammenhang mit den Figuren 8 bis 10 beschrieben, jedem Lichtfleck eine Mehrzahl von optischen Elementen, hier einer Mehrzahl von Mikrospiegeln zuordnet.

Bei der Anordnung der Mikrospiegel im Flächenbereich des Sicherheitselements werden dann für das Lichtfleckenbild A diejenigen Mikrospiegel weggelassen, bei denen die x-Komponente n_x des Normalenvektors größer als Null ist. Dadurch wird die Hälfte der Spiegelplätze frei und das Bild ist nur in einem eingeschränkten Winkelbereich sichtbar.

Für das Lichtfleckenbild B werden diejenigen Mikrospiegel weggelassen, bei denen die x-Komponente n_x des Normalenvektors kleiner als Null ist. Mit dieser reduzierten Spiegelanordnung werden die freigewordenen Spiegelplätze des Lichtfleckenbilds A belegt. Beim seitlichen Kippen der Anord-

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nung wird dann abwechselnd das Lichtfleckenbild A und das Lichtfleckenbild B sichtbar.

Das Sicherheitselement kann auch auf vertikales Kippen ausgelegt werden, beispielsweise indem für das Lichtfleckenbild A diejenigen Mikrospiegel weggelassen werden, bei denen die y-Komponente des Normalenvektors n_y größer als Null ist, und für das Lichtfleckenbild B die Mikrospiegel, für die $n_y < 0$ ist. Die reduzierten Spiegelanordnungen mit ihrem eingeschränkten Sichtbarkeitsbereich werden dann auf dem Flächenbereich des Sicherheitselements gemischt.

Anstelle der genannten Bedingungen können selbstverständlich auch andere Kriterien zur Trennung der Lichtfleckenbilder eines Wechselbilds verwendet werden. Beispielsweise können durch die Bedingungen

$$n_y > c_1 \text{ für Bild A}, \quad c_1 < n_y < c_2 \text{ für Bild B}, \quad n_y < c_2 \text{ für Bild C}$$

mit zwei Zahlenwerten $c_1 < c_2$ drei Lichtfleckenbilder A, B, C beim vertikalen Kippen wechseln. Durch die Wahl der Zahlenwerte c_1 und c_2 kann die Größer der Sichtbarkeitsbereiche nach Wunsch eingestellt werden.

Neben dem Wechsel zwischen mehreren 3D-Lichtfleckenbildern kommt auch ein Wechsel zwischen einem oder mehreren 3D-Lichtfleckenbildern und einem oder mehreren auf andere Weise erzeugten Bildern in Frage.

Es kann sich auch empfehlen, in dem Lichtfleckenbild ein dreidimensionales Motiv mit einem zweidimensionalen Motiv zu kombinieren, bei dem alle Bildpunkte in derselben Höhe, vorzugsweise in Höhe der Ebene des Sicherheitselements oder nach der Ebene des Sicherheitselements liegen. Solche

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zweidimensionalen Lichtfleckenmotive lassen sich nämlich auch bei schlechteren Beleuchtungsbedingungen noch gut erkennen. Wird beispielsweise ein zweidimensionales Vordergrund-Motiv mit einem dreidimensionalen Hintergrund-Motiv kombiniert, so verschwindet das Lichtfleckenbild auch bei schlechten Lichtverhältnissen nicht vollständig, sondern wird lediglich auf das robustere zweidimensionale Vordergrundmotiv reduziert. Eine Echtheitsprüfung ist daher auch bei schlechten Lichtverhältnissen noch möglich.

Ein Lichtfleckenbild kann also neben schwebenden 3D-Lichtflecken, die aus bestimmten Blickwinkeln sichtbar sind, auch 2-dimensional erscheinende Bereiche enthalten, die aus den gleichen oder anderen Blickwinkeln sichtbar sind. Die 2D-und 3D-Partien können also nebeneinander liegen und/oder bei Änderung der Betrachtungsrichtung wechselweise am gleichen Ort erscheinen.

Bei 2D-3D-Bildern hat man neben 3-dimensional wirkenden Partien (die vor oder hinter der Ebene des Sicherheitselements zu sehen sind oder die Ebene des Sicherheitselements zu durchdringen scheinen) auch 2-dimensional wirkende Partien in Höhe der Ebene des Sicherheitselements oder nahe der Ebene des Sicherheitselements (in der Höhenstufe 0 oder nahe der Höhenstufe 0).

Für einen Bereich in der Höhe Null kann man ausgehen von der Spiegel- oder Prismenbelegung, die für Lichtpunkte in geringer Höhe (z.B. die Höhe 0,5 mm) mit dem gewünschten Blickwinkelbereich berechnet wird. Hier sind alle Normalenvektoren enthalten, die den avisierten Raumwinkel bedienen. Während für schwebende Lichtpunkte die Mikrospiegel oder Mikroprismen in der Ebene des Sicherheitselements so sortiert sind, dass bestimmte Punkte im Raum bedient werden, müssen die so berechneten Mik-

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rospiegel einschließlich ihrer Neigung in dem für die Höhe 0 vorgesehenen Bereich statistisch verteilt werden. Dann werden keine bestimmten Punkte im Raum beleuchtet, sondern wie erwünscht ein Raumwinkel bedient. Für kleinere Intensität ist diese statistisch gemischt belegte Fläche entsprechend lückenhaft zu gestalten, indem z.B. nicht alle Pixel belegt werden oder die Pixel nicht voll belegt werden.

Nach einer anderen Weiterbildung weist das Lichtfleckenbild zusätzlich zu der offen sichtbaren Bildinformation noch eine versteckte Bildinformation (Hidden Image) auf. Dazu werden die optischen Elemente der offenen Bildinformation beabstandet angeordnet und die Lücken zumindest teilweise mit optischen Elementen der versteckten Bildinformation belegt.

Eine versteckte Bildinformation kann beispielsweise erzeugt werden, indem den zugehörigen Lichtflecken sehr kleine Öffnungswinkel zugeordnet werden, etwa ein Öffnungswinkel = 0 für Parallellicht.

Den Lichtflecken der versteckten Bildinformation können auch unterschiedliche Richtungen zugeordnet werden, die so weit auseinander liegen, dass beim Betrachten ohne Hilfsmittel kein zusammenhängendes Bild erfasst wird. Zur Echtheitsprüfung kann das Bild auf einer Mattscheibe aufgefangen werden. Die Richtungen der versteckten Bildinformation liegen vorzugsweise außerhalb der Richtungen, unter denen das offene 3D-Lichtfleckenbild betrachtet wird, so das Vorliegen einer versteckten Information nicht ohne weiteres erkennbar ist.

In einer vorteilhaften Ausgestaltung werden die optischen Elemente der versteckten Bildinformation teilweise oder vollständig in eng benachbarten Teilbereichen des Sicherheitselements untergebracht und gegebenenfalls

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mehrfach über die Fläche des Sicherheitselements wiederholt. Die versteckte Bildinformation kann dann durch Beleuchtung mit einem schmalen Laserstrahl sukzessive oder als Ganzes erfasst und auf einen geeignet platzierten Schirm projiziert werden.

Nachfolgend wird eine besonders bevorzugte Vorgehensweise beim Herstellen eines allgemeinen dreidimensionalen Lichtfleckenbilds genauer beschrieben.

Zunächst wird ein gewünschtes dreidimensionales Motiv mit Bildpunkten Pj und Höhenwerten Zj über der xy-Ebene definiert, wobei die Bildpunkte den bei Beleuchtung entstehenden Lichtflecken entsprechen. Für einen normalen Betrachtungsabstand von etwa 30 cm sollen die Bildpunktabstände dabei im Bereich von 0,1 bis 0,5 mm liegen. Weiter wird den Bildpunkten P_j eine Helligkeit I_j zwischen 0% und 100% zugeordnet. Dann werden den Bildpunkten Öffnungskegel zugeordnet, die ein Öffnungsverhältnis > 0,2 aufweisen, beispielsweise ein Öffnungsverhältnis von 0,4. Für jeden Bildpunkt Pj definiert der Schnitt des von dem Bildpunkt ausgehenden Öffnungskegels mit der xy-Ebene dort einen Einzugsbereich Ej zu dem Bildpunkt Pj.

Die xy-Ebene selbst wird in erste, größere Felder, beispielsweise einer Abmessung von 0,1mm × 0,1 mm aufgeteilt. Jedes der größeren Felder wird weiter in zweite, kleinere Felder, beispielsweise einer Größe von 10µm × 10µm aufgeteilt. Die größeren Felder werden nachfolgend als Grobfelder, die kleiner Felder als Feinfelder bezeichnet.

Im Einzugsbereich E_j jedes Bildpunkts P_j werden nun so viele Feinfelder für diesen Bildpunkt reserviert, wie auf Grundlage des Höhenwerts Z_j und des Helligkeitswerts I_j bestimmt werden. Beispielsweise kann die Feinfelderan-

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zahl proportional zum Helligkeitswert und umgekehrt proportional zu $(Zj)^{\alpha}$ mit einem Exponenten α 1 gewählt werden, der bei durch rinnenförmige Spiegel oder Zylinderlinsen gebildeten Lichtflecken $\alpha = 1$ und bei durch zweidimensional fokussierende Linsen oder Spiegel gebildeten Lichtflecken $\alpha = 2$ beträgt. Die für den Bildpunkt P_j reservierten Feinfelder werden dann im Wesentlichen gleichmäßig auf die Grobfelder im Einzugsbereich E_j des Bildpunkts P_j verteilt.

In die Anzahl der Feinfelder pro Grobfeld kann dabei auch ein Korrekturfaktor einfließen, der beispielsweise wie folgt bestimmt wird: Zunächst wird ohne Korrektfaktor innerhalb jedes Grobfelds die Anzahl der zu belegenden Feinfelder, die zu unterschiedlichen Bildpunkten P_j gehören, addiert. Dadurch ergibt sich ein Belegungsvorschlag für die Anzahl der insgesamt belegten Feinfelder in jedem Grobfeld.

Ist die Anzahl der belegten Feinfelder für alle Grobfelder geringer als die maximal mögliche Anzahl, so kann ein Korrekturfaktor größer 1 gewählt werden, und die Belegung mit diesem Korrekturfaktor multipliziert werden, so dass die maximale Belegung in einigen Grobfeldern erreicht wird. Übersteigt andererseits die Anzahl der belegten Feinfelder die Maximalbelegung, so wird entsprechend ein Korrekturfaktor kleiner 1 gewählt, der nach Multiplikation zu einer Belegung kleiner oder gleich der Maximalbelegung führt. Wenn die Maximalbelegung in nur wenigen Grobfeldern überschritten wird, können statt einer gleichmäßigen Reduktion auch nur die höchsten Intensitäten auf die Maximalbelegung gekappt werden oder die Feinfelder der überschreitenden Grobfelder werden in angrenzende Grobfelder verschoben.

Die so erhaltene Belegung kann nun im Flächenbereich des Sicherheitselements realisiert werden. In den belegten Feinfeldern werden Spiegel oder

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Prismen angeordnet, die das einfallende Licht auf den entsprechenden Lichtfleck spiegeln bzw. brechen. In dabei freibleibenden Flächenbereichen des Sicherheitselements können zusätzliche Sicherheitselemente eingebracht werden, beispielsweise kann dort ein Hidden Image der oben beschriebenen Art untergebracht werden.

Ein erfindungsgemäßes Lichtfleckenbild kann auch als Master für ein Volumenhologramm dienen, wie nunmehr anhand dreier Ausgestaltungen mit Bezug auf Fig. 13 illustriert.

Bei dem Ausführungsbeispiel der Fig. 13(a) dient eine Darstellungsanordnung 140 als Master, die ein reflektierendes 3D-Lichtfleckenbild mit Mikrospiegeln aufweist, welches für senkrechten Lichteinfall berechnet ist. Eine Photopolymerplatte 142 dient als Aufzeichnungsplatte für das Volumenhologramm. Die Photopolymerplatte 142 wird vor der Darstellungsanordnung 140 angeordnet, so dass die Laserstrahlung des Aufzeichnungslasers 144 nach der Strahlaufweitung 146 als Referenzwelle 148 senkrecht auf die Photopolymerplatte 142 einfällt. Ein Teil der Laserstrahlung durchstrahlt die Photopolymerplatte 142, fällt senkrecht auf die Darstellungsanordnung 140 und bildet nach der Reflexion an der Darstellungsanordnung 140 die Objektwelle, die in der Photopolymerplatte 142 mit der Referenzwelle 148 interferiert. In die Photopolymerplatte 142 werden dadurch Bragg-Gitter einbelichtet, die als Volumengitterbild das gleiche 3D-Bild wie das als Master dienende 3D-Lichtfleckenbild der Darstellungsanordnung 140 zeigt.

Bei der Abwandlung der Fig. 13(b) enthält die als Master dienende Darstellungsanordnung 140 ein reflektierendes 3D-Lichtfleckenbild, das für Lichteinfall unter einem bestimmten Winkel zur Senkrechten berechnet ist. Entsprechend werden die Darstellungsanordnung 140 und die vor der Darstel-

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lungsanordnung angeordnete Photopolymerplatte 142 unter diesem Winkel mit der Laserstrahlung beaufschlagt. Durch Interferenz der Referenzwelle 148 und der nach Durchstrahlung der Photopolymerplatte 142 von der Darstellungsanordnung reflektierte Objektwelle wird ein Volumengitterbild in der Photopolymerplatte 142 erzeugt, das das gleiche 3D-Bild wie das als Master dienende 3D-Lichtfleckenbild der Darstellungsanordnung 140 zeigt.

Schließlich dient bei dem Ausführungsbeispiel der Fig. 13(c) eine Darstellungsanordnung 140 mit einem brechenden 3D-Lichtfleckenbild mit Mikroprismen, das für senkrechten Lichteinfall berechnet ist, als Master. Hier werden die Darstellungsanordnung 140 und die vor der Darstellungsanordnung angeordnete Photopolymerplatte 142 durch einen Strahlteiler 150 und Umlenkspiegel 152 von gegenüberliegenden Seiten her mit der Laserstrahlung beaufschlagt. In der Photopolymerplatte 142 interferieren die Referenzwelle 148 und die von der Darstellungsanordnung 142 gebrochene Objektwelle und erzeugen so ein Volumengitterbild, das das gleiche 3D-Bild wie das als Master dienende 3D-Lichtfleckenbild der Darstellungsanordnung 140 zeigt.

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Patentansprüche

1. Darstellungselement mit einem Substrat mit einem Flächenbereich, in dem eine Mehrzahl optischer Elemente angeordnet ist, **dadurch gekennzeichnet, dass** das Darstellungselement ausgelegt und bestimmt ist, bei Beleuchtung ein Lichtfleckenbild aus einer Mehrzahl von Lichtflecken zu erzeugen, die für einen Betrachter oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind, wobei die optischen Elemente durch refraktive und/oder reflektive optische Elemente gebildet sind und jedem Lichtfleck des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element zugeordnet ist, welches bei Beleuchtung des Darstellungselements zur Erzeugung des ihm zugeordneten Lichtflecks beiträgt.

2. Darstellungselement nach Anspruch 1, **dadurch gekennzeichnet, dass** für die Lichtflecke und die zugeordneten optischen Elemente jeweils $f/d < 5$ gilt, wobei f die Schwebehöhe des Lichtflecks oberhalb oder unterhalb des Flächenbereichs bezeichnet und d den Durchmesser der zu diesem Lichtfleck beitragenden optischen Elemente.

3. Darstellungselement nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Lichtflecken des Lichtfleckenbilds in mehreren verschiedenen Schwebehöhen oberhalb oder unterhalb des Flächenbereichs schweben, um ein dreidimensionales Motiv zu bilden.

4. Darstellungselement nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Lichtflecken des Lichtfleckenbilds bereichsweise alle in dersel-

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ben Schwebehöhe oberhalb oder unterhalb des Flächenbereichs schweben, um ein Kulissenmotiv zu bilden.

5. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die optischen Elemente gewölbte Spiegel umfassen, insbesondere Hohlspiegel oder Wölbspiegel.

6. Darstellungselement nach Anspruch 5, **dadurch gekennzeichnet, dass** die gewölbten Spiegel sphärisch, elliptisch, rotationssymmetrisch asphärisch, nichtrotationssymmetrisch asphärisch oder rinnenförmig ausgebildet sind, wobei im letzteren Fall die Rinnen geradlinig oder krummlinig verlaufen.

7. Darstellungselement nach Anspruch 5 oder 6, **dadurch gekennzeichnet, dass** die gewölbten Spiegel zumindest teilweise durch Fresnelspiegel gebildet sind.

8. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** die optischen Elemente Linsen umfassen, insbesondere sphärische, elliptische, rotationssymmetrisch asphärische, nichtrotationssymmetrisch asphärische oder zylindrische Linsen.

9. Darstellungselement nach Anspruch 8, **dadurch gekennzeichnet, dass** die Linsen zumindest teilweise durch Fresnellinsen gebildet sind.

10. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet, dass** jedem Lichtfleck des Lichtfleckenbilds genau ein optisches Element zugeordnet ist.

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11. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet, dass** jedem Lichtfleck des Lichtfleckenbilds eine Mehrzahl von optischen Elementen zuordnet ist, vorzugsweise, dass die optischen Elemente beabstandet auf dem Flächenbereich verteilt sind.

12. Darstellungselement nach Anspruch 11, **dadurch gekennzeichnet, dass** die Lichtflecke des Lichtfleckenbilds unterschiedliche Helligkeiten aufweisen und jedem Lichtfleck eine solche Anzahl von optischen Elementen zuordnet ist, die der Helligkeit des Lichtflecks innerhalb des von den Lichtflecken gebildeten Motivs entspricht, oder jedem Lichtfleck eine solche Gesamtfläche von optischen Elementen zuordnet ist, die der Helligkeit des Lichtflecks innerhalb des von den Lichtflecken gebildeten Motivs entspricht.

13. Darstellungselement nach Anspruch 11 oder 12, **dadurch gekennzeichnet, dass** optische Elemente, die verschiedenen Lichtflecken zugeordnet sind, in dem Flächenbereich ineinander verschachtelt angeordnet sind.

14. Darstellungselement nach wenigstens einem der Ansprüche 11 bis 13, **dadurch gekennzeichnet, dass** die optischen Elemente durch ebene Mikrospiegel oder durch kleine Mikroprismen gebildet sind.

15. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 14, **dadurch gekennzeichnet, dass** das vorbestimmte Motiv ein Wechselbild ist, das aus unterschiedlichen Betrachtungsrichtungen unterschiedliche Bilder zeigt.

16. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 15, **dadurch gekennzeichnet, dass** der Flächenbereich, in dem die Mehrzahl optischer Elemente angeordnet ist, gekrümmt ist.

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17. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 16, **dadurch gekennzeichnet, dass** eine Teilmenge der optischen Elemente eine versteckte Bildinformation erzeugt, die ohne Hilfsmittel nicht erkennbar ist.

18. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 17, **dadurch gekennzeichnet, dass** die optischen Elemente eine periodische Anordnung von Mikrospiegeln umfassen, die jeweils einen Abstand zum nächsten Nachbarn von 2 mm oder weniger aufweisen.

19. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 18, **dadurch gekennzeichnet, dass** die optischen Elemente in eine Umgebungsschicht oder einen Umgebungsschichtverbund, insbesondere in eine Schutzschicht eingebettet sind.

20. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 19, **dadurch gekennzeichnet, dass** die optischen Elemente als Prägestrukturen in einer Prägelackschicht ausgebildet sind.

21. Darstellungselement nach Anspruch 20, **dadurch gekennzeichnet, dass** die Prägestrukturen mit einer reflexionserhöhenden Beschichtung, insbesondere mit einer Metallisierung, einer hochbrechenden Beschichtung, einem Dünnschichtelement mit Farbkippeffekt oder einer cholesterischen Flüssigkristallschicht versehen sind.

22. Darstellungselement nach Anspruch 20 oder 21, **dadurch gekennzeichnet, dass** die Prägestrukturen Strukturhöhen von weniger als 100 µm, bevorzugt von weniger als 20 µm, besonders bevorzugt von weniger als 5 µm aufweisen.

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23. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 22, **dadurch gekennzeichnet, dass** das vorbestimmte Motiv ein durch die Lichtflecken gebildeter vollplastischer Körper ist.

24. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 23, **dadurch gekennzeichnet, dass** das Darstellungselement ein Sicherheitselement für Sicherheitspapiere, Wertdokumente und andere abzusichernde Gegenstände ist, insbesondere ein Sicherheitsfaden, ein Sicherheitsband, ein Sicherheitsstreifen, ein Etikett oder ein Transferelement ist.

25. Verfahren zum Herstellen eines Darstellungselements nach einem der Ansprüche 1 bis 24, das ausgelegt und bestimmt ist, bei Beleuchtung ein Lichtfleckenbild aus einer Mehrzahl von Lichtflecken zu erzeugen, die für einen Betrachter oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind, wobei bei dem Verfahren ein Substrat bereitgestellt wird und in einem Flächenbereich des Substrats eine Mehrzahl refraktiver und/oder reflektiver optischer Elemente angeordnet wird, wobei jedem Lichtfleck des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element zugeordnet wird, welches bei Beleuchtung des Darstellungselements zur Erzeugung des ihm zugeordneten Lichtflecks beiträgt.

26. Verfahren nach Anspruch 25, **dadurch gekennzeichnet, dass**

- ein gewünschtes dreidimensionales Motiv mit Bildpunkten Pj und Höhenwerten Zj über einer xy-Ebene vorgegeben wird, wobei die Bildpunkte den bei Beleuchtung entstehenden Lichtflecken entsprechen,

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- für jeden Bildpunkt P_j eine Helligkeit I_j zwischen 0% und 100% festgelegt wird,
- den Bildpunkten P_j Öffnungskegel zugeordnet werden, die ein Öffnungsverhältnis > 0,2 aufweisen,
- für jeden Bildpunkt Pj durch einen Schnitt des von dem Bildpunkt ausgehenden Öffnungskegels mit der xy-Ebene ein Einzugsbereich Ej bestimmt wird,
- die xy-Ebene in eine Anzahl von Grobfeldern und die Grobfelder jeweils in eine Anzahl von Feinfeldern aufgeteilt wird,
- für jeden Bildpunkt P_j auf Grundlage des festgelegten Höhenwerts Z_j und des festgelegten Helligkeitswerts I_j eine Anzahl an zu füllenden Feinfeldern bestimmt werden,
- die für den Bildpunkt P_j bestimmten zu füllenden Feinfelder im Wesentlichen gleichmäßig auf die Grobfelder im Einzugsbereich E_j des Bildpunkts P_j verteilt werden, und
- die zu füllenden Feinfelder mit refraktiven und/oder reflektiven optischen Elementen belegt werden, die bei Beleuchtung des Darstellungselements zur Erzeugung des dem Bildpunkt P_j entsprechenden Lichtflecks beitragen.

27. Datenträger mit einem Darstellungselement nach wenigstens einem der Ansprüche 1 bis 24.

28. Datenträger nach Anspruch 27, **dadurch gekennzeichnet, dass** das Darstellungselement ein zumindest teilweise durchsichtiges Sicherheitselement ist, das in oder über einem transparenten Fensterbereich oder einer durchgehenden Öffnung des Datenträgers angeordnet ist.

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29. Datenträger nach Anspruch 27, **dadurch gekennzeichnet, dass** das Darstellungselement ein reflektierendes Sicherheitselement ist, das in einem opaken Bereich des Datenträgers angeordnet ist.

30. Datenträger nach wenigstens einem der Ansprüche 27 bis 29, **dadurch gekennzeichnet, dass** der Datenträger ein Wertdokument, wie eine Banknote, insbesondere eine Papierbanknote, eine Polymerbanknote, eine Folienverbundbanknote oder eine Urkunde, ein Pass oder eine Ausweiskarte ist.

31. Anzeigeeinrichtung mit einer Steuereinrichtung und einem Darstellungselement nach einem der Ansprüche 1 bis 24, wobei die räumliche Ausrichtung der optischen Elemente des Darstellungselements durch die Steuereinrichtung einstellbar ist.

32. Verfahren zum Herstellen eines Volumenhologramms, bei dem in einer Aufzeichnungsplatte als Referenzwelle ungestreute Laserstrahlung und als Objektwelle die von einem Darstellungselement nach einem der Ansprüche 1 bis 24 reflektierte oder abgelenkte Laserstrahlung zur Interferenz gebracht werden.

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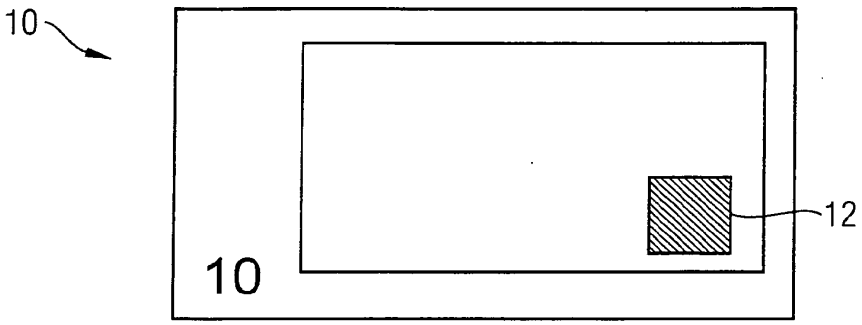


Fig. 1

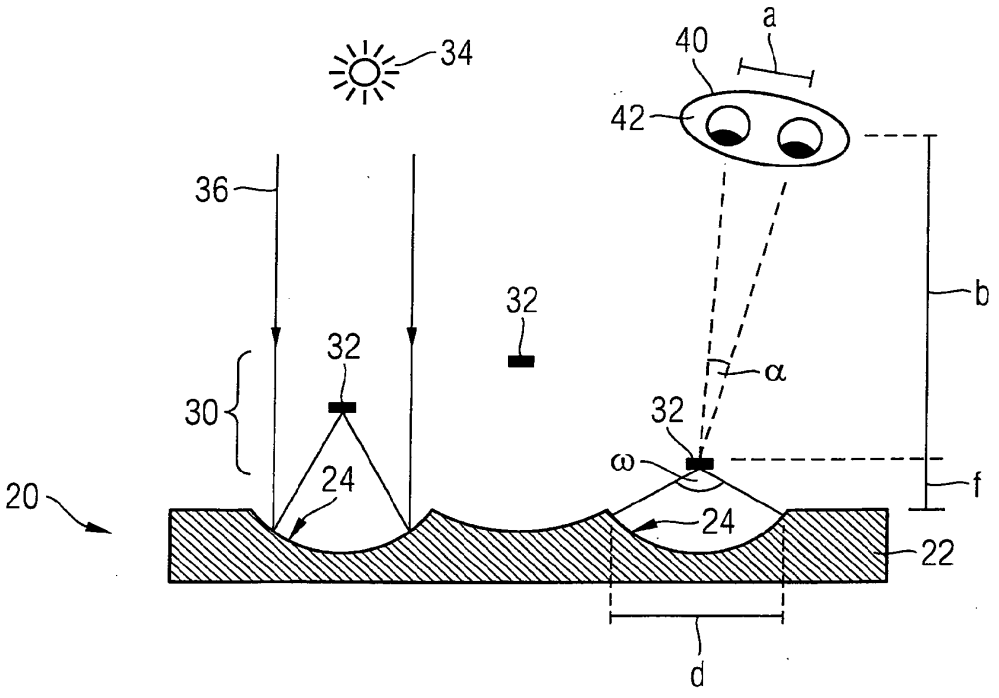


Fig. 2

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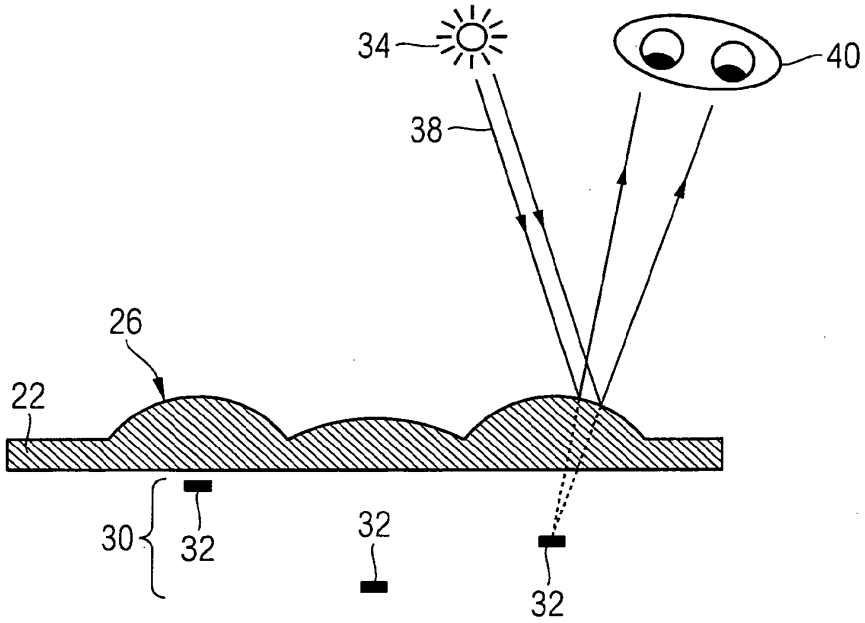


Fig. 3

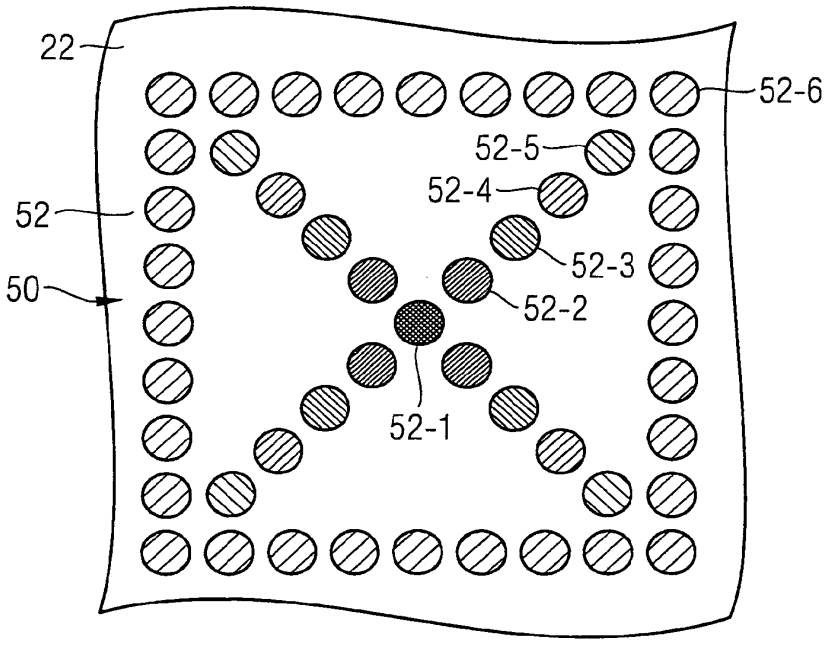


Fig. 4

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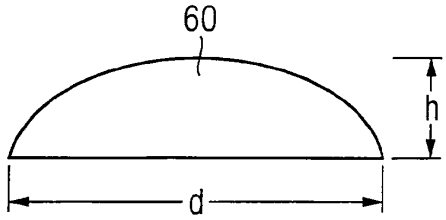


Fig. 5a

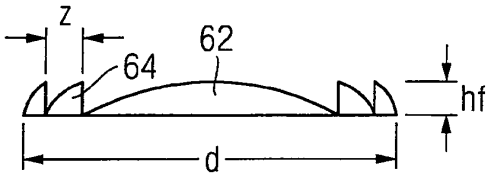


Fig. 5b

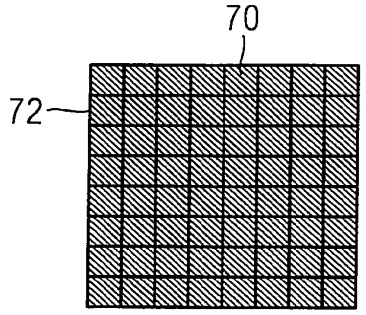


Fig. 6a

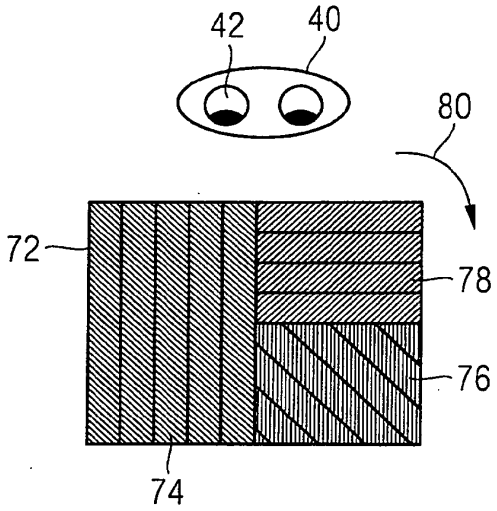


Fig. 6b

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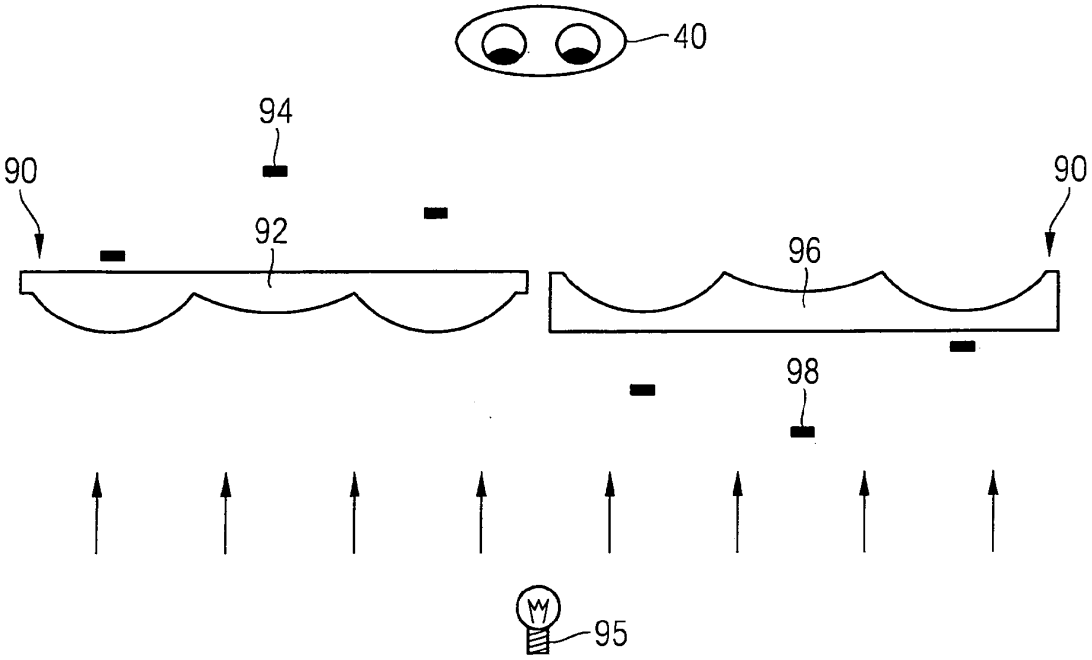


Fig. 7

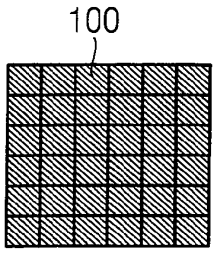


Fig. 8a

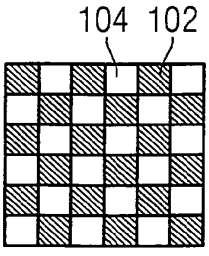


Fig. 8b

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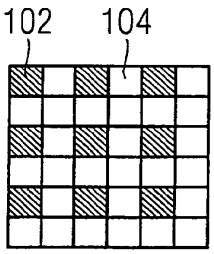


Fig. 8c

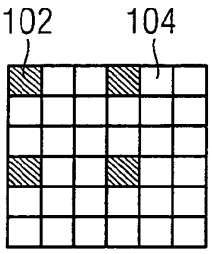


Fig. 8d

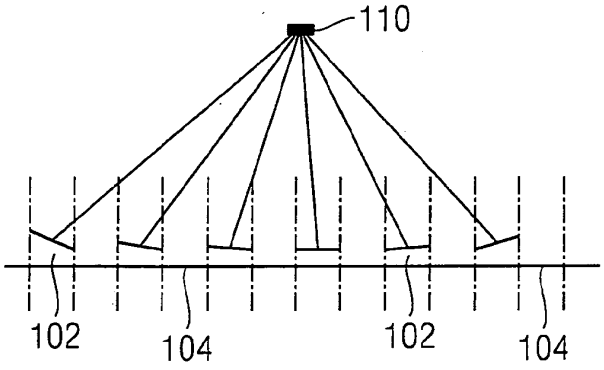


Fig. 9a

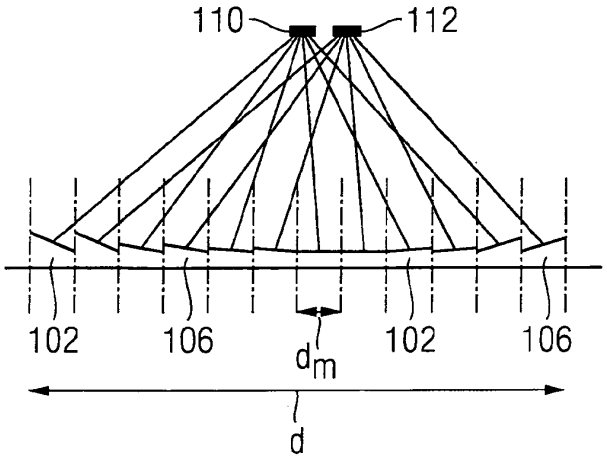


Fig. 9b

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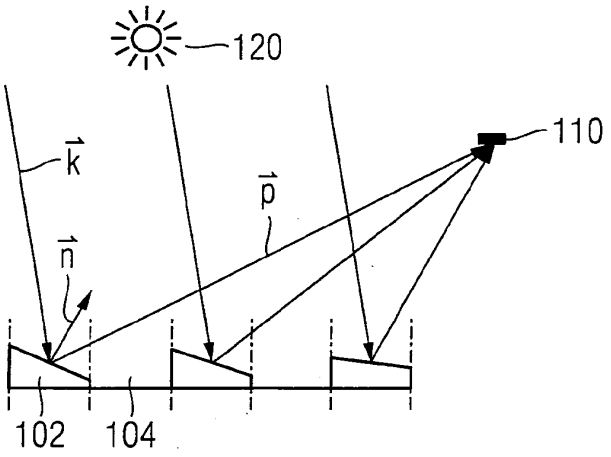


Fig. 10

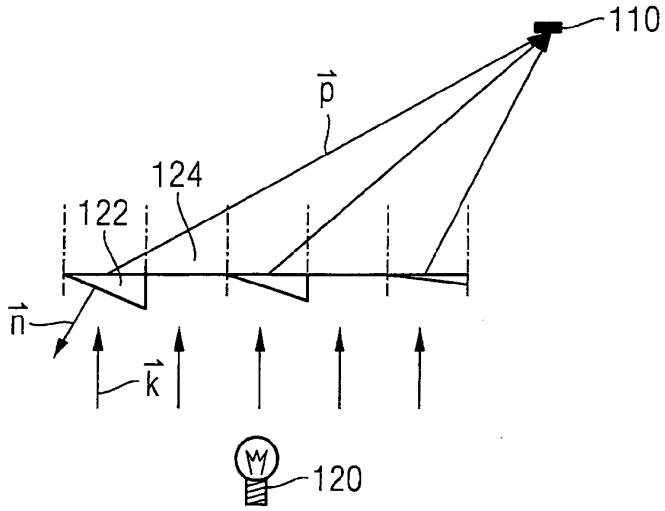


Fig. 11

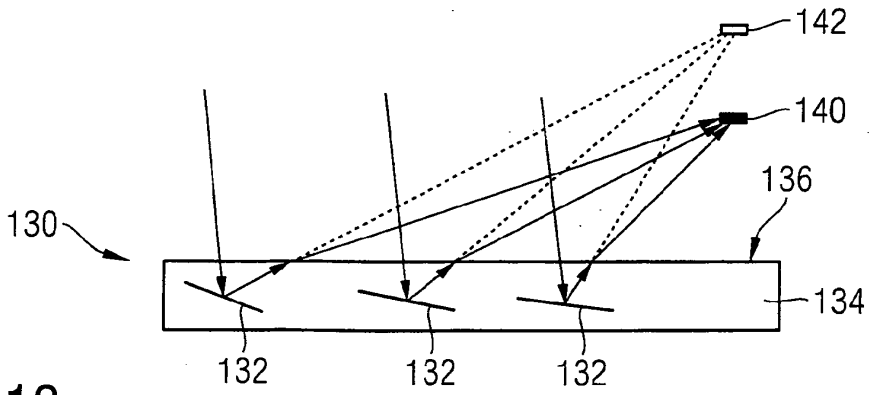


Fig. 12

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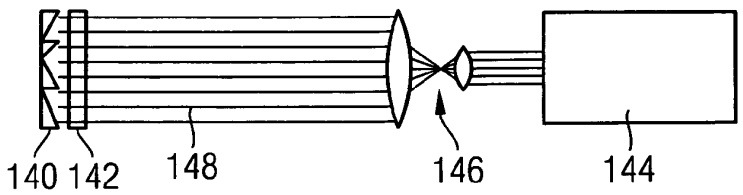


Fig. 13a

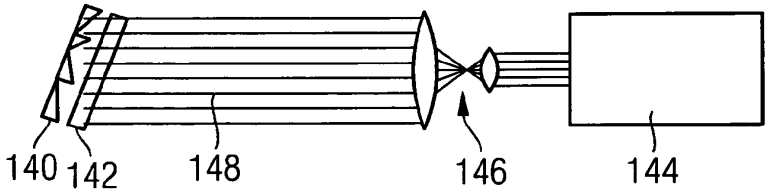


Fig. 13b

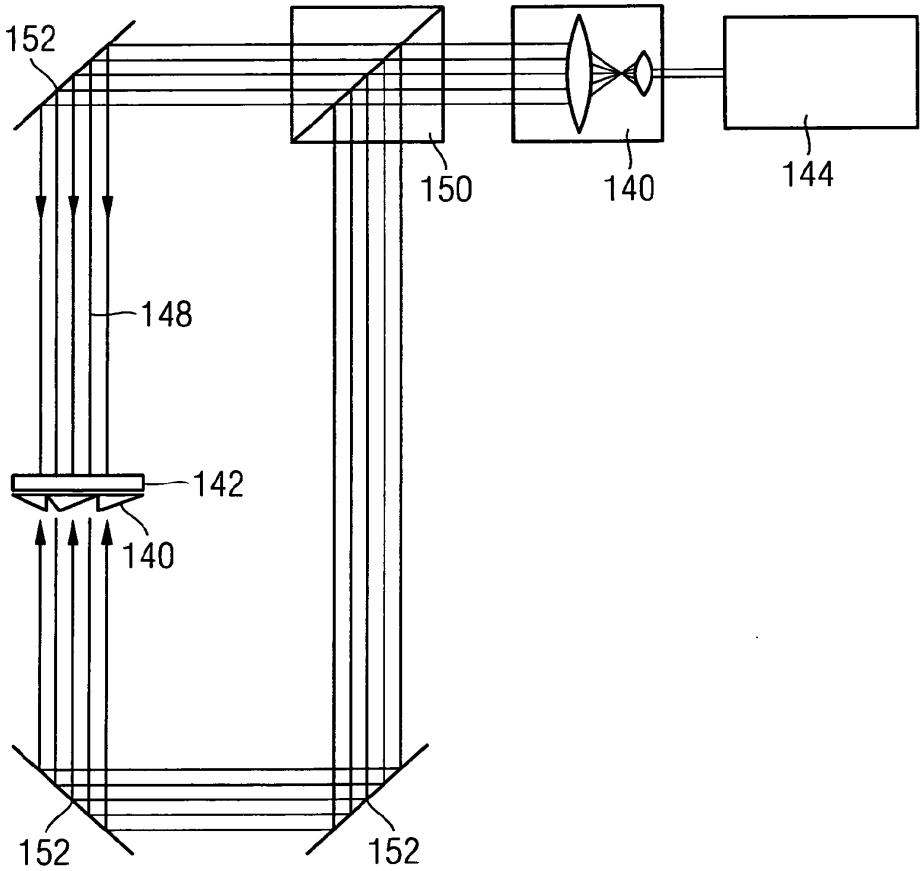


Fig. 13c

ERSATZBLATT (REGEL 26)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2011/005071

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
1-30

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☒ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/005071

A. CLASSIFICATION OF SUBJECT MATTER
INV. B42D15/00 G02B27/22 G02B3/00 G02B5/04 G02B5/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B42D G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/114078 A1 (HALLE MICHAEL [US] ET AL) 22 August 2002 (2002-08-22) figures 1-3	1-23,25
X	US 2010/231860 A1 (MAEKAWA SATOSHI [JP]) 16 September 2010 (2010-09-16) figures 1-6	1-23,25
X	US 5 105 306 A (OHALA JOHN J [US]) 14 April 1992 (1992-04-14)	1,25
A	figures 1, 2	14,20,21
X	US 6 288 842 B1 (FLORCZAK JEFFREY M [US] ET AL) 11 September 2001 (2001-09-11) figures 9,10	1,24,25, 27-30
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 February 2012	15/02/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Rödig, Christoph

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/005071

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7 261 417 B2 (CHO GYOUNG I [KR] ET AL CHO GYOUNG IL [KR] ET AL) 28 August 2007 (2007-08-28) figure 4c -----	1,25,26

2

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/005071

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002114078 A1	22-08-2002	NONE	
US 2010231860 A1	16-09-2010	CN 101405627 A	08-04-2009
		EP 2009469 A1	31-12-2008
		KR 20090008265 A	21-01-2009
		US 2010231860 A1	16-09-2010
		WO 2007116639 A1	18-10-2007
US 5105306 A	14-04-1992	CA 2007313 A1	18-07-1990
		EP 0457815 A1	27-11-1991
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		JP H04502822 A	21-05-1992
		US 5105306 A	14-04-1992
		WO 9008338 A1	26-07-1990
US 6288842 B1	11-09-2001	AR 031555 A1	24-09-2003
		AT 479125 T	15-09-2010
		AU 5627100 A	03-09-2001
		AU 2000256271 B2	03-02-2005
		BR 0017132 A	05-11-2002
		CA 2400894 A1	30-08-2001
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		TW 522257 B	01-03-2003
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		WO 0163341 A1	30-08-2001
		ZA 200206714 A	21-02-2003
US 7261417 B2	28-08-2007	US 2005180019 A1	18-08-2005
		WO 2006050428 A2	11-05-2006

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The International Searching Authority has determined that this international application contains multiple (groups of) inventions, as follows:

1. **Claims 1-23**

Details of the display element

2. **Claims 25, 26**

A design process for creating a three-dimensional motif from pixels

3. **Claims 24, 27-30**

The use of a display element as a security feature

4. **Claim 31**

A display element with a controller

5. **Claim 32**

A process for producing a 3D hologram

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
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Feld Nr. II Bemerkungen zu den Ansprüchen, die sich als nicht recherchierbar erwiesen haben (Fortsetzung von Punkt 2 auf Blatt 1)

Gemäß Artikel 17(2)a) wurde aus folgenden Gründen für bestimmte Ansprüche kein internationaler Recherchenbericht erstellt:

1. ☐ Ansprüche Nr.
weil sie sich auf Gegenstände beziehen, zu deren Recherche diese Behörde nicht verpflichtet ist, nämlich

2. ☐ Ansprüche Nr.
weil sie sich auf Teile der internationalen Anmeldung beziehen, die den vorgeschriebenen Anforderungen so wenig entsprechen, dass eine sinnvolle internationale Recherche nicht durchgeführt werden kann, nämlich

3. ☐ Ansprüche Nr.
weil es sich dabei um abhängige Ansprüche handelt, die nicht entsprechend Satz 2 und 3 der Regel 6.4 a) abgefasst sind.

Feld Nr. III Bemerkungen bei mangelnder Einheitlichkeit der Erfindung (Fortsetzung von Punkt 3 auf Blatt 1)

Diese Internationale Recherchenbehörde hat festgestellt, dass diese internationale Anmeldung mehrere Erfindungen enthält:

siehe Zusatzblatt

1. ☐ Da der Anmelder alle erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht auf alle recherchierbaren Ansprüche.

2. ☐ Da für alle recherchierbaren Ansprüche die Recherche ohne einen Arbeitsaufwand durchgeführt werden konnte, der zusätzliche Recherchengebühr gerechtfertigt hätte, hat die Behörde nicht zur Zahlung solcher Gebühren aufgefordert.

3. ☒ Da der Anmelder nur einige der erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht nur auf die Ansprüche, für die Gebühren entrichtet worden sind, nämlich auf die Ansprüche Nr.
1-30

4. ☐ Der Anmelder hat die erforderlichen zusätzlichen Recherchengebühren nicht rechtzeitig entrichtet. Dieser internationale Recherchenbericht beschränkt sich daher auf die in den Ansprüchen zuerst erwähnte Erfindung; diese ist in folgenden Ansprüchen erfasst:

Bemerkungen hinsichtlich eines Widerspruchs

☒ Der Anmelder hat die zusätzlichen Recherchengebühren unter Widerspruch entrichtet und die gegebenenfalls erforderliche Widerspruchsgebühr gezahlt.

☐ Die zusätzlichen Recherchengebühren wurden vom Anmelder unter Widerspruch gezahlt, jedoch wurde die entsprechende Widerspruchsgebühr nicht innerhalb der in der Aufforderung angegebenen Frist entrichtet.

☐ Die Zahlung der zusätzlichen Recherchengebühren erfolgte ohne Widerspruch.

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
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A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
INV. B42D15/00 G02B27/22 G02B3/00 G02B5/04 G02B5/10
ADD.

Nach der Internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
B42D G02B

Recherchierte, aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal, WPI Data

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	US 2002/114078 A1 (HALLE MICHAEL [US] ET AL) 22. August 2002 (2002-08-22) Abbildungen 1-3	1-23,25
X	US 2010/231860 A1 (MAEKAWA SATOSHI [JP]) 16. September 2010 (2010-09-16) Abbildungen 1-6	1-23,25
X	US 5 105 306 A (OHALA JOHN J [US]) 14. April 1992 (1992-04-14)	1,25
A	Abbildungen 1, 2	14,20,21
X	US 6 288 842 B1 (FLORCZAK JEFFREY M [US] ET AL) 11. September 2001 (2001-09-11) Abbildungen 9,10	1,24,25, 27-30

-/--

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen [X] Siehe Anhang Patentfamilie

* Besondere Kategorien von angegebenen Veröffentlichungen :
"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist
"E" älteres Dokument, das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist
"L" Veröffentlichung, die geeignet ist, einen Prioritätsanspruch zweifelhaft erscheinen zu lassen, oder durch die das Veröffentlichungsdatum einer anderen im Recherchenbericht genannten Veröffentlichung belegt werden soll oder die aus einem anderen besonderen Grund angegeben ist (wie ausgeführt)
"O" Veröffentlichung, die sich auf eine mündliche Offenbarung, eine Benutzung, eine Ausstellung oder andere Maßnahmen bezieht
"P" Veröffentlichung, die vor dem internationalen Anmeldedatum, aber nach dem beanspruchten Prioritätsdatum veröffentlicht worden ist
"T" Spätere Veröffentlichung, die nach dem internationalen Anmeldedatum oder dem Prioritätsdatum veröffentlicht worden ist und mit der Anmeldung nicht kollidiert, sondern nur zum Verständnis des der Erfindung zugrundeliegenden Prinzips oder der ihr zugrundeliegenden Theorie angegeben ist
"X" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann allein aufgrund dieser Veröffentlichung nicht als neu oder auf erfinderischer Tätigkeit beruhend betrachtet werden
"Y" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als auf erfinderischer Tätigkeit beruhend betrachtet werden, wenn die Veröffentlichung mit einer oder mehreren anderen Veröffentlichungen dieser Kategorie in Verbindung gebracht wird und diese Verbindung für einen Fachmann naheliegend ist
"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
2. Februar 2012	15/02/2012

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Rödig, Christoph

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2011/005071

C. (Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	US 7 261 417 B2 (CHO GYOUNG I [KR] ET AL CHO GYOUNG IL [KR] ET AL) 28. August 2007 (2007-08-28) Abbildung 4c -----	1,25,26

2

Formblatt PCT/ISA/210 (Fortsetzung von Blatt 2) (April 2005)

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INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/EP2011/005071

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
US 2002114078 A1	22-08-2002	KEINE	
US 2010231860 A1	16-09-2010	CN 101405627 A	08-04-2009
		EP 2009469 A1	31-12-2008
		KR 20090008265 A	21-01-2009
		US 2010231860 A1	16-09-2010
		WO 2007116639 A1	18-10-2007
US 5105306 A	14-04-1992	CA 2007313 A1	18-07-1990
		EP 0457815 A1	27-11-1991
		JP 3117991 B2	18-12-2000
		JP H04502822 A	21-05-1992
		US 5105306 A	14-04-1992
		WO 9008338 A1	26-07-1990
US 6288842 B1	11-09-2001	AR 031555 A1	24-09-2003
		AT 479125 T	15-09-2010
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		AU 2000256271 B2	03-02-2005
		BR 0017132 A	05-11-2002
		CA 2400894 A1	30-08-2001
		CN 1452726 A	29-10-2003
		EP 1259851 A1	27-11-2002
		EP 2278384 A2	26-01-2011
		EP 2284596 A2	16-02-2011
		HU 0301412 A2	29-09-2003
		JP 2003524205 A	12-08-2003
		JP 2010211237 A	24-09-2010
		MX PA02008143 A	28-01-2003
		NZ 520890 A	29-04-2003
		PL 356536 A1	28-06-2004
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		WO 0163341 A1	30-08-2001
		ZA 200206714 A	21-02-2003
US 7261417 B2	28-08-2007	US 2005180019 A1	18-08-2005
		WO 2006050428 A2	11-05-2006

Formblatt PCT/ISA/210 (Anhang Patentfamilie) (April 2005)

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WEITERE ANGABEN **PCT/ISA/** 210

Die internationale Recherchenbehörde hat festgestellt, dass diese internationale Anmeldung mehrere (Gruppen von) Erfindungen enthält, nämlich:

1. Ansprüche: 1-23

   Details des Darstellungselements
   ---

2. Ansprüche: 25, 26

   Design-Verfahren zum Erzeugen eines dreidimensionalem Motivs aus Bildpunkten
   ---

3. Ansprüche: 24, 27-30

   Verwendung eines Darstellungselementes als Sicherheitsmerkmal
   ---

4. Anspruch: 31

   Darstellungselement mit Steuereinrichtung
   ---

5. Anspruch: 32

   Herstellungsverfahren für ein Volumenhologramm

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Espacenet

Bibliographic data: WO2012048847 (A1) — 2012-04-19

REPRESENTATION ELEMENT COMPRISING OPTICAL ELEMENTS ARRANGED ON A SUBSTRATE, FOR PRODUCING AN IMAGE COMPOSED OF LIGHT SPOTS AND SUSPENDED ABOVE OR BELOW THE SUBSTRATE

Inventor(s): FUHSE CHRISTIAN [DE]; KAULE WITTICH [DE] ± (FUHSE, CHRISTIAN, ; KAULE, WITTICH)

Applicant(s): GIESECKE & DEVRIENT GMBH [DE]; FUHSE CHRISTIAN [DE]; KAULE WITTICH [DE] ± (GIESECKE & DEVRIENT GMBH, ; FUHSE, CHRISTIAN, ; KAULE, WITTICH)

Classification: - international: ***B42D15/00; G02B27/22; G02B3/00; G02B5/04; G02B5/10***
- cooperative: **B42D25/29**; **B42D25/355**; **B42D25/425**; **B44F1/02**; **G02B27/2207**; **G02B3/0043**; **G02B3/0056**; B42D2033/10; B42D2033/18; B42D2033/26; B42D2035/20; B42D25/324; B42D25/328

Application number: WO2011EP05071 20111011 Global Dossier

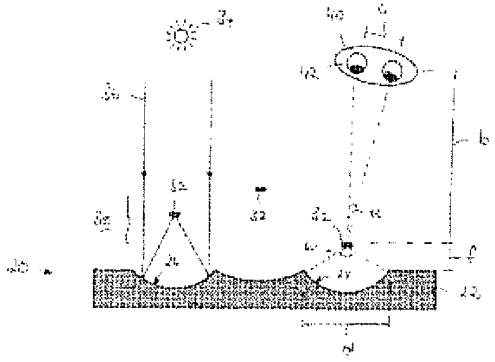
Priority number (s): DE20101048262 20101012

Also published as: DE102010048262 (A1) RU2013120905 (A) RU2599361 (C2) HK1187308 (A1) EP2627520 (A1) CN103260893 (A) CN103260893 (B) less

Abstract of WO2012048847 (A1)

The invention relates to a representation element (20) comprising a substrate (22) having a surface region containing a plurality of optical elements (24). According to the invention, the representation element (20) is designed to produce, when illuminated (34), a light spot image (30) consisting of a plurality of light spots (32) that appear to the observer (40) to be suspended above or below the surface region, and are arranged in the form of a pre-determined pattern. Said optical elements are formed by refractive and/or reflective optical elements (24) and at least one refractive and/or reflective optical element is associated with each light spot (32) of the light spot image, contributing to the production of the light spot (32) associated therewith when the representation element (20) is illuminated (34).

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DESCRIPTION WO2012048847

DESCRIPTION OF THE PREFERRED EMBODIMENT (S) AND (DE). (EN) PLATING ELEMENT (DE)

The invention relates to a display element with a substrate with a surface area in which a plurality of optical elements are arranged.

The invention also relates to a method for producing such a display element and to a data carrier with such a display element.

10

Data carriers, such as value or identification documents, but also other valuables, such as branded articles, are often provided with security elements for safeguarding, which permit a verification of the authenticity of the data carrier and which at the same time serve as protection against unauthorized reproduction.

Special attention is being given to security elements with three-dimensionally effective images, since these are easy to recognize and verifiable for the lay person, and on the other hand, they

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can not be faithfully reproduced with common copying methods.

A number of techniques are known with which a three-dimensional image impression can be produced when looking at flat images in a bidirectional view.

In anaglyphs, two stereoscopic half-images are superimposed. When viewed with an aid, such as a Red25 green spectacle or a polarization spectacle, the two fields are separated for the two eyes.

Another technique uses lenses or mirror raster images, which are composed of a multi-layer structure with a motif layer and lenses, Mirror layer. An example of this technique are the 3D moire magnifiers, as described in the printed publication WO 2009/000530 A2.

A further approach, as described, for example, in printed publication WO 90/08338 A1, is to form the motif as a flat relief, the surface of the motif being imitated and / or pieced in the surface of the image.

Finally, holograms, holographic stereograms and hologram-like grating images have been used for security elements for a long time to produce a three-dimensional image impression. In this technique, diffraction and interference with the holographic structures and diffraction gratings play a decisive role. SUMMARY OF THE INVENTION It is an object of the present invention to provide a process for the production of such a process

To provide a display element of the type mentioned at the beginning, which has an attractive visual appearance. For safety applications, the display element should also have a high security against counterfeiting and, in addition, must also be checked for authenticity for lay persons.

This object is achieved by the display element having the features of the main claim. A method for producing such a display element, a data carrier equipped with such a display element, and a display device equipped with such a display element are specified in the adjoining claims. Further developments of the invention are the subject matter of the subclaims.

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According to the invention, a generic display element comprises a substrate with a surface area in which a plurality of optical elements are arranged. The imaging element is designed and designed to generate, during illumination, a light spot image from a plurality of light spots which appear to be above a viewer or below the surface area and which are arranged in the form of a predetermined motif. For this purpose, the optical elements mentioned are formed by refractive and / or reflective optical elements, wherein at least one refractive and / or reflective optical element is associated with each light spot of the light spot image, said light element contributing to the illumination element being illuminated.

The invention is thus based on the idea of specifying a three-dimensional motif consisting of light spots floating above or below the display element. In order to produce the light spot during illumination, the display element has juxtaposed or interleaved parts of mirrors, lenses or prisms which are designed such that they generate floating light reflections in a picture space in suitable illumination, which together represent the predetermined three-dimensional motif. The floating light reflections are, in the physical sense, real pictures or virtual images of the illuminating light sources, as explained in more detail below. The visual impression is particularly good when the display element is illuminated with parallel light, for example a far-away light source. The three-dimensional light patch image resulting from the illumination provides the observer with an unusual and visually appealing three-dimensional image impression, which gives the visual element a high attention and recognition value.

The presence or absence of the effect is easy to determine for each user, so the visual element is easily verifiable. Nevertheless, the mirror- Lens arrangement due to the necessary know-how and the technology required for a potential forger. In the following, the refractive and / or reflective optical elements of the shorter designations are usually referred to only as "optical elements". However, it is to be understood that refractive and / or reflective optical elements are always meant within the scope of the invention. The optical elements can either be purely refractive, such as a lens or a microprism, purely reflective, such as a mirror or a micro-mirror, or both refractively and reflectively, such as a lens provided with a semitransparent coating, or a semitransparent coating Provided microprism. In any case, diffraction and interfering effects are irrelevant in the refractive and / or reflective optical elements according to the invention and can always be neglected.

In a preferred embodiment, the optical elements and the levitation heights of the light spot are designed so that the condition f / d <5 applies to the light spot and the associated optical elements,

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where f denotes the levitation height of a light spot above or below the area of the area, Diameter of the optical elements contributing to this light spot. This ensures that the light spots lie within the opening of the associated optical element for both eyes of the observer at a normal viewing distance of approximately 30 cm.

According to an advantageous variant of the invention, the light spots of the light spot image float above or below the surface area in several different levitation heights in order to form a three-dimensional motif. According to an alternative, likewise advantageous variant of the invention, the light patches of the light spot image are, as a matter of course, all suspended in the same levitation above or below the surface area in order to form a slide motif. Advantageously, a three-dimensional motif can also be combined with a two-dimensional motif in the light spot image, since a light spot image is then recognizable even in poor light conditions and thus a test for authenticity is possible. The optical elements advantageously comprise domed mirrors, in particular hollow mirrors (concavely curved mirrors) or convex mirrors (convex curved mirrors). The curved mirrors can be spherical, elliptical, rotationally symmetrical aspherical, non-rotationally symmetrical aspherical or gutter-shaped, in the latter case the channels can be rectilinear or curvilinear.

Elliptical mirrors have a different mirror curvature in the x and y directions. For aspheric mirrors, the mirror surface deviates from a spherical shape. Aspherical mirrors can be rotationally symmetrical or, in the most general case, non-rotationally symmetrical. Straight-line channel-shaped mirrors can be regarded as a special case of elliptical mirrors, in which the radius of curvature is infinite in a spatial direction. In order to realize a low structural height, the curved mirrors can also be at least partially formed by Fresnel mirrors. Alternatively or additionally, the optical elements can also comprise lenses, in particular spherical, elliptical, rotationally symmetrical aspherical, nonrotation-symmetrical aspherical or cylindrical lenses. Elliptical lenses have a different curvature in the x and y directions; in the case of aspherical lenses, the refractive lens surface deviates from a spherical shape. Aspherical lenses can be rotationally symmetrical or, in the most general case, non-rotationally symmetrical.

Cylindrical lenses can be regarded as a special case of elliptical lenses in which the radius of curvature is infinite in a spatial direction. The lenses can also be formed at least partially by Fresnel lenses in order to achieve a lower structural height.

In an advantageous variant of the invention, exactly one optical element is assigned to each light spot of the light spot image.

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According to an alternative, likewise advantageous variant of the invention, each light spot of the light spot image is assigned not just an optical element but a plurality of optical elements. Assignment here means that the optical element contributes to the generation of this light spot during illumination by reflection (reflection) and / or light refraction (refraction). The optical elements are preferably distributed in a distributed manner on the surface region. As a result of the resulting interspaces between the individual optical elements, a plurality of groups of optical elements, each of which is associated with different light spots, can then be interleaved in the same area. In this way, a particularly high spatial resolution in the light spot image can be achieved, as explained in more detail below.

As a further advantage of the assignment of a plurality of optical elements to a light spot, it has been found that due to the then possible smaller dimensions of the individual optical elements, elements with plane limiting surfaces can be used which are easier to calculate and to manufacture than a single curved optical element Same optical effect. In order to produce a light spot image in which the light spots have different brightnesses, advantageously each light spot of the light spot image is assigned such a number of optical elements which correspond to the brightness of the light spot within the motif formed by the light spots. If the optical elements are of different sizes, each light spot can also be assigned such a total area of optical elements which corresponds to the brightness of the light spot within the motif formed by the light spots.

Particularly preferably, the optical elements are formed by plane micro-mirrors or by small microprisms.

The predetermined motif may also be a change image showing different images from different viewing directions. A concrete example for the generation of such a change pattern is described below. It is understood that the term "alternating images" also includes those images in which only image parts are subjected to the change. In the case of change images, images or picture parts change when the viewing direction changes, in particular when the picture is tilted; Which is why such images are called tilting pictures. The change can be made by tilting horizontally or vertically, or tilting in a direction that is between horizontal and vertical.

If the change in image content abruptly, one speaks of flip images. If the change over intermediate stages is called morphing images. Furthermore, 2D 3D images can also be formed as light spot images. In addition to 3-dimensional parts (which appear in front of or behind the plane of the representation element or the plane of the representation element appear to be interspersed), 2-dimensionally acting parts are also present in or near the plane of the representation element (in the height step 0 or near Of altitude 0)

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In the case of a 2D 3D image, 2D and 3D parts can lie side by side and / or appear alternately at the same location when the viewing direction changes. With such a 2D-3D exchange image, For example, a two-dimensional image content (e.g. (Eg a font or a logo) can be blended into a 3D image.

In an advantageous variant of the invention, the predetermined motif produced by the display arrangement is a fully plastic body formed by the light spots.

According to a development of the invention, the surface area in which the plurality of optical elements are arranged can also be curved, for example cylindrically or spherically curved.

In a further variant of the invention, a partial quantity of the optical elements produces a hidden image information, which is not recognizable without the aid. The hidden image information is in contrast to the open image information formed by the above-described light spot image which can be seen with normal eyes without further aids with the naked eye. The hidden image information, on the other hand, is not readily visible to the naked eye under normal illumination, but is, for example, visible only with directed illumination with laser light or requires a special screen.

In an advantageous variant of the invention, the optical elements comprise a periodic arrangement of micro-mirrors each having a distance to the nearest neighbor of 2 mm or less, in particular of 1 mm or less. An observer then no longer recognizes the mirror images of the mirrors, but sees only one light point per mirror, the shape of which depends on the illumination of the surroundings. If the observer tilts the imaging element, the light points of the mirrors move somewhat to one side, depending on the design of the mirrors as a hollow or a mirror of the mirror, as if the light points were located before or preferably behind the plane of the display element. Due to the periodic arrangement of the micro-mirrors, the observer thus sees a regular grid of light points which, when the display element is tilted, preferably appears to move in such a way as to be located in a further rearward plane. The light-point grating can thus form the background for a further motif, for example for the arch effect described in the co-pending German patent application DE 10 2009 056 934.0, or for a sawtooth presentation with kinematic effect, such as the hologram structures of the printed document EP 0 868 313 B1 (Paragraph [0034] or

8 with reflective sawtooth structures).

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In order to protect the optical elements from contamination and abrasion, and in order to effectively prevent unauthorized adjustment by embossing the surface structure, the optical elements are advantageously embedded in an environmental layer or an environmental layer composite, in particular in a protective layer. Such an embedding generally changes the levitation height of the light spots, since a refractive index difference between embedding material and air or Embedding material and lens material changes the optical beam path. Such a change in the optical beam path can, however, be taken into account in the design of the optical elements so that, after embedding, the desired levitation heights are realized.

In an advantageous configuration, the optical elements are designed as pre-structures in an embossing lacquer layer. If the imaging element is at least partially reflecting, the pre-structures are preferably provided with a reflection-enhancing coating. A reflection-enhancing coating is, in particular, a full-area or rasterized metallization, a high-breaking coating, a thin-layer element with a color shift effect or a cholesteric liquid-crystal layer.

The structural heights of the pre-structures are preferably below 100 µm, preferably below 20 µm, particularly preferably below 5 µm.

The display elements according to the invention can be combined with other safety features, for example with diffractive structures, with hologram structures in all variants, metallized or non-metallized, with subwave length structures, metallized or nonmetallized, with subwave length gratings, with layer systems which show a color change during tilting, semitransparent or opaque , With diffractive optical elements, with refractive optical elements, such as prism beam sensors, with special perforated shapes, with safety features with specifically adjusted electrical conductivity, with incorporated materials with magnetic coding, with substances with phosphorescent, fluorescent or luminescent effect, with safety features on the basis Of liquid crystals, with matt structures, with additional microspheres, with elements with blind effect or with sawtooth structures. Further safety features with which the imaging elements according to the invention can be combined are given in the printed publication WO 2005/052650 A1 on pages 71 to 73; These are included in the present description.

The invention also includes a method of manufacturing a refractive imaging element of the type described, which is designed and adapted to produce, during illumination, a light spot image from a plurality of light spots which appear to be above a surface or below the surface area and which are arranged in the form of a predetermined Motifs. In the method, a substrate is provided and a plurality of refractive and / or reflective optical elements are arranged in a surface region of the

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substrate, wherein at least one refactive and / or reflective optical element is allocated to each light spot of the light spot image Of the light spot assigned to it.

According to an advantageous method variant,

A desired three-dimensional motif with image points Pj and height values Zj are specified over an xy plane, the image points corresponding to the light spots resulting from illumination, a brightness Ij between 0% and 100% is determined for each image point P, the image points Pj are assigned opening cones , Which have an opening ratio> 0.2,

A draw-in area Ej is determined for each image point Pj by an intersection of the opening cone which emanates from the image point with the xy plane,

The xy plane is divided into a number of coarse fields and the coarse fields are each divided into a number of fine fields,

A number of fine fields to be filled are determined for each pixel Pj on the basis of the fixed height value Zj and the fixed brightness value Ij,

The fine fields to be filled for the image point Pj are distributed substantially uniformly to the coarse fields in the area Ej of the image point Pj, and

The fine fields to be filled are occupied by refractive and / or reflective optical elements which contribute to the generation of the light spot corresponding to the image point Pj when the imaging element is illuminated.

According to a further advantageous method variant, a fully plastic body is represented by floating light points. A data set which describes the surface of the body to be represented by points in space, corner points of polygons, normal vectors and absorption (color, brightness) is preferably emanated from a data set.

Such data records, suitable data formats and processing methods are basically known to a person

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skilled in the art, examples being, for example, VRML (virtual reality modeling language), STL (surface tesselation language) or 3D CAD (3D computer-aided design). Records describing the surface of a body can be generated, for example, in computer-assisted technical drawing, or by 3D laser scanning of true three-dimensional bodies. In the latter method, when scanning a body with laser beams, points are detected in the space which describe the body. These points can be stored, for example, in the so-called point-cloud format in the computer.

In order to produce a 3D lighted spot image of a fully plastic body, such a data record has to be processed, as described in the following with reference to steps a) to c): a) lighting concept

To make the body surface visible, light-dark contrasts are required. The most natural effect of a body is when these light-dark contrasts are generated by means of an illumination concept. For this purpose, one or more light sources are thought to be placed outside the body and determine the surface brightness at all relevant points of the body by means of Lambert's Cosine law, the law of reflection or other suitable physical laws from the directions of the fictive light sources, the surface normals and the absorption behavior , B) light point generation

As described above, each of the relevant body points is associated with feed-in regions in an array of micro-mirrors or micro-prisms. Within the pull-in area, certain areas with micro-mirrors or micro-prisms are occupied in the manner described above in such a way that the body point illuminates in the desired brightness. C) Cover calculation

Finally, a fully-plastic body, viewed from a viewing direction, has a front and a back, so that some body parts are hidden and invisible. Therefore, for each microelement (resp. Microspheres, or microprisms), it is to be associated with only the point of the body surface closest to or remote from the compound straight IV microcomputer body point depending on which side the light spot image is to be viewed. This point of the body surface is determined by methods of concealment calculation, as known from 3D CAD, such as ray tracing or Z-Buff. If, in fact, hidden points are included in the light spot image, the body appears transparent, although this may also be desired in exceptional cases.

Finally, the invention also contains a data carrier with a display element of the described type, wherein the display element can be arranged, in particular, as a reflecting security element in an opaque region of the data carrier, or as a at least partially transparent security element in or over a transparent window region or a continuous opening of the data carrier , The data medium can be, in particular, a value document, such as a banknote, in particular a paper banknote, a polymer

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banknote or a foil banknote note, but also a credit card, a bank card, a cash payment card, an authorization card, a personnel ID card or a credit card Pass personalization page.

The invention further includes a display device with a control device and a display element of the type described above, the spatial alignment of the optical elements of the display element being adjustable by the control device. In this way, the display element can show different light spot images depending on the control. The change in the spatial orientation of the optical elements can thereby take place very rapidly, so that the impression of a continuous image sequence arises for the viewer. The display device can thus be used as a 3D display for a wide variety of applications. Finally, the invention provides a method for producing a volume hologram in which the laser radiation, which is scattered as a reference wave, is impaired in a recording plate, for example a photopolymer plate, and the laser radiation reflected or deflected by a representation element of the type described above is brought into interference as an object wave.

In the case of display elements with reflective optical elements, such as micro-mirrors, for example, the reflected laser radiation is used as the object wave, while in the case of display elements with refractive optical elements, such as microprisms, the deflected laser radiation is used as an object wave.

Further exemplary embodiments and advantages of the invention are explained in the following with reference to the figures, in which a representation which is faithful to scale and proportion has been dispensed with in order to increase the clarity.

Show it:

FIG. 1 is a schematic representation of a banknote with a security element according to the invention; FIG. 2 is a schematic of a first exemplary embodiment of the invention with FIG

FIG. 3 shows another exemplary embodiment of the invention with cube mirrors as reflective optical elements, FIG.

4 shows a predefined light spot motif in the form of a three-dimensional light pyramid, FIG.

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FIG. 5 shows (a) a camber mirror and in (b)

Mirror replaced cube mirrors of (a),

FIG. 6 is a plan view of a plurality of curved domes. FIG

(A) with mirrors with a square base and in (b) with gutter-shaped mirrors of different orientation,

FIG. 7 shows a further exemplary embodiment of the invention, in which the refractive optical elements are formed by lenses,

FIG. 8 in (a) to (d) shows four exemplary embodiments, in which a curved hollow mirror is divided into microoptical elements with a square base surface and flat mirror surface, FIG.

FIG. 9 shows the layout of a checkerboard-like arrangement according to FIG.

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8(B) with microspheres, wherein (a) shows an intermediate step with only one micro-mirror group, and (b) shows complete coverage with two micro-mirror groups for two closely adjacent light spots,

FIG. 10 illustrates the calculation of the planar mirror surfaces of the micro-mirrors of FIGS. 8 and 9,

FIG. 11 illustrates the calculation of microprisms resulting from the decomposition of a collecting lens, FIG. 12 schematically shows a safety element with embedded electrodes

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FIG. 13 shows in FIGS. (A) to (c) three embodiments in which a light spot image according to the invention serves as a master for a volume hologram.

The invention will now be explained with reference to the example of security elements for banknotes. FIG. 1 shows a schematic representation of a bank note 10 which is provided with a security element 12 according to the invention. The security element 12 can be designed as a reflecting security element, which is present in an opaque region of the bank notes 10, or can be designed as a transparency security element which is arranged, for example, over a transparent window region of the banknotes 10. In the case of illumination, for example by sunlight or a ceiling lamp, the safety element 12 generates a three-dimensional light spot image for a viewer from a plurality of light spots, which appear to float above or below the plane of the safety element 12 for a viewer. Different light spots have different levitation heights, so that the light spots together form a three-dimensional motif, for example a light pyramid protruding from the banknotes.

These light spot images, which arise from the lighting and spring back from the banknotes, offer the viewer an unusual, visually appealing three-dimensional image impression, which is easy to test and memorize even for laymen. 2 illustrates a first exemplary embodiment of a security element 20, in which the three-dimensional motif 30 is illustrated in simplified form by three image points 32. The security element 20 contains a substrate 22, which contains a plurality of small hollow mirrors 24 in a surface region. Since, in the figure, only three image points 32 of the subject are illustrated in a simplified manner, only three hollow mirrors 24 are shown correspondingly. However, it is to be understood that a safety element 20 will typically have a large number, for example several tens, a few hundred or even several thousand referective and / or reflective optical elements 24 in practice. Concrete examples of security elements with a large number of optical elements are described below.

2, the focal length f of the hollow mirror 24 arranged in the plane of the substrate 22 is selected such that the hollow mirrors 24 generate the predetermined image points as light spots 32 when illuminated with a far-away light source 34. More specifically, the light spots 32 represent real images of the light source, as indicated by the geometric beam path 36 in the left-hand image part of FIG. A three-dimensional image impression, ie, the perception of the observer 40 that the light spots 32 'float at a certain height above the surface of the substrate 22, is produced only by two-eyed vision. For this purpose, it must be ensured by the design of the hollow mirror arrangement that the real images 32 of the light source 34 lie for the two eyes 42 within the opening of the relevant optical system, in this case, therefore, a vertical mirror 24. 2, a light spot 32 is located

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exactly for both eyes 42 within the opening of the hollow mirror 24 when the opening angle ω of the hollow mirror 24 as viewed from the light spot 32 is greater than the viewing angle α of the observer 40. In the embodiment shown in FIG.

The opening angle ω is given by the ratio of the mirror diameter d and the focal length f, ω = d / f and the viewing angle α by the ratio of the eye distance a and the viewing distance b, that is, α = a / b. For a typical eye distance a »6.5 cm and a typical viewing distance b» 30 cm one thus obtains the condition f / d <b / a «5, that is the condition that the ratio of the levitation height f of a light spot 32 to the diameter of the light beam Light spot-producing hollow mirror 24 must be less than about 5. If the diameter of the hollow mirrors 24, as in the exemplary embodiment of FIG. 2, is, for example, d = 0.5 mm, then float heights of up to 2.5 mm with three-dimensional image impression can be realized. The re-active and / or reflective optical elements can have dimensions of several 100 µm or even a few millimeters, but can also be significantly smaller. For example, a hollow mirror can be divided into a plurality of microspiegels and these can be distributed over a specific area of the substrate 22, as explained in more detail below.

In any case, however, the dimension of an optical element used according to the invention is significantly above the wavelength of the lightwave, so that diffraction and interfering effects can be neglected. In particular, the dimension of the optical elements is therefore advantageously above 2 µm, preferably even above 5 µm.

The light spots 32 of the predetermined motif 30 can float for the observer 40 not only above but also below the surface 22 of the substrate. 3, for this purpose, a plurality of small warp mirrors 26 are arranged in a surface area of the substrate 22, the focal lengths of which are selected in such a way that the warp mirrors 26 produce the predetermined image points as light spots 32 when illuminated with a far- More specifically, in this case, the light spots 32 represent virtual images of the light source 34, which appear to float below the surface of the substrate for the observer, as indicated by the geometric beam path 38 in the right-hand image part of FIG.

Hollow and cambered mirrors, both can also be provided in the same safety element if parts of the motif protrude, other parts behind the substrate surface. 4 shows a predetermined motif in the form of a three-dimensional light pyramid 50 consisting of a plurality of light spots 52 which float above and below the surface of the substrate 22 at different levitation heights. In the exemplary embodiment of FIG. 4, all the curved mirrors are designed with a diameter of 0.5 mm. The focal length f is given as a positive value for hollow mirrors (floating height above the substrate surface), negative in the case of creeping mirrors (float height below the substrate surface). With this convention, the light spot 52-1 of the pyramid tip has a levitation height of f = + 2 mm while the

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light spots 52-2 and 52-3 of the pyramidal edges are at a height f = + 1.2 mm and f = + 0, 4 mm. The light spots 52-1 to 52-3 with their positive levitation heights are generated by hollow mirrors, as is already explained in principle in FIG.

In the pyramid 50, the light spots 52-4 and 52-5 have a levitation height of f = -0.4 mm and f = -1.2 mm, respectively, for the observer, below the substrate surface 22. The pyramid base is finally formed from light spots 52-6, which have a float height of f = -2 mm and thus lie 4 mm below the pyramid tip 52-1.

For all light spots 52 the condition | F | / D <5 so that the pyramid 50 appears to be truly three-dimensional for the viewer at a normal viewing distance and the substrate plane appears to penetrate from the bottom to the top.

The levitation height of the light spots is determined by the radius of curvature of the arched mirrors, as shown in FIG. 5 (a) for a curved mirror 60. For a diameter d and a radius of curvature r, the deflection mirror 60 has a focal length of f = r / 2. For example, with a mirror diameter d = 0.5 mm for a focal length or A radius of curvature of r = 4 mm is required. In this case, the structure height of the deflection mirror is obtained by the relation h * (2r-h) = (d / 2) <2> to h = 7.8 μm.

Depending on the desired levitation height, mirror structures can be provided, the height h of which is too great for a desired application, for example because a maximum permissible embossing height or a pre-depth depth in an embossed layer is exceeded. In this case, the concave mirror 60 of FIG. 5 (a) can be replaced with a corresponding Fresnel mirror 62 having a substantially lower structural height hf, as shown in FIG. 5 (b). The zone widths z of the Fresnel zones 64 can be chosen arbitrarily as long as they are large compared to the wavelength of the light wave, in particular as long as z> 2 μm. Otherwise, the width z of the Fresnel zones 64 plays no role for the optical efficiency of the Fresnel mirror 62. If the domed mirrors of a safety element have several different focal lengths, the light spots of the light spot image thus have several different levitation levels above and / or below the substrate surface, a genuinely three-dimensional motif is created.

In some embodiments, however, it is also possible to provide all curved mirrors with the same focal length, so that all light spots of the light spot image have the same levitation height. In this way, a slide motif is created that floats above or below the substrate surface at a certain height.

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The curved mirrors do not have to be spherically curved. As optical elements according to the invention, it is also possible, for example, to use elliptical hollow or mirrored mirrors, which have a different mirror curvature in the x and y directions. Since the focal length f of a curved mirror is proportional to the radius of curvature r, the rotation height f of the associated light spot for the observer changes when an elliptically curved mirror is rotated.

If a given motif contains at least partially elliptical hollow or convex mirrors, the light spots in the burner planes of the respective parts rise against the background when the arrangement is rotated or sink into the background. This effect is particularly noticeable when the light spots rising or falling as they rotate are combined with light spots which do not change during rotation and which represent a stationary reference point for the eye.

With reference to the plan view of FIG. 6 (a), the plurality of arched mirrors 70, for example with a rectangular or square base area, can be arranged in a surface area 72 of the safety element.

For a three-dimensional image impression for an observer, a lateral parallax, that is to say a parallax along the connecting line of the two eyes 42 of the observer 40, suffices. The curved mirrors 74, 76, 78 can therefore also be formed in the form of a trough, as shown in the plan view of FIG. 6 (b). Mold-shaped domed mirrors have a non-zero curvature only in one direction, namely perpendicular to the channel, while the curvature disappears in the direction of the channel.

A picture constructed from a gutter-shaped, arched mirror 74, 76, 78 also allows attractive visual effects to be realized. The light spots appear at a suitable viewing angle above or below the substrate surface, suspended in the form of luminous lines suspended in the air. Because of the juxtaposed eyes, the strongest spatial effect is obtained in the case of an SD picture with grooves 74 running perpendicular to the connecting line of the eyes 42. However, slanting grooves 76 also have a vertical portion and thus also produce a light spot image with a three-dimensional effect.

When an image is rotated (80) with oblique grooves 76 in the image plane, the three-dimensional effect is enhanced. If the observer rotates the grooves 76 into the horizontal, the three-dimensional impression is reduced. 6 (b), the light spots of the respective subregions are raised against the background when the assembly (80) is rotated (80). FIG The background.

In this case, gutter-shaped domed mirrors are to be understood as gutter-shaped hollow mirrors as well as gutter-shaped concave mirrors. Channel-shaped hollow mirrors generate light spots that

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float above the substrate surface, while gutter-shaped concave mirrors generate light spots that float below the substrate surface.

Further, the trough-shaped domed mirrors do not need to be straight, as shown in FIG. 6 (b), but may also be curved. Attractive visual effects can also be achieved by such a design.

In another embodiment variant illustrated in FIG. 7, the optical elements are formed by refractive lenses instead of reflecting mirrors. In this case, the refractive security element 90 represents a transparency security element, which is examined by the observer 40 for transparency in view of an ideally remote light source 95. As lenses, both collection lenses 92 and scattering lenses 96 can be considered, whereby the convex collecting lenses 92 generate real light spots 94 as real images above the safety element 90, and the concave scattering lenses 96 float as virtual images below the safety element 90, viewed from the viewer 40 Light spots 98.

The lenses can be spherical, elliptical or cylindrical in particular. Cylindrical lenses produce dot-like light spots; in the case of elliptical lenses, the levitation height of the light spots changes as the ellipsoid mirrors have already been described. For the plano-convex or plano-concave lenses 92, 96 shown in FIG. 7, the diameter d, the radius of curvature r, the focal length f and the lens height h with a refractive index of the lens material of n = 1.5,

$$F = 2 * r \text{ and}$$

$$H * (2r-h) = (d / 2) <2>$$

Given a given lens diameter d and a given desired float height f, the radius of curvature r and the structural height h of the lens can thus be determined. If the structural height of a lens is too large for a desired application, the lenses can also be replaced by corresponding Fresnel lenses as described in connection with FIG. 5 for Fresnel mirrors. Here, too, care must be taken that the zone widths of the Fresnel zones are large compared to the wavelength of the lightwave, but otherwise can be chosen as desired.

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In the embodiments described so far, each light spot of the light spot image is assigned precisely one optical element which produces this light spot during illumination, namely a hollow mirror 24 (FIG. 2), a mirror mirror 26 (FIG. 3), a collecting lens 92 or a scattering lens 96 FIG. 7), The resolution achievable in the light spot image, ie, the minimum distance between two light spots in the light spot image, is, however, limited to the diameter d of the curved mirror or lens in such a design. This diameter is in turn coupled to the levitation height of the light spots via the above-mentioned condition for a three-dimensional image impression f / d <5. A high resolution in the light spot image is thus only achievable for low levitation levels and thus a low three-dimensional effect.

In order nevertheless to obtain a higher resolution in the generated light spot image with an unchanged high levitation height, the large mirrors or lenses used in the present exemplary embodiments are each replaced by a plurality of smaller micro-mirrors or microprisms which together have essentially the same optical effect as the original optical element , For the sake of simplicity, micro-mirrors and micro-prisms are hereinafter collectively referred to as microoptical elements.

A plurality of optical elements in the form of microoptical elements are then assigned to each light spot of the light spot image. The higher resolution in the light spot image is thereby achieved by the fact that the microoptical elements are not distributed in a continuous manner next to one another, but at a distance on the surface area. The interstices of the optical elements of a light spot can then be covered with optical elements which are associated with other light spots. In this way, a plurality of groups of microoptical elements, each of which is associated with different light spots, can be arranged interleaved in the same area.

The spatial distance between two light spots in the light spot image is then no longer given by the dimension of the original large mirrors or lenses but by the much smaller dimensions of the microoptics elements into which the original mirrors or lenses are disassembled.

In addition, in the case of the decomposition of a curved mirror or a curved lens into a plurality of microoptical elements, the surfaces of the microoptical elements which are in the first case likewise curved are, as a rule, replaced by planar surfaces because of their small size. This replacement remains particularly when the dimensions of the microoptical elements are smaller than the resolution capability of the viewing situation, without adversely affecting the generated light spot image. As an advantage it is found that microoptical elements with flat surfaces are easier to calculate and to manufacture. From this point of view, it may even be advisable to dissect curved mirrors or lenses into small microoptics elements with planar surfaces if no interleaving of

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several groups of microoptical elements is desired or necessary.

For illustration purposes, FIG. 8 in (a) to (d) shows four exemplary embodiments in which a curved hollow mirror is divided into microoptics elements 100 having a square base surface and a plane mirror surface. In the exemplary embodiment of FIG. 8 (a), a hollow mirror for generating a light spot is replaced by an arrangement of n × n micro mirrors 100, which are arranged side by side without any spacing in the surface of the safety element. The micro-mirrors 100 have, for example, a dimension of 50 µm × 50 µm and can be formed with a flat mirror surface without impairing the imaging quality. The number n x n of the micro-mirrors is, for example, 10 × 10, so that the micro-mirrors occupy a total area of 0.5 mm × 0.5 mm. The calculation of the orientation of the planar mirror surfaces is explained below with reference to FIG. As will be apparent to those skilled in the art, the calculation and fabrication of the planar micro-mirrors 100 is much simpler than the calculation and fabrication of a curved hollow mirror having the same optical effect.

The embodiment of FIG. 8 (b) shows a configuration in which a curved hollow mirror is first replaced by a plurality of micro mirrors 102 with a flat mirror surface, as in FIG. 8 (a). However, the micro-mirrors 102 are arranged in the manner of a chessboard in the area of the security element so that every second mirror position remains free. These fields 104, which are initially unoccupied and are shown white in the figure, can then be covered with microspheres which are assigned to a different light spot.

The resolution of the light spot image can be significantly increased by such an interlacing of micro-mirror groups. For example, if two light patches, which float at a height of 5 mm, lie only 0.2 mm next to each other, then curved mirrors or lenses with a

Focal length f = 5 mm is required. As described above, the diameter and the focal length of the optical elements have to satisfy the condition f / d <5 for a three-dimensional effect, resulting in an optical diameter d> 1 mm for the given specifications. Adjacent arched mirrors or lenses would thus have to be spaced by more than 1 mm so that the required resolution of 0.2 mm can not be achieved in this way.

8 (b), in which only every second field with 50 micro-x 50 micro-mirrors of large microspots 102 is used for generating the first light spot, the intervening fields 104 can be provided with micro-mirrors which have a Second 0.2 mm adjacent light spot. The condition f / d <5 requires an optical

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diameter of more than 1 mm, which is for example by means of a checkerboard-like arrangement of 12 x 12 micro-mirrors 102 with 12 × 12 free fields 104 and thus d = 2 × 12 × 50 µm = 1.2 mm can be achieved. The minimum distance of the light spot produced by the micro-mirror group 102 and the second light spot produced by the microspiegels arranged in the fields 104 is now 50 µm, so that the required resolution of 0.2 mm can be achieved without difficulty.

The occupation of a checkerboard-like arrangement according to FIG. 8 (b) with micro-mirrors is again illustrated in FIG. 9 in a sectional view.

With reference to FIG. 9 (a), every second field is occupied with microscopes 102 of 50 µm x 50 µm to produce the first light spot 110. The

Micro mirrors 102 form a group of microspheres, all of which are associated with the same light spot 110 and which generate them together when illuminated. The fields 104 located between the micro mirrors 102 are available for the micro-mirror assignment associated with other light spots. In the extreme case, the fields 104 may be provided with micro-mirrors 106 which serve to produce a light spot 112 which is only a micro-mirror diameter dm, in the exemplary embodiment 50 µm, from the first light spot 110, as illustrated in FIG. 9 (b).

9, the optical diameter d of the micro-mirror groups 102, 106 in the case of the alternating mirror arrangement is given by d = 2 * n * dm, where n is the number of the micro-mirrors of a group in a spatial direction. By suitable selection of n, the optical diameter d can therefore always be made large enough to satisfy the condition f / d <5 despite the high resolution dm.

Returning to the representation of FIG. 8, it is understood that the occupancy of the area of the security element can be selected according to the desired number of groups to be interleaved of microoptical elements. For example, it is also possible to occupy only every fourth field with micro-mirrors 102 which are assigned to a specific light spot as illustrated in FIG. 8 (c). The fields 104 which are initially still free in the figure, can then be covered with microspheres which are assigned to up to three other light spots. In another embodiment, each ninth field is occupied by the microspots 102 associated with a particular light spot, as shown in FIG. 8 (d). The fields 104 which are initially still free in the figure, can then be covered with microspheres, which are assigned to up to eight other light spots.

The calculation of the planar mirror surfaces of the micro-mirrors is illustrated in FIG. Shown in the

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cross-section are some of the microspiegels 102 and the interposed free fields 104 of a configuration according to FIGS. 8 (b) and 9 (a). The position of the mirror spot to be calculated, n is the normal vector of the mirror at the position (x, y). For the calculation (xo, yo, , 0), k is the directional vector of the incident light beam, and p is the directional vector of the reflected light beam.

The position of the mirror surface, that is to say the normal vector n, is determined in each case so that the light incident from a predetermined direction k is reflected to the focal point (xo, yo, zo) for all the mirrors 102 assigned to the light spot 110. This is achieved according to the invention

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If the light source 120 is at the position (xL, yL, ZL),

If the micro-mirror group 102 is designed for vertical light incidence, 0 is such that the normal vector n becomes

, Where the abbreviation <~> = j (x0 - x) <2> + (y0 - y) <2> + z0 <2> was used.

In an analogous manner, the normal vector n can be calculated for micro-mirrors whose focal point (xo, yo, zo) with zo <0 lies below the plane of the safety element. To this end, one proceeds according to the invention from the relationship

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, The further calculation is carried out as with hollow mirrors.

Curved lenses can be reproduced by micro microoptics by small microprisms which, when the size of the microprisms is below the resolving power of the viewing situation, can be used with the same optical effect, but are easier to calculate and to manufacture.

In FIG. 11, a microchip 122 is shown in cross-section for illustration in a checkerboard-like disassembly, as in FIG. 8 (b). Analogous to the procedure for the micro-mirrors 102, the normal vector n can also be calculated for the microprisms 122 such that the light incident from the light source 120 is broken to the desired position of the light spot 110, respectively. The fields 124 which are free in FIG. 11 can be occupied by microprisms which are assigned to a different light spot.

In all the variants described, the refractive and / or reflective optical elements could also be embedded in an ambient material or provided with a protective layer. Such an embedding protects the optical elements against contamination and abrasion and, on the other hand, prevents unauthorized readjustment by embossing the surface structure.

The embedding is schematically shown in FIG. 12 for a safety element 130 with micro-mirrors 132. By embedding the microspheres 132 in the transparent protective layer 134 and the resulting crack of the refractive index on the surface 136 of the protective layer 134, the position of the generated light spot 140 changes relative to the light spot position 142 in the case of a non-embedded micro-mirror arrangement. More specifically, upon embedding the microspheres 132 in a protective layer having a refractive index n, the levitation height of a light spot 140 generated by the micro-mirrors 132 changes approximately by a factor of 1 / n. Conventional protective lacquer layers 134 have a refractive index of approximately n = 1.5 such that the suspended heights of the light spots decrease by approximately 2/3 compared to the suspended heights calculated for an open application. As a rule, this change is already taken into account in the design of the micro-mirror arrangement, so that the desired levitation levels are achieved after embedding.

In the case of embedded prisms or lenses, the difference in refractive index between prisms or prisms can be reduced. Lens material and embedding material can be correspondingly taken into account in the calculation of the light beam deflection. In order to produce a visually appealing

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three-dimensional light patch bump, the light patches may have different brightnesses. It may also be desirable that a light spot, that is to say a point of a motif suspended in space, appears differently bright from different directions. Such different brightnesses of light spots can be produced in various ways within the scope of the invention. For example, the optical elements which are associated with a light spot can be darkened according to the desired fraction of the maximum brightness.

However, at present, it is preferred to adjust the brightness of a light spot after disassembly into microoptical elements over the area portion occupied by microoptical elements or the number of fields which are responsible for the angle of the space for a light spot. This results in image areas which do not contain mirrors or prisms directed at a light spot and which must be kept dark.

Such image regions can be produced, for example, in one of the following ways. In a first variant, the darker parts in the reflecting light spot are provided with light traps, for example with subwave length structures, such as moth eye structures, or with funnel-shaped, reflecting structures with stepped flanks in which incident light is reflected back slightly or not at all. However, due to the stepped flanks, such light traps are not easy to manufacture. Therefore, it is advisable to equip the dark parts in the reflecting light patches with mirrors which are oriented in such a way that they reflect reflective areas which do not contain light sources. The mirrors can, for example, be directed towards the body of the observer. In the case of transparency elements, the dark parts are preferably provided with prisms which direct light beams from directions towards the eye of the viewer in which there are no light sources, for example from the floor.

The area in which the optical elements are arranged does not have to be flat, but can be curved in any manner. This is achieved particularly easily if the optical elements are formed by small microoptical elements. Since a normal vector is calculated for each micro-optic element (FIGS. 10, 11), the local position and orientation of the surface of the safety element can be taken into account without great additional expense, as explained below in the example of a micro-mirror arrangement:

If the position of the desired light spot, (x, y, z) the position of a micro-mirror in space, this position including the curved surface of the safety element, further denotes the normal vector of the micro-mirror at the position (X, y, z), k is the directional vector of the incident light beam, and p is the directional vector from the micro-mirror to the light spot, then according to the invention

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The upper sign for zo> 0, that is, a real image floating above the substrate plane, and the lower sign for zo <0, ie a lower image below the substrate plane , Virtual image applies. In a further development of the invention, the security element can also generate a light patch interchange image during illumination in which different images are visible to the viewer from different directions. For this purpose, it is possible, for example, to proceed as follows for a reflecting security element: the procedure for a transparency element is analogous:

The safety element is intended to show a change of image from a light spot image A to a light spot image B during lateral tilting. First of all, the required optical elements which generate the light spot images during illumination are determined for both light spot images. As described in connection with FIGS. 8 to 10, a plurality of optical elements, in this case a plurality of microspheres, is assigned to each light spot. In the arrangement of the micro-mirrors in the surface area of the safety element, those micro-mirrors are then omitted for the light spot image A, in which the x-component nx of the normal vector is greater than zero. As a result, half of the mirror spaces are free and the image is visible only in a limited angular range.

For the light spot image B, those microspheres are omitted in which the x component nx of the normal vector is less than zero. With this reduced mirror arrangement, the liberated mirror locations of the light spot image A are occupied. When the arrangement is laterally tilted, the light spot image A and the light spot image B are alternately visible.

The security element can also be designed for vertical tilting, for example by omitting for the light spot image A those micro-mirrors in which the y-component of the normal vector ny is greater than zero, and for the light spot image B the micro-mirrors for which ny <0. The reduced mirror arrangements with their limited visibility range are then mixed on the area of the security element.

Instead of the stated conditions, other criteria for the separation of the light spot images of a change image can, of course, also be used. For example, three light patch images A, B, C can change during the vertical tilting by the conditions ny> ci for image A, ci <ny <c2 for image B, ny <c2 for image C with two numerical values ci <c2. By selecting the numerical values c i and c 2, the size of the visibility regions can be set as desired.

In addition to the alternation between several 3D light spot images, a changeover between one or more 3D light spot images and one or more images produced in other ways can also be considered.

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It may also be useful to combine in the light spot image a three-dimensional motif with a two-dimensional motif in which all image points lie at the same height, preferably at the level of the plane of the security element or the plane of the security element. Such two-dimensional light spot motifs can still be recognized well even under poorer illumination conditions. If, for example, a two-dimensional foreground motif is combined with a three-dimensional background motif, the light spot image does not disappear completely even in poor light conditions, but is merely reduced to the more robust two-dimensional foreground motif. An authenticity test is therefore still possible even in poor light conditions.

A light spot image can thus contain, in addition to floating 3D light spots which are visible from certain viewing angles, also two-dimensional appearing areas which are visible from the same or different viewing angles. The 2D and 3D parts can thus be juxtaposed and / or appear alternately at the same location when the viewing direction changes.

In the case of 2D 3D images, two-dimensionally active parts at the level of the security element or near the three-dimensionally active parts (which are to be seen in front of or behind the plane of the security element or the plane of the security element appear to pass through) Level of safety element (in altitude 0 or near altitude 0).

For a range in height zero, one can start from the mirror or prismatic arrangement, which for light points at low altitude (eg. The height 0.5 mm) is calculated with the desired viewing angle range. Here, all standard vectors are used, which use the indicated angle of the room. While the microspheres or microprisms are arranged in the plane of the safety element so that certain points in the room are operated, the thus calculated micro-mirrors, including their inclination, must be statistically distributed in the area provided for the height 0. In this way, Then, no specific points are illuminated in the room, but a space angle is served as desired. For smaller intensities, this surface, which is mixed in statistical terms, must be correspondingly gapped, Eg not all pixels are occupied or the pixels are not fully occupied.

According to another development, the light spot image has a hidden image information (Hidden Image) in addition to the open-view image information. For this purpose, the optical elements of the open image information are arranged at a distance and the gaps are at least partially occupied by optical elements of the hidden image information.

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A hidden image information can be generated, for example, by assigning very small opening angles to the associated light spots, such as an opening angle = 0 for parallel light.

The light spots of the hidden image information can also be assigned different directions, which are so far apart that no coherent image is acquired when viewing without aids. The image can be captured on a matte screen to verify the authenticity. The directions of the hidden image information are preferably outside the directions under which the open 3D light spot image is viewed, so the presence of hidden information is not readily apparent.

In an advantageous embodiment, the optical elements of the hidden image information are accommodated partially or completely in closely adjacent partial regions of the security element and, if necessary, are repeated several times over the surface of the security element. The hidden image information can then be recorded successively or as a whole by illumination with a narrow laser beam and projected onto a suitably placed screen.

A particularly preferred procedure for producing a general three-dimensional light spot image will now be described in detail. Firstly, a desired three-dimensional motif with image points Pj and height values Zj above the xy plane is defined, the image points corresponding to the light spots resulting from illumination. For a normal viewing distance of approximately 30 cm, the pixel spacings should be in the range from 0.1 to 0.5 mm. Furthermore, a brightness Ij between 0% and 100% is assigned to the image points Pj. Then, image points are assigned to opening cones having an opening ratio> 0.2, for example, an opening ratio of 0.4. For each image point Pj, the intersection of the opening cone which emanates from the image point and the xy plane there defines a drawing-in area Ej to the image point Pj.

The xy plane itself is divided into first, larger fields, for example a dimension of 0.1 mm × 0.1 mm. Each of the larger fields is further divided into second, smaller fields, for example a size of IOμιτι x IOμτπ. The larger fields are referred to below as coarse fields, the smaller fields as fine fields.

In the intake region Ej of each image point Pj, so many fine fields are reserved for this image point, as determined on the basis of the height value Zj and the brightness value Ij. For example, the fine field number can be selected in proportion to the brightness value and inversely proportional to (Zj) <a> with an exponent α 1, the light spots α = 1 formed by channel-shaped mirrors or cylindrical lenses and light spots α = 2-dimensionally focusing lenses or mirrors 2. The fine fields reserved for the image point Pj are then distributed substantially uniformly to the coarse fields in the area Ej of the image point Pj.

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The number of fine fields per coarse field can in this case also be influenced by a correcting actuator, which is determined as follows, for example: First, the number of fine fields to be assigned, which belong to different image points P, are allocated within each coarse field. This results in a guideline for the number of the total fine fields in each coarse field.

If the number of occupied fine fields for all coarse fields is less than the maximum possible number, a correction factor greater than 1 can be selected and the allocation with this correction factor can be multiplied so that the maximum allocation is achieved in some coarse fields. If, on the other hand, the number of occupied fine fields exceeds the maximum occupancy, then a correction factor less than 1 is selected which, after multiplication, leads to a occupancy of less than or equal to the maximum occupancy. If the maximum occupancy is exceeded in only a few coarse fields, only the highest intensities can be capped to the maximum occupancy instead of an even reduction, or the fine fields of the crossing coarse fields are shifted to adjacent coarse fields.

The thus obtained occupancy can now be realized in the area of the safety element. Mirrors or prisms are arranged in the occupied fine fields, which reflect or break the incident light onto the corresponding light spot. Additional security elements can be introduced into the region of the security element which is free of the process, for example a hidden image of the type described above can be accommodated there.

A light spot image according to the invention can also serve as a master for a volume hologram, as now illustrated by means of three embodiments with reference to FIG.

In the embodiment of FIG. 13 (a), a display arrangement 140 serves as a master, which has a reflective 3D light spot image with micro-mirrors, which is calculated for perpendicular light incidence. A photopolymer plate 142 serves as a recording plate for the volume hologram. The photopolymer plate 142 is arranged in front of the display arrangement 140 so that the laser radiation of the recording laser 144 after the beam width 146 as the reference wave 148 perpendicularly impinges on the photopolymer plate 142. Part of the laser radiation passes through the photopolymer plate 142, falls perpendicularly to the imaging arrangement 140, and after reflection on the imaging arrangement 140, forms the object wave which interferes with the reference wave 148 in the photopolymer plate 142. Bragg gratings, which as the volume grating image show the same 3D image as the 3D light patch image of the display arrangement 140 serving as a master, are thereby imparted to the photopolymer plate 142.

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In the modification of FIG. 13 (b), the display arrangement 140 serving as a master contains a reflective 3D light spot image which is calculated for light incidence at a certain angle to the vertical. Correspondingly, the imaging arrangement 140 and the photopolymer plate 142 arranged in front of the imaging arrangement are acted on by the laser radiation at this angle. By interference of the reference wave 148 and the object wave reflected by the imaging arrangement after irradiation of the photopolymer plate 142, a volume lattice image is generated in the photopolymer plate 142 which exhibits the same 3D image as the 3D light spot image as the master of the display arrangement 140.

Finally, in the embodiment of FIG. 13 (c), a display arrangement 140 with a refractive 3D light spot image with microprisms calculated for perpendicular light incident serves as a master. Here, the imaging arrangement 140 and the photopolymer plate 142 arranged in front of the imaging arrangement are subjected to laser radiation from opposite sides by means of a beam splitter 150 and deflecting mirror 152. In the photopolymer plate 142, the reference wave 148 and the object wave refracted by the display arrangement 142 interfere and thus produce a volume lattice image which exhibits the same 3D image as the 3D light spot image serving as the master of the display arrangement 140.

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CLAIMS WO2012048847

[2]

F a t e n s p ro u b h 1. A display element comprising a substrate with a surface region in which a plurality of optical elements are arranged, characterized in that the display element is designed and designed to generate, during illumination, a light spot image from a plurality of light spots which are suspended above or below the surface region for an observer Wherein the optical elements are formed by reflective and / or reflective optical elements, and at least one refractive and / or reflective optical element is assigned to each light spot of the light spot image, said refractive and / or reflective optical element being arranged to illuminate the display element for the generation Of the light spot assigned to it. 2, 4. The imaging element as claimed in claim 1, wherein the light spot and the associated optical elements are respectively f / d <5, where f is the float height of the light spot above or below the surface area, and d is the diameter of the optical elements contributing to this light spot.

[7]

3, A display element according to claim 1 or 2, characterized in that the light spots of the light spot image float above or below the surface region in several different levitation heights in order to form a three-dimensional motif. 4, A display element as claimed in claim 1 or 2, characterized in that the light spots of the light spot image all of them float above or below the surface region in the same

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levitation height in order to form a slide motif. 5, A display element according to at least one of Claims 1 to 4, characterized in that the optical elements comprise curved mirrors, in particular hollow mirrors or concave mirrors. 6, A representation element according to claim 5, characterized in that the curved mirrors are spherical, elliptical, rotationally symmetrical aspherical, non-rotationally symmetrical aspherical or gutter-shaped, the grooves being rectilinear or curvilinear in the latter case. 7, A display element according to claim 5 or 6, characterized in that the curved mirrors are at least partially formed by Fresnel mirrors.

[12]

8, A display element according to at least one of claims 1 to 7, characterized in that the optical elements comprise lenses, in particular spherical, elliptical, rotationally symmetrical aspherical, non-rotationally symmetrical aspherical or cylindrical lenses. 9, A display element according to claim 8, characterized in that the lenses are at least partially formed by Fresnel lenses. 10, A display element according to at least one of claims 1 to 9, characterized in that precisely one optical element is assigned to each light spot of the light spot image. 11, A display element as claimed in at least one of claims 1 to 9, characterized in that a plurality of optical elements is assigned to each light spot of the light spot image, preferably the optical elements are distributed in a distributed manner on the surface region. 12, A display element according to claim 11, characterized in that the light spots of the light spot image have different brightnesses and to each light spot is assigned such a number of optical elements which corresponds to the brightness of the light spot within the motif formed by the light spots or to each light spot such a total area of optical light Elements corresponding to the brightness of the light spot within the motif formed by the light spots.

[17]

13, A display element according to claim 11 or 12, characterized in that optical elements, which are assigned to different light spots, are interleaved in the surface area. 14, A display element according to at least one of claims 11 to 13, characterized in that the optical elements are formed by planar micro-mirrors or by small microprisms. 15, A display element according to at least one of Claims 1 to 14, characterized in that the predetermined motif is an interchangeable image which shows different images from different viewing directions. 16, A display element according to at least one of claims 1 to 15, characterized in that the surface area in which the plurality of optical elements is arranged is curved. 17, A display element according to at least one of Claims 1 to 16, characterized in that a partial quantity of the optical elements produces a hidden image information which is not recognizable without the aid.

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[19]

[22]

18, A display element according to at least one of Claims 1 to 17, characterized in that the optical elements comprise a periodic arrangement of microspheres, each of which has a distance to the nearest neighbor of 2 mm or less. 19, A display element according to at least one of claims 1 to 18, characterized in that the optical elements are embedded in an environmental layer or an environmental layer composite, in particular in a protective layer. 20, A display element according to at least one of claims 1 to 19, characterized in that the optical elements are designed as pre-patterning structures in an embossing lacquer layer. 21, A display element according to claim 20, characterized in that the pre-structures are provided with a reflection-enhancing coating, in particular with a metallization, a high-refractive coating, a thin-layer element with a color shift effect or a cholesteric liquid crystal layer. 22,

[25]

A display element according to claim 20 or 21, characterized in that the pre-structures have structural heights of less than 100 µm, preferably less than 20 µm, more preferably less than 5 µm. 23, A display element according to at least one of Claims 1 to 22, characterized in that the predetermined motif is a fully plastic body formed by the light spots. 24, A display element as claimed in at least one of claims 1 to 23, characterized in that the display element is a security element for security papers, documents of value and other objects to be secured, in particular a safety thread, a safety tape, a safety strip, a label or a transfer element. 25, A method of manufacturing a display element as claimed in any one of claims 1 to 24 adapted and adapted to produce, during illumination, a light spot image of a plurality of light spots which appear to a viewer above or below the surface area and arranged in the form of a predetermined subject , Wherein a substrate is provided in the method and a plurality of refractive and / or reflective optical elements is arranged in a surface region of the substrate, wherein at least one refractive and / or reflective optical element is assigned to each light spot of the light spot image, which illuminates when the display element is illuminated For producing the light spot assigned to it.

Method according to claim 25, characterized in that a desired three-dimensional motif with image points Pj and height values Zj is defined over an xy plane, the image points corresponding to the

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light spots resulting from illumination, a brightness Ij between 0% and 100% , For each image point Pj, an indentation region Ej is defined for each image point Pj by an intersection of the opening cone which emanates from the image point and the xy plane is set into a region of the image Number of coarse fields and the coarse fields are each divided into a number of fine fields, a number of fine fields to be filled can be determined for each pixel Pj on the basis of the fixed height value Zj and the fixed brightness value Ij, the fine fields to be filled for the image point Pj being determined Substantially evenly on the coarse fields in the entry area I Ej of the image point Pj, and the fine fields to be filled are occupied with refractive and / or reflective optical elements which contribute to the generation of the light spot corresponding to the image point Pj when the imaging element is illuminated.

[31]

27, Data carrier with a display element according to at least one of claims 1 to 24. 28, A data carrier according to claim 27, characterized in that the display element is a at least partially transparent security element which is arranged in or over a transparent window region or a through opening of the data carrier. 29, A data carrier according to claim 27, characterized in that the display element is a reflecting security element which is arranged in an opaque region of the data carrier. 30, A data carrier as claimed in at least one of claims 27 to 29, characterized in that the data carrier is a value document, such as a banknote, in particular a paper banknote, a polymer banknote, a sheet banknote note or a document, a passport or a card. 31, A display device with a control device and a display element according to one of claims 1 to 24, wherein the spatial orientation of the optical elements of the display element can be adjusted by the control device.

[32]

32, A method for producing a volume hologram in which laser radiation which is not scattered in a recording plate as a reference wave and the laser radiation reflected or deflected by a representation element according to one of claims 1 to 24 is brought into interference as an object wave.

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SECURITY ELEMENT FOR AN ARTICLE TO BE PROTECTED AND ARTICLE TO BE PROTECTED WITH SUCH A SECURITY ELEMENT

Inventor(s): RAHM MICHAEL [DE]; KAULE WITTICH [DE]; HEIM MANFRED [DE]; RAUCH ANDREAS [DE]; SCHINABECK JOSEF [DE]; GREGAREK ANDRE [DE]; HILGENRAINER ANGELIKA [DE] ± (RAHM, MICHAEL, ; KAULE, WITTICH, ; HEIM, MANFRED, ; RAUCH, ANDREAS, ; SCHINABECK, JOSEF, ; GREGAREK, ANDRE, ; HILGENRAINER, ANGELIKA)

Applicant(s): GIESECKE & DEVRIENT GMBH [DE]; RAHM MICHAEL [DE]; KAULE WITTICH [DE]; HEIM MANFRED [DE]; RAUCH ANDREAS [DE]; SCHINABECK JOSEF [DE]; GREGAREK ANDRE [DE]; HILGENRAINER ANGELIKA [DE] ± (GIESECKE & DEVRIENT GMBH, ; RAHM, MICHAEL, ; KAULE, WITTICH, ; HEIM, MANFRED, ; RAUCH, ANDREAS, ; SCHINABECK, JOSEF, ; GREGAREK, ANDRE, ; HILGENRAINER, ANGELIKA)

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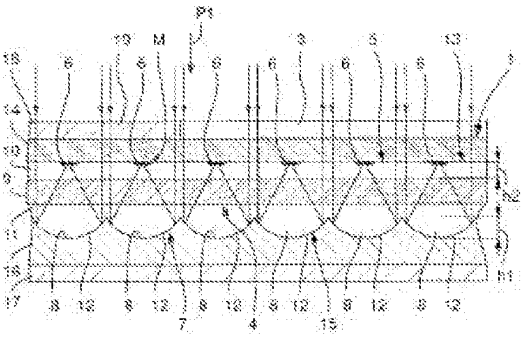
Abstract of WO2011012460 (A2)

The invention relates to a security element for an article (2, 37) to be protected, having an upper face (13) and a lower face (15), one or more imaging optical arrangements, which all image a respective associated object to a magnified scale only in front of the upper face (13), wherein the one optical arrangement or at least one of the optical arrangements comprises a plurality of reflective micro-imaging elements (8) arranged two-dimensionally in a first pattern, and the associated object is in the form of a

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microstructure object having a plurality of microstructures (6), which are arranged in a microstructure pattern so matched to the first pattern that the microstructure object is imaged to a magnified scale in front of the upper face (13) by means of the reflective micro-imaging elements. On both its upper face (13) and its lower face (15) the security element (1) has an adhesive layer (14, 16), with which the security element (1) can be embedded in the article (2, 37) to be protected such that both the upper face (13) and the lower face (15) are adhesively secured to the article (2, 37) to be protected.



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DESCRIPTION WO2011012460

Safety element for an object to be protected and an object to be protected with such a safety element

The invention relates to a security element for an object to be protected, such as security papers, value documents or the like, as well as an object to be protected with such a security element.

Objects to be protected are often provided with a security element which allows a check of the authenticity of the object and / or as protection from unauthorized reproduction.

Items to be protected are, for example, security documents, identification and value documents (such as banknotes, chip cards, passports, identification cards, identity cards, shares, bonds, certificates, vouchers, checks, tickets, credit cards, health cards, ...) and product security elements, such as labels , Seals and packages.

For example, if the security element is formed as a security thread for a banknote and, for example, has a plurality of microlenses for magnifying a safety feature, there is a problem that the surface of the thread on the lens side can not be provided with adhesive; of the paper webs which span the embedding in the paper of the banknotes are not connected to the thread and therefore an undesirable take-off (or respectively, Loops) of these webs can occur from the safety thread.

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The result is a reduction in the circulation stability of the banknotes. It is an object of the invention to provide a safety element for an object to be protected, with which the difficulties mentioned at the outset can be solved. Furthermore, an object to be protected with such a safety element is to be made available.

According to the invention, the object is achieved by means of a safety element for an object to be protected, with an upper side and a lower side, one or more imaging optical arrangements, each imaging an assigned object only in front of the upper side reflective microimage elements arranged in a first pattern and the assigned object is designed as a microstructural object with a plurality of microstructures which are arranged in a microstructural pattern adapted to the first pattern in such a way that the microstructural object is imaged enlarged in front of the upper side by means of the reflective microimage elements , and wherein the safety element has, on both the upper side and the lower side, an adhesive layer with which the safety element can be embedded in the object to be protected in such a way that both the upper side of the outer side and of the outer side of the outer side of the safety element, s also the underside is glued to the object to be protected.

After using reflective imaging elements, the backs of these reflective micro imaging elements, as well as the micr o structures spaced therefrom, or the layer carrying the latter, Adhesive layers so that the security element can be glued with its two sides, for example, into a banknote. This avoids the undesirable lifting-off of the webs between the fenders, which are provided in the banknote, in order to make the magnifying image possible.

Micro-imaging elements are preferably designed as micro-hollow mirrors, which have a reduced focal length compared to refractive microlenses, so that the thickness of the safety element (for example the filament thickness) can be significantly reduced. Thicknesses of less than 30 µm can be achieved. In particular, the microimage elements can be arranged on one side of a film and the microstructures on the other side of the film. The film can in particular be designed as a transparent film, for example as a PET film. This makes possible a simple way of producing the safety element while at the same time excellent adjustment of the reflective microimage elements to the microstructures.

In particular, the microimage elements lie in a first plane and the microstructures lie in a second plane parallel to the first plane. The distance between the two planes can correspond to the focal length of the micro imaging elements. This makes a very compact construction of the safety

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element according to the invention possible.

At least one of the adhesive layers or the adhesive layers can be formed as a heat seal lacquer layer. Both adhesive layers or, in particular, the adhesive layer on the upper side of the security element is transparent, wherein transparent transmission is at least 10% and in particular at least 50%. The adhesive layer among the reflective micro-imaging elements may also be intransparent, preferably white, in order to reduce the transparency of the thread through the back of the bills (backsheet). The safety element according to the invention is preferably designed in such a way that all the optical arrangements of the safety element can always represent the object assigned to them in an enlarged manner only in front of the upper side.

Microstructuring methods such as embossing methods can be used to produce the microimage elements as well as the microstructures. For example, suitable structures can be exposed, possibly refined, molded and used for the production of embossing tools with methods known from semiconductor manufacture (photolithography, electron beam lithography, laser lithography, etc.). Particularly suitable for the production of large areas are the known methods for embossing in thermoplastic films or in films coated with radiation-curing varnishes.

The safety element can in particular be designed as a safety thread, tear-open thread, safety tape, safety strip, patch or as a label for embedding in the object to be protected.

The dimensions of the micro imaging elements are preferably chosen such that they lie below the resolution capability of the human eye. In particular, the dimensions can be in a range from 3 µm to

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µm, preferably from 3 µm to 50 µm and particularly preferably from 3 µm to 30 µm. The first pattern as well as the microstructure pattern can be designed as a hexagonal grid or else as a polygonal grid, such as a rectangular or parallelogram-shaped grid. Furthermore, an object to be protected is provided with a front side in which at least one window is formed, wherein a security element according to the invention is embedded in the object to be protected so that it is arranged at least in the region of the window and faces the window with its upper side , both the upper side and the lower side of the safety element being glued to the object by means of the adhesive coatings.

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By the two-sided bonding of the safety element in the object to be protected, a high durability can be ensured. If, for example, the object to be protected is designed as a banknote and the security element is an embedded safety thread, an undesirable lifting of the webs between the windows can be avoided.

In the region of the window, the one optical arrangement, one of the optical circuits or even several of the optical arrangements of the safety element can lie.

In the object to be protected, the window may be closed with a transparent cover. This leads to a further increase in the durability of the object to be protected.

The object to be protected is preferably substantially flat. In particular, the object to be protected can be designed as a security paper, value document or the like. The term "security paper" here is understood to mean, in particular, the precapable precursor which has not yet been transformed into a value document which, in addition to the security element according to the invention, can, for example, also have further authenticity features (such as, for example, luminescence substances provided in the volume). Here, value documents are understood to be documents made from security papers. On the other hand, value documents can also be other documents or objects which can be provided with the security feature according to the invention so that the value documents have non-reproducible authenticity features, whereby a verification of authenticity is possible and at the same time undesired copies are prevented.

The substrate of a security paper or value document is particularly preferably made of paper of cotton fibers, as is used, for example, for banknotes. Preferably, the substrate can also be made of paper from other natural fibers, also preferably from synthetic fibers, i. a mixture of natural and synthetic fibers, or else preferably of at least one plastic film. By coating on both sides Lamination of the substrate with in each case at least one plastic film results in a security paper as described in DE 102 43 653 A9, the disclosure of which is incorporated herein in its entirety into this invention. In this case, the security element according to the invention is applied to the substrate before the two-sided coating or Lamination is applied to the substrate. The security element according to the invention is thus advantageously embedded in the security paper. It is to be understood that the above-mentioned and the features to be explained below can be used not only in the indicated combinations, but also in other combinations or in a single setting without leaving the scope of the present invention.

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In the following, the invention is explained in more detail by way of example with reference to the accompanying drawings, which also disclose inventive features. FIG. 1 is a plan view of a banknote 2 with a security element 1 according to the invention;

FIG. 2 is an enlarged view of the section along the line A-A in FIG. 1; FIG. 3 shows a further embodiment of the security element 1 according to the invention in a sectional view according to FIG. 2;

FIG. 4 shows a further embodiment of the security element 1 according to the invention in a sectional view according to FIG. 2;

FIG. 5 shows a further embodiment of the security element 1 according to the invention in a sectional view according to FIG. 2, and FIG

6 shows a plan view of a chip card 37 with a security element 35 according to the invention.

In the embodiment shown in FIG. 1, the security element 1 according to the invention is designed as a safety thread and is thus integrated into an object 2 to be protected (in this case banknotes 2) in such a way that the security thread is exposed in spaced-apart window regions 3 and is not covered by the banknotes; in the window regions 3, recesses are formed in the upper side of the banknotes, so that there is a clear view of the safety thread 1.

As shown in the sectional view in FIG. 2, which shows a part of the embedded safety element 1 along the section line AA of FIG. 1, the safety element 1 comprises a carrier 4 which has microstructures 6 on its first side 5 and on its opposite second 7 has a plurality of micro-hollow mirrors 8.

The sectional view of FIG. 2 as well as all further sectional views of further embodiments of the safety element 1 according to the invention are not shown to scale for greater clarity. Furthermore, partial hatching is not shown in order to be able to more clearly illustrate the design of the corresponding safety element 1.

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The micro-hollow mirrors 8 are arranged in a plane perpendicular to the drawing plane of FIG. 2 in a grid with a fixed geometry (here, for example, a hexagonal grid), and thus in a flat pattern in a first pattern.

The microstructures 6, which form a microstructure object or image M, are likewise arranged in a plane perpendicular to the character plane of FIG. 2 in a grid with a fixed geometry (here, for example, a hexagonal grid) and thus in a microstructured pattern, wherein the microstructure pattern is matched to the first pattern and the two patterns are aligned with each other so that when the safety element is viewed through the window regions 3 (direction of the arrow PI), the microstructures 6 together with the micro hollow mirror 8 form a modulo magnification arrangement. The basic principle of such a module enlargement arrangement is described, for example, in WO 2009/000528 A1, the entire content of which is hereby incorporated, wherein the microstructural object M of the present invention corresponds to the motif image according to the teaching of the

WO 2009/000528 A1.

Thus, when viewed in the direction of the arrow PI for an observer in the respective window region 3, the microstructural object M is magnified as a safety feature (as a target image in the sense of WO 2009/000528 A1). This is, for example, the letter P.

It is, of course, also possible to match the microstructure pattern of the microstructures 6 as well as the first pattern of the micro-hollow mirrors 8 in such a way that there is a moire magnification arrangement. The basic principle of a moire magnification arrangement is, for example, in the

WO 2006/087138 A1, the entire contents of which are hereby incorporated by reference.

In the structure shown in FIG. 2, the carrier 4 comprises a PET film 9 on which a first layer 10 of radiation-curing lacquer (for example UV lacquer) is applied, which has the microstructures 6. The microstructures 6 can be produced in a known manner, for example by embossing in the UV varnish 10 and subsequent printing and doctoring of ink. Other coloring processes which can be used are certain color transfer processes or microprint printing techniques, which are described, for example, in PCT / EP2008 / 010739 or WO 2008/000350 and the disclosure content of which is

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hereby incorporated by reference into the present application. On the underside of the PET film 9, a second layer 11 of radiation-curing lacquer (for example UV lacquer) is formed, in which the negative shape of the micro-hollow mirrors 8 is embossed. In order to produce the micro-hollow mirrors 8, the side of the second layer facing away from the PET film 9 is provided with a mirror coating 12 (e.g. A metallization).

The micro hollow mirrors 8 are thus designed as a surface mirror.

A mirroring 12 in the form of a metallization has the advantage that it is electrically conductive and magnetizable. In addition, under the mirroring 12, a color with magnetic pigments can also be concealed, which has a uniformly constant or different magnetization in different partial regions. The safety element according to the invention thus has the additional safety features electrical conductivity and magnetic coding.

The inside of the mirroring 12 of each micro hollow mirror 8 or the embossed shape for the micro hollow mirrors 8 has here the form of a spherical dome with a radius of curvature of 38 µm and a height hl of approximately 3.1 µm. The maximum thickness of the second layer 11 (from the crest of a micro hollow mirror 8 to the PET film 9) is approximately 5.1 µm, the PET film has a thickness of 12 µm, and the height h 2 of the first layer 10 is 2 µm ,

Since the radius of curvature of the micro-hollow mirrors 8 is 38 µm, the micro-hollow mirrors 8 have a focal length of 19 µm. The microstructures 6 are spaced approximately 19 µm apart from the micro-hollow mirrors 8 and thus lie in the same plane as the focal points of the micro-hollow mirrors 8 so that the desired magnifying image of the microstructures 6 of the safety feature is effected. The side of the first layer 10 facing away from the micro-hollow mirrors 8 is the upper side 13 of the security element 1 on which a first adhesive layer 14 of heat-sealable lacquer is applied. Furthermore, the rear side of the micro-hollow mirrors 8 and thus the mirroring 12 form the underside 15 of the safety element 1. A second adhesive layer 16 (here, in turn, a heat seal lacquer layer) is applied to the underside 15. Because of the use of micro-hollow mirrors 8, it is therefore possible with the security element 1 according to the invention to form an adhesive layer 14, 16 on both the upper side 13 and the lower side 15.

The second adhesive layer 16 serves to bond the security element 1 to a back sheet 17 of the banknote 2, as shown in FIG. The first adhesive layer 14 is used to connect the security element 1

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to a front side sheet 18 of the banknotes 2, wherein, in particular, the webs 19 of the front sheet 18 are glued between the window regions 3 with the safety element 1 so that undesired lifting of these webs 19 from the safety element 1 can be prevented. Thus, the security element 1 is inserted into the banknote 2 and an enlarged image of the security feature now takes place in front of the top side 13 or in front of the front side sheet 18.

In the illustration in FIG. 1, the width of the safety thread 1 (expansion from the left to the right in FIG. 1) is equal to the width of the window regions 3. It is, of course, possible to select the width of the safety thread 1 to a greater extent, so that gluing with the front side sheet 18 is also possible by means of the first adhesive layer 14 laterally adjacent to the window regions 3.

The micro-hollow mirrors 8 with the associated microstructures 6, which lie in front of one of the window regions 3, can be referred to as an optical arrangement which magnify the microstructure object M (the object assigned to the micro-hollow mirror 8) Thus, the micro-hollow mirrors 8 and the microstructures 6 can be designated as a separate optical arrangement before each window area 3, so that the safety thread 1 has several optical arrangements. Of course, all micro-hollow mirrors 8 and all microstructures 6 can also be considered as belonging to a single optical arrangement. However, it is also possible to provide several optical arrangements per window area 3. It is important here that all the optical arrangements always image the respective object only in front of the upper side 13 in an enlarged manner.

In a modification (not shown) of the safety element 1 of FIG. 2, the microstructures 6 on the one hand, and the micro hollow mirrors 8 on the other hand, are placed on two separate foils (e.g. PET films) and is provided with a metallization or color. These two films are then combined to form a structure according to FIG. 2, so that instead of the PET film 9 shown in FIG. 2, two laminated PET films are present. If the distance between the micro-hollow mirrors 8 and the microstructures 6 is changed by this design, the curvature of the micro-hollow mirrors 8 would have to be adapted so that the microstructures 6 again lie in the focal points of the micro-hollow mirrors 8 in the assembled state. The distance is, of course, essentially dependent on the thickness of the two PET films and the amount of adhesive necessary for lamination.

It should be pointed out that the sizes of the already described embodiments as well as the subsequent embodiments are only to be understood as an example. Other values may vary depending on, for example, For example the materials and sample sizes used. FIG. 3 shows an embodiment of the security element 1 according to the invention in the state embedded in the banknote 2, which can be referred to as a lamination variant. In this variant, the microstructures 6 as well as the micro hollow mirror 8 are initially produced separately. The microstructures 6 are

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formed on a UV lacquer layer 20, which is applied to a first carrier film 21. In the same way, the micro hollow mirrors 8 are formed in a UV lacquer layer 22 (by embossing and metallizing) which is applied to a second carrier film 23. The two carrier films 21 and 23 are preferably PET films. The microstructures 6 and micro-hollow mirrors 8 thus formed are laminated together, the micro-hollow mirrors 8 and the microstructures 6 facing each other, as can be seen in FIG.

Between them is merely the laminating adhesive 24. However, it is also possible to use one or more additional lacquer layers

(not shown) between the micro-hollow mirrors 8 and the microstructures 6 to adjust a desired spacing.

A first adhesive layer 14 is formed on the upper side 13 of the safety element 1 formed in this way, and a second adhesive layer 16 is formed on the lower side 15 of the safety element 1, with which the security element 1 is glued with the front and rear side sheets 18, 17 of the banknotes 2. In the embodiment of FIG. 3, the carrier films 21 and 23 protect the inner microstructures 6 as well as the inner micro hollow mirrors 8 excellently against environmental influences and attacks by potential counterfeiters. 3, a structure is shown in which it is not necessary to place a film between the microstructures 6 and the micro-hollow mirror 8 as spacers.

FIG. 4 shows a further embodiment of the security element 1 according to the invention in the state embedded in the banknotes, which can be produced as follows.

Firstly, microstructures 6 are embossed in a first UV lacquer layer 25, which is applied to a PET film 26, and are colored by means of a suitable method. Subsequently, a second UV lacquer layer 27 is applied to the embossed UV lacquer layer 25, and the molds for the micro hollow mirrors 8, which are then formed by vapor deposition with a metal layer 12, are produced in a second embossing. The second adhesive layer 16 is then applied to the micro hollow mirrors 8 thus formed. Alternatively, a protective lacquer layer (not shown) can initially be formed on the micro-hollow mirrors 8, on which the second adhesive layer 16 is then applied. On the upper side 13 (the side of the PET film 26) facing away from the micro-hollow mirrors 8) of the safety element 1, the first adhesive layer 14 is again applied. With the two adhesive layers 14 and 16, an adhesive Securing the security element 1 in the banknote 2.

In a modification not shown, the PET film 26 can be designed such that it can be detached from

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the UV lacquer layer 25. In this case, the second adhesive layer is applied directly to the UV lacquer layer 25 after the PET film 26 has been dissolved. FIG. 5 shows a further embodiment of the security element 1 according to the invention, which is inserted into the banknote 2. In this embodiment, the microstructures 6 and the micro hollow mirrors 8 are first produced separately from one another. For this purpose, the microstructures 6 are embossed in a UV varnish layer 30, which is formed on a PET film 31, and subsequently dyed. In a separate operation, the micro hollow mirrors (or their negative form) are embossed into a UV lacquer layer 32, which is applied to a PET film 33. The embossed shapes for the micro hollow mirrors 8 are either mirrored now or after lamination.

The PET film 33 is then laminated together with the UV lacquer layer 30 (laminating adhesive 34), the application quantity of the laminating adhesive 34 being adjusted such that the Moirebzw. Modulo-magnified images (ie, the microstructural object) are sharp.

On the upper and lower side 13, 15, the first and second adhesive layers 14, 16 are in turn formed in order to bond the security element 1 to the front and rear side sheets 18, 17 of the banknotes 2 in the described manner.

The PET film 31 can in turn be detachably connected to the UV lacquer layer 30. In this case, the first adhesive layer 14 is applied directly to the UV lacquer layer 30.

The safety element 1 according to FIG. 5 can also be produced by the following working steps. First, the UV lacquer layer 30 is embossed and colored to produce the microstructures 6. The PET film 33 is then laminated onto the UV lacquer layer 30. The UV lacquer layer 32 is formed on the laminated PET film 33, and the micro hollow mirror 8 is formed in this UV lacquer layer 32 by embossing and coating.

By this procedure, it is advantageously achieved that the PET film 31 during the embossing of the micro hollow mirrors 8 produces an additional strength of the structure, which is of great importance in view of the effect of even small distortions on the optical appearance in the case of moire or modulo magnification. The security element 1 according to the invention can, for example, For example as a security element 35 with a rectangular shape, can be formed such that it lies in the window area 36 of the front sheet 18 of the banknote 2. In this case, the security element 35 is preferably larger than the window area 36, as indicated by the dotted outline in FIG. 1, so that the security element 35 can be glued to the front side sheet 18 by means of the first adhesive layer 14.

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6, the window area 38 may have a transparent cover 39, with which the safety element 35 is glued by means of the first adhesive layer. This ensures a permanent embedding of the safety element 35.

Of course, such a transparent cover can also be present in the banknote 2 according to FIG. For example, For example, in the form of foil laminate banknotes in which both the front and the rear sheet 17, 18 are of multilayer construction, the respective outermost layer being transparent and the window regions 3 being formed in the underlying layer on the front side sheet 18. In the above embodiments, micro-hollow mirrors 8 were respectively described. It is understood that the micro hollow mirrors are representative of reflective micro imaging elements. It is, in particular, possible to use diffractive elements as reflective imaging elements, provided that they achieve the desired imaging properties (in the same way as the micro-hollow mirrors 8).

The micro imaging elements may be formed, in particular, by micro-hollow mirrors having a circular or polygonally limited base area, or else by means of elongate cylindrical micro-hollow mirrors whose extension in the longitudinal direction is more than 250 µm, preferably more than 300 µm mm. Furthermore, mirrors, Fresnel mirrors, zone mirrors or other elements with a reflecting effect are possible as micro-imaging elements. The micro-hollow mirrors 8 may have a spherical curvature or an aspherical curvature.

The mirroring 12 of the micro-hollow mirrors 8 can, For example by means of an applied metal layer (for example, vaporized). Typically, an aluminum layer having a thickness of, for example, For example 50 µm. Of course, other metals, such as, For example, silver, copper, chromium, iron, etc., or alloys thereof. The combination of several metals on and / or adjacent to one another is likewise possible, For example a partial evaporation with Cu and then a full-surface evaporation with aluminum. Alternatively, high-breaking coatings can be applied, for example MgF 2, ZnS or TiO 2. When a suitable thickness is selected, the reflective effect can be additionally increased by interfering effects. For ZnS, the corresponding layer thickness is, for example, approximately 60 µm. A thin layer system consisting of, for example, alternately high and low-breaking layers can also be applied in such a way that the layer sequence acts as a reflector.

Such layer systems can be tailor-made for a specific wavelength.

The mirroring 12 can be overlapping with the individual micro-hollow mirrors 8. However, it is also

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possible to carry out a coating-only or raster-shaped coating so that the micro-hollow mirrors 8 are semitransparent. The thickness of the coating can also be selected in such a way that a semitransparent mirroring is present instead of a complete mirror coating.

A semitransparent mirroring is understood here to mean, in particular, such a mirroring in which the transmission averaged over at least one micro-hollow mirror is in the range from 10% to 90%.

The mirroring can also be implemented as a color-tilting coating which, For example a layer system of absorber, dielectric and reflector. The color-tilting side of the layer system may be facing or facing away from the microstructures 6. In the first case, the color generated by the layer system can be adapted to the color of the microstructures 6.

In addition, it is possible to effect a color-tipping action with the layer system when, for example, For example a layer sequence of absorber, dielectric, reflector, dielectric and absorber is applied. The described color-shifting layer systems can also be applied over the full area or only in some areas. The security element 1 may also have further security features, such as holograms, cleartext or other known safety features described, for example, on the description page 18 of the

WO 2009/000528 A1.

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CLAIMS WO2011012460

P a te n s p ro u c h e 1. A safety element for an object (2, 37) to be protected, comprising - an upper side (13) and a lower side (15), one or more imaging optical arrangements, all of which respectively represent an associated object enlarged in front of the upper side (13) an optical arrangement, or at least one of the optical arrangements, a plurality of reflective microimage elements (8) arranged in a planar manner in a first pattern, the associated object being designed as a microstructural object with a plurality of microstructures (6) arranged in a microstructure pattern adapted to the first pattern, wherein the microstructural object is imaged in an enlarged manner in front of the upper side by means of the reflective micro imaging elements, and wherein the safety element has an adhesive layer on both the upper side and the lower side , with which the safety element (1) can be embedded in the object (2, 37) to be protected in such a way that, both the upper side (13) and the lower side (15) are glued to the object (2, 37) to be protected.

[7]

2, A security element according to claim 1, wherein said microimage elements (8) are formed as micro-hollow mirrors (8). 3, Safety element according to claim 1 or 2, wherein the microimage elements (8) lie in a first plane and the microstructures (6) lie in a second plane parallel to the first plane. 4, A security element according to claim 3, wherein the distance between the two planes corresponds to the focal length of the microimage elements (8). 5, Safety element according to

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one of the preceding claims, in which the microimage elements (8) are arranged on one side of a film (9) and the microstructures (6) are arranged on the other side of the film (9). 6, Safety element according to one of the preceding claims, wherein at least one of the adhesive layers (14, 16) is designed as a heat seal lacquer layer. 7, A protective element (1; 35) according to one of the preceding claims, characterized in that the object (2; 37) comprises a front side (18) in which at least one window (3; 36; (3; 36; 38) with its upper side (13) facing the window (2; 37; 38), wherein both the upper side (13) and the upper side (13) of the window (2; (15) of the safety element (1; 35) are glued to the object (2; 37) by means of the adhesive layers (14; 16).

[9]

8, The article (2; 37) of claim 7, wherein the window (38) is sealed with a transparent cover (39). 9, The article (2; 37) of claim 7 or 8, wherein the article (2; 37) is substantially flat. The object (2; 37) according to one of claims 7 to 9, wherein the object (2; 37) is designed as a security paper, value document or the like.

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Drawing pages of WO2013012460 A2

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Espacenet

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METHOD FOR PRODUCING MICRO-CONCAVE MIRRORS

Inventor(s): KECK ANGELIKA [DE]; HEINE ASTRID [DE]; MENGEL CHRISTOPH [DE] ± (KECK, ANGELIKA, ; HEINE, ASTRID, ; MENGEL, CHRISTOPH)

Applicant(s): GIESECKE & DEVRIENT GMBH [DE] ± (GIESECKE & DEVRIENT GMBH)

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Abstract of WO2013056825 (A1)

The invention relates to a method for producing micro-concave mirrors, comprising the steps of: providing a carrier substrate; pre-structuring said carrier substrate such that protuberances are produced on a rear side of said carrier substrate and depressions which substantially correspond to those protuberances are produced on a carrier substrate front side which lies opposite said rear side; and applying a reflective coating to at least one side of the carrier substrate, in the region of the protuberances or depressions, such that micro-concave mirrors are formed by these depressions when viewed from the front side of the substrate.

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DESCRIPTION WO2013056825

Process for the production of micro hollow mirrors

The invention relates to a manufacturing process for micro hollow mirrors and to a substrate with micro hollow mirrors which can be used as a verification or safety feature for a data carrier.

Data carriers, such as value or ID documents, or else other valuables, such as branded articles, are often provided with security elements for the purpose of security, which permit a verification of the authenticity of the object and at the same time serve as protection against unauthorized reproduction.

The term "data carriers" also includes non-volatile precursors of such data carriers, which are, for example, in the case of security paper in a virtually endless form and are further processed at a later point in time. Data carriers for the purposes of the present invention are, in particular, banknotes, shares, bonds, certificates, vouchers, checks, high-quality admission tickets, but also other documents liable to falsify such as passports and other identification documents , Packaging and the like.

A security element can be embedded in such a data carrier, for example in a banknote or a chip card, or can be embodied as a self-supporting transfer element, for example as a patch or as a

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label, which after its manufacture is applied to a data carrier or other object to be secured.

Safety elements often produce a clearly visible optical impression, which is why such safety elements are sometimes used exclusively as decorative elements in addition to their function as a means of viewing.

In order to prevent counterfeiting or re-setting of safety elements, for example with high-quality color photo copying devices, safety elements often have optically variable elements which convey a different image impression to the viewer at different viewing angles and show a different color impression or different graphic motifs. In this connection, for example, the use of diffraction-optical micro-nanostructures in the form of embossed holograms or other hologram-like diffraction structures is known.

WO 2010/015383 A1 discloses a method for producing safety elements made of microlenses, in which a carrier substrate is pre-patterned in a superimposed printing process in such a way that elevations are formed on the front side of the carrier substrate and depressions substantially corresponding to the elevations on the rear side. By applying translucent plastic to the side of the support substrate on which the recesses are located, microlenses are formed. Safety elements with microlenses, however, have the disadvantage that the optical properties of the microlenses change or worsen when they are coated with their surface with a lacquer or adhesive. Such security elements can thus not easily be embedded in a data carrier. Furthermore, their surface can not be protected against soiling by a dirt-repellent coating.

The use of micro hollow mirrors instead of or as a supplement to microlenses is known, for example, from WO 2010/136339 A2 or WO 2011/012460 A2. A disadvantage of these micro hollow mirrors is, however, that the process for their production is complex and cost-intensive. This increases the protection against counterfeiting, since the cost of counterfeiting is considerably increased for a counterfeiter, but in security elements which serve as a supplement to additional security elements or which require a lower protection against counterfeiting, these methods are only of limited economic use.

SUMMARY OF THE INVENTION The object of the invention is to avoid the disadvantages of the prior art and, in particular, to provide a manufacturing method for micro hollow mirrors and a substrate with micro hollow mirrors which can also be used as a verification or safety feature for a data carrier simplified production.

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This object is achieved according to the invention by a manufacturing method for micro hollow mirrors having the features of independent claim 1. The dependent claims relate to preferred embodiments and further developments of the invention.

The method according to the invention for producing micro-hollow mirrors comprises the steps of providing a carrier substrate and pre-structuring the carrier substrate such that elevations are formed on a rear side of the carrier substrate and substantially corresponding depressions are formed on a front side of the carrier substrate opposite the elevations. In addition, the method comprises the step of applying a reflective coating to at least one side of the carrier substrate in the region of the elevations or depressions so that micro-hollow mirrors are formed by the depressions viewed from the front side of the substrate.

The pre-structuring of the carrier substrate preferably takes place by embossing, in particular by embossing in the stamping method. In the embossing of the carrier substrate by the gravure printing method with a gravure printing plate, the depressions in the gravure printing plate have a gravure depth of about 20 µm to about 150 µm and an gravitational width of about 50 µm to about 500 µm, preferably about 250 µm to about 300 µm. The recesses are preferably produced in a regular, in particular raster-like, arrangement. A combination of spherical lenses with cylindrical lenses is also possible. In addition to a regular grid-like arrangement, an irregular arrangement is also possible, for example an arrangement with a combination of different angles, shapes and depths and / or spacings.

In a further preferred embodiment, the reflective coating is applied to the carrier substrate such that it is spatially interrupted between the micro-hollow mirrors or forms a continuous layer. This ensures that at least the recesses, which form the micro-hollow mirrors, have the reflective coating. The surface located between the micro-hollow mirrors may either have a reflective coating or not. A partial coating of a reflective coating is also possible.

The application of the reflective coating preferably takes place by means of printing technology and, in this case, preferably by means of screen printing, press printing, offset printing or flexographic printing. Alternatively, the application of the reflective coating is carried out by applying a prefabricated layer by means of transfer or laminating processes. In principle, all methods known from the prior art can be used with which the reflective coating can be applied to the carrier substrate. In a further preferred embodiment, the depressions in the carrier substrate are filled with a transparent material and a microstructure is applied, preferably imprinted or impressed, on the side of the transparent material which opposes the depressions. In this case,

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the thickness or the shape of the transparent material is preferably selected in such a way that the microstructure lies in the focal plane of the micro hollow mirrors. In this case, the micro hollow mirrors, together with the microstructures, form known optically variable effects, in particular a moiré structure or a moiré magnifier, in which the microstructural elements are, in particular, magnified, for an observer preferably appearing before or behind the plane of the microscope mirror Carrier substrate and / or also have a tilting effect, ie when the carrier substrate tilts, apparently change its position relative to the carrier substrate.

The invention thus particularly preferably relates to the production of optically variable effects such as, for example, "moiré magnifiers" for the verification of banknotes by means of lithographically produced hollow mirrors.

The invention is based on the discovery that a pre-structured carrier substrate with elevations and depressions can be used as an impression body for producing micro hollow mirrors. Such a pre-patterned carrier substrate can be provided by embossing a suitable carrier substrate. Embossing tools known per se may be used for this purpose. The support substrate is preferably embossed in a stamping method. In this case, recesses, in particular engravings, are produced in a gravure plate used for the embossing, which form pre-structures which are suitable on the carrier substrate. The shape and dimension of the elevations and depressions and thus of the micro hollow mirrors to be produced can be specifically influenced by means of the depth and width of the gravure.

In a color-carrying stitch-printing process, the depressions of the intaglio printing plate are filled with ink so that the carrier substrate is not only deformed, but also inked. This has the advantage that the reflective coating and the corresponding reflective coating, which form the micro-hollow mirrors, can be produced in one working operation when reflective color is used, which reflects the incident light or incident electromagnetic radiation almost completely in a preferred wavelength range. Alternatively, the micro-hollow mirrors can also be produced with blind embossing, the embossing being effected by means of a gravure printing plate without ink filling, ie no printing ink is provided in the depressions of the gravure printing plate. The embossing takes place under very high contact pressure, so that very high forces act between the gravure plate and a counterpressure plate, which can be covered with a special thin rubber blanket, which ensure a permanent embossing of the carrier substrate.

In this case, the reflective coating is applied, before or after blind embossing, to at least one of the two sides of the blind embossed carrier substrate in the region of the elevations or depressions.

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In both embodiments, the pseudo-printing process is preferably a line or a line. In which, in the form of lines, indentations, for example in the form of lines, are engraved into the printing plate by means of a manually or mechanically guided, rotating engraving. In addition, a gravure plate can, of course, also be provided with appropriate engravings by means of a suitable laser.

The surface shape of a micro hollow mirror is thus determined by the shape of the recess. In the engraving or screen printing process, the carrier substrate embossed with a correspondingly designed intaglio printing plate has a virtually spherical or cylindrical pre-structure suitable for the formation of micro-hollow mirrors. Such a pre-structure results on the carrier substrate both in the case of spherical, pyramidal, polygonal, linear or aspherical depressions in the gravure plate as well as in the case of engravings or etching which have been designed differently. The generated micro hollow mirrors can in principle be designed both as spherical as well as aspherical, as hollow mirrors based on Fresnel lens shapes, and as cylindrical hollow mirrors, in particular as curved cylindrical hollow mirrors. A further particular advantage of the low-pressure printing process is that elevations occur on the side of the carrier substrate which faces the gravure printing plate, and depressions corresponding to the opposite side of the substrate are produced by the depressions in the gravure printing plate.

The depressions in the gravure plate are designed in such a way that the elevations and / or the depressions of the embossed substrate are suitable for shaping micro-hollow mirrors. This provides a simple possibility for producing elevations and / or depressions suitable for the removal of micro hollow mirrors. In the case of an opaque or only slightly translucent carrier substrate, the reflective coating is applied over the entire surface in the region of the recesses on the front side of the carrier substrate, which faces a viewer. The electromagnetic beams incident on the safety element are thus reflected directly by the reflective coating without being attenuated by the carrier substrate, which would reduce the reflection of the electromagnetic radiation.

In the case of a transparent or virtually completely translucent carrier substrate, the reflective coating can alternatively be applied over the entire area in the region of the recesses also on the rear side of the carrier substrate. The electromagnetic beams impinging on the security element thus first pass through the substrate, are reflected by the reflective coating, and then pass through the carrier substrate again. Due to the low attenuation in the carrier substrate or the low energy loss, the reflected electromagnetic radiation reappears almost completely or without substantial energy loss from the carrier substrate. When the reflective coating is applied to the rear side of the carrier substrate, the geometry of the micro hollow mirrors can be adapted to the thickness of the carrier substrate such that the microstructures can be applied directly to the side of the substrate opposite the coating and lie directly in the focus of the micro hollow mirrors.

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The filling of the micro hollow mirrors with the transparent material can thus be dispensed with in this case. If, for example, the thickness of the carrier substrate is 80 µm, the geometry of the micro-hollow mirrors can be selected in such a way that the focus distance, i. the distance from the vertex of a micro hollow mirror to its focal plane, is also 80 µm, and the focal plane lies on the surface of the substrate which is opposite the coating.

Within the scope of the present description, translucent means translucently in the sense of a certain or complete transparency of light, and thus also includes transparency. A translucent layer makes it possible to perceive the objects behind or below it, even if the brightness of the objects can be reduced by the translucent layer and / or the color of the objects can be altered. By translucent material, such as plastic, varnish or printing ink, a transparent or semitransparent material, in particular a translucent printing ink, is also understood.

The carrier substrate preferably comprises paper and / or a carrier film, in particular a translucent carrier film. In the simplest case, the carrier substrate consists entirely of either paper or plastic. However, the carrier substrate can also consist in a range of different materials, in particular in one area of paper and at the same time in another area of plastic, preferably a translucent carrier film. This makes it possible to emboss different materials as a carrier substrate in one operation. In this context, translucent carrier film is understood to mean either a transparent or a semitransparent carrier film, for example a transparent carrier film which comprises, for example, polyamide, polyester, polyethylene or biaxially oriented polypropylene (BOPP).

Preferably, the micro-hollow mirrors are spaced apart from one another and spatially separated from each other. As a result, a micro hollow mirror is formed independently in each recess, without mutual interference with adjacent micro hollow mirrors. In this case, the distance between adjacent micro-hollow mirrors is expediently selected as small as possible in order to ensure a high-level coverage of the surface and thus, in conjunction with, for example, a safety element explained in more detail below. However, it is also possible to arrange the micro hollow mirrors so as to form a continuous, full-surface layer of translucent plastic, which comprises the micro hollow mirrors. The printing of the recesses with a reflective coating on the front or rear side of the carrier substrate is carried out, preferably by printing a printing ink with reflective pigments in flexographic printing or screen printing.

This has the advantage that both the quantity and the location of the applied printing ink can be well controlled. In particular, it is thereby possible to produce the individual micro-hollow mirrors

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with colors which produce a different color impression. In general, variable parameters of the micro hollow mirrors can be selected individually for each of these micro hollow mirrors. In addition, the flexographic printing and also the screen printing process are common printing processes with the aid of which printing can be carried out in a simple manner and thus cost-effectively and at high speed.

Alternatively, the reflective coating can also be applied to the carrier substrate by a transfer method, wherein the reflective coating is applied to a transfer substrate and is transferred to the carrier substrate, for example by means of mechanical pressure and / or elevated temperature. Furthermore, the reflective coating can also be applied to the carrier substrate by a lamination process, the reflective coating itself being in the form of a film which is laminated to the carrier substrate.

Advantageously, regular, for example, raster-like, identical depressions are provided for pre-structuring by blind embossing in a gravure plate, whereby a regular arrangement of identical micro-hollow mirrors can be obtained and thus an array of micro-hollow mirrors is obtained. The blind embossed carrier substrate is thereby a part of the substrate with the micro hollow mirrors. If desired, the substrate is cut to the desired size.

Alternatively depressions with different widths and / or depths can also be provided in the gravure plate. Likewise, a grid-like grid-like arrangement of the recesses with differently different angles or a partial arrangement of such recesses can be provided in geometric shapes or motifs. Correspondingly, different depressions and elevations can be created in the carrier substrate. In a further preferred embodiment, the carrier substrate according to the invention with the micro-hollow mirrors is applied to a data carrier, for example a banknote, which has at least one further security element and at least one folding axis. Along this folding axis, the data carrier is folded, so that the micro-hollow mirrors are brought into coincidence with the security element and optically interact for verification with the security element.

In particular in the case of a symmetrical construction of the arrangement of the micro-hollow mirrors, the bank notes can advantageously be folded in different directions, and the carrier substrate can cooperate with different security elements for verification. Furthermore, a plurality of folding axes can also be provided in the data carrier, wherein the verification means can interact with two security elements per folding axis.

The two following preferred embodiments show, in addition to the above-mentioned dynamic

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movement effects on the basis of moire mag- nifiers, further applications of the micro-hollow mirrors according to the invention.

The first preferred embodiment relates to a combination of three-colored lines arranged at an angle of 60 ° with one-color microstructures arranged in a grid array. This combination of three-colored lines and single-color microstructures is arranged in the focal plane before grid-like micro-hollow mirrors. Due to the magnifying effect of the micro hollow mirrors, an optically dynamic rainbow effect is created as a background for the dynamic enlarged microstructures due to the colored impression of the three-colored lines. This effect can also be realized without a hollow mirror with a microlens field, which is known, for example, from WO 2010/015382 A2, WO 2010/015383 A and WO 2011/015384 A1. The printed image can be printed directly on the transparent lacquer, or, in the case of self-verification, on a region of the banknote onto which the microlens field is then folded for verification.

The second preferred embodiment relates to a safety element, as is known from DE 10 2010 019 616 A1. In contrast to the safety element of DE 10 2010 019 616 A1, in this embodiment the two information is not produced by a printed "analyzer" in the form of a line screen but by a raster-like arrangement of microlenses or micro hollow mirrors according to the above-mentioned WO 2010/015382 A2, WO 2010/015383 A1 and WO 2011/015384 A1, whereby both spherical and cylindrical lenses or Micro hollow mirrors or a combination of both can be used. In this case, the two information can be made visible alternately by means of self-verification, or the information can be printed directly onto the transparent lacquer of the arrangement of microlenses. A further application is to print the information on a transparent lacquer, with which the micro-hollow mirrors are filled. Thus, when the security element or banknotes are tilted, the one and the other information is made visible depending on the viewing angle.

Instead of an information exchange, for example, a dynamic, three-dimensional effect can also be generated, for example a three-dimensionally acting value which represents different views of the three-dimensionally acting value from different viewing directions. This effect can, in turn, be colored with the above-mentioned rainbow effect.

The present invention is distinguished from the safety features known from the prior art by a much simpler design and a correspondingly simple manufacturing process. In particular, multi-colored motifs and tilting motifs can be created in a simple manner.

The particular advantages over existing micro hollow mirrors of the prior art lie in the technically

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simpler method of manufacture on the basis of existing printing and embossing processes,

the order of magnitude of the hollow mirrors,

Which enables the printing of the text / image information in the simultaneous, flexo or superimposed printing process, as a result of which the possibility of the multicolor is also given,

- in the combination of supervisory and transparency features through the combination of hollow mirrors and hole mask,

- Use of laser technology for printing plate production as well as for perforating mask production.

A further advantage over known methods of the prior art is the possible combination of micro hollow mirrors and a perforated mask, ie a combination of control and transparency. A further advantage is that no printing process to be developed is required, but printing methods known from the prior art can be used. Further exemplary embodiments and advantages of the invention are explained below with reference to the figures. For the sake of better clarity, the figures are without reference to scale and proportion. They show schematically:

FIG. 2 shows a further construction in which the pre-structures are of elliptical shape, the focus is achieved by curing the transparent lacquer to form a biconvex mold, in which the microstructures of the microstructure, FIG. 3 is a plan view of a hollow mirror structure according to the invention,

FIG. 4 shows a substrate with a film element on the back or front side and on

5 shows a substrate with a film element according to the invention, the reflecting coating being arranged on the front side or the rear side of the carrier substrate, and additionally having recesses, FIG. 6 shows a banknote with safety features according to the invention, FIG.

FIG. 7 shows a pressure plate with recessed / inverted pre-structure

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(Production by means of laser technology) for the production of micro hollow mirrors,

FIG. 8 shows a pre-press plate (milled) with a pre-structure for producing micro-hollow mirrors,

FIG. 9 shows an arrangement of, for example, hemispherical micro-hollow mirrors in a honeycomb grid.

1 shows a safety element according to the invention with micro-hollow mirrors, which together with the microstructures provided provide a dynamic safety feature. In this case, a substrate 1 is coated with a reflective coating 2, the recesses being introduced into the substrate 1 by the superimposition method. The reflective coating 2 is advantageously designed as a metallic or metal-like layer, for example with a gold or silver-like hue, and partially covers the micro hollow mirrors as shown over the entire area or (not shown), the region of the recesses having the coating and the interspaces between the recesses Coating. Subsequently, the patterning is filled with a transparent colorless or translucent colored lacquer layer 3 and printed onto these lacquer layer microstructures 4, for example in the offset, sieboder flexographic printing process. The thickness of the resulting lacquer layer 3 is selected such that the microstructures 4 are located in the region of the focus of the micro hollow mirrors.

The result is a so-called dynamic safety feature, in which the microstructures 4 are imaged by the micro-hollow mirrors for an observer in an enlarged manner, and on the other hand a tilting effect results. In a particular arrangement of the microstructures, for example, the magnified microstructure can move when the safety element tilts in an axis rotated by 90 °, the so-called orthoparallactic effect. When the safety element tilts about its longitudinal axis, the image moves along the vertical axis of the safety element. Furthermore, the imaged microstructure appears to float above or below the plane of the substrate.

The reflective coating 2 can be a fully or partially metallized laminate film, a fully or partially metallised transfer film or a printed mirror ink, independently of the substrate, the latter being applied, for example, to the substrate in the stitch, offset, flexographic or screen printing process.

In the basic configuration, the resulting reflecting structures correspond, for example, to hemispheres. These are preferably filled with the transparent lacquer as a spacer, in order to print the microstructure in the focus of the hollow mirrors produced by the metallization. The focus distance is here half the radius of the spherical structures. FIG. 2 shows an alternative

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construction in which the pre-structures have an elliptical shape. The arrangement of the microstructures in the focus of the pre-structuring is achieved by curing the lacquer layer 3 to a biconvex form. Further embodiments include alternative forms of pre-structuring, such as pyramids, squares, polygons (see FIG. 9, "facet eye"), hemispheres, ellipses, and spherical and aspheric shapes. FIG. 3 shows a schematic plan view of two adjacent spherical micro-hollow mirrors 5 on a carrier substrate, not shown. The micro hollow mirrors 5 have a diameter d of 50 µm to 500 µm and in this exemplary embodiment a distance a of approximately 2 µm.

The distance can also be reduced to 0 µηη, i. the micro-hollow mirrors would collide directly in this case. The maximum distance between the micro hollow mirrors should not exceed half the diameter of the micro hollow mirrors. The spatial periodicity of such an arrangement is thus 50 µm to 500 µm. The gravure depth of the depressions in the gravure plate used for the embossing of the carrier substrate 5 is 20 µm to 150 µm. The thickness of the carrier substrate is usually in the range from about 15 µm to about 100 µm and is negligible in the ideal case.

4 shows an embodiment in which the safety element 8 pre-patterned with micro-hollow mirrors projects beyond a transparent region or an opening of the substrate 6. FIG. The substrate can here be either a paper substrate with a security element 8 according to the invention on the front side (FIG. 4a) or rear side (FIG. 4b) or according to FIG. 4c a hybrid substrate.

In the embodiment according to FIG. 4c, the substrate consists of a paper core 10 which is coated on the front side and the rear side with a transparent film. On the surface of the transparent film is applied a coloring film 11, which ensures an improved color acceptance of the transparent film 9. In the region of an opening in the paper core 10, the two transparent foils 9 of the front and rear sides are combined and form a transparent window in which the micro hollow mirrors according to the invention are arranged. In the arrangement according to FIGS. 4a and 4b, the structure of the safety element basically corresponds to the basic construction described above. In contrast to or in addition to the above-described basic structure, two variants of the structure are possible in the transparent region of a substrate: according to FIG. 5 a, the reflective coating can be applied either to the rear side of the substrate 1 or to the front side of the substrate 1 as shown in FIG in this case, because of the transparency of the substrate 1, the reflective coating produces a hollow mirror effect in both cases.

FIG. 5c shows an embodiment in which a monitoring and a screening feature are obtained in the transparent region. In this variant, a preliminary structuring of the carrier substrate in the form of depressions or And subsequently filling the recesses with transparent varnish 3, preferably in the screen, offset, flexographic printing process. The microstructures 4 are then printed on the cured

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lacquer 3. Finally, the reflective coating 2 is applied, either by the pressure of reflecting color in the screen, flexographic or offset process, the reflective coating can also be printed as a variant before the pre-structuring, or alternatively the reflective coating before the pre-structuring (Window) substrate, for example in the form of a fully or partially metallized transfer or laminate film.

As an addition to the above-described safety features, which are only visible in the top view, an additional effect can be realized in the area of the window. The basis for the transparency function is the principle of a perforated mask, the reflective coating 3 being converted into a semitransparent layer by targeted laser ablation in the reflectively mirrored window area. Preferably, the reflective coating 3 is ablated or removed at the vertex of the pre-structuring by means of a laser process, and a defined perforated mask 7 is thus produced. In this case, enough reflecting material is retained to make the monitoring effect visible, and at the same time a magnification effect with a dynamic depth effect can be seen through the generated semitransparency of the perforated mask 7. The supervisory principle works both in the semitransparent and in the opaque reflecting region, ie is independent of transparent recesses (windows) in the substrate.

The transparency function can be produced only in a transparent region of the substrate.

FIG. 6 shows a further exemplary embodiment in the form of a verification feature based on self-verification. 6a, two regions 13 and 14 are laid over one another on a banknote 12 by folding the banknotes 12 along the dashed line in such a way that they form a dynamic tilting image. The region 13 here contains the carrier substrate according to the invention with the micro hollow mirrors, the transparent or translucent region 14 the associated microstructure. The substrate of the bills 12 may be either paper with a front or rear sheet member or a hybrid substrate with a window area.

According to FIG. 6b, the region 13 with the reflectively coated micro-hollow mirrors is constructed as follows:

Embossing the pre-structuring in the non-color-guiding stitch-printing process and subsequently producing the reflective coating 2 by printing with reflective or reflecting printing ink in the screen or flexographic printing process, or

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the reflective coating 2 is produced first, either by application of a metallized film element in the transfer or laminating process, or by printing with reflecting or reflecting printing ink in the screen, offset or flexographic printing process, and subsequent structuring of the hollow mirrors by the oblique printing process; reflecting ink and patterning of the micro-hollow mirrors in one pass in the color-carrying stitch-printing process. The micro hollow mirrors, which have been produced according to one of the three mentioned embodiments, can additionally be filled with transparent lacquer by screen printing. Preference can be given here, by admixing fluorescence or the effect pigments (e.g. For example on the basis of liquid crystals) an additional effect and an increase in the counterfeiting security can be achieved.

The transparent region 14 with the image information or the microstructures is constructed as follows:

- foil strip applied to an opening in the banknote 12, which is printed with the microstructures in the offset or the superimposed printing process, or

- Hybrid substrate, which in region 14 has a transparent region, which is also printed with the microstructures in the offset or the superimposition printing process.

Here, too, the printing ink used for the microstructures can be added for an additional effect fluorescence or effect pigments. As the transparent region imprinted with microstructures is folded onto the hollow mirror region, a moiré magnifier effect known from the prior art is, for example, visible in plan view. A further possibility here is also the combination of the hollow mirrors with a perforated mask, that is also the extension by a translucent effect by the lasering of a perforated mask into the metallization. In principle, in all embodiments for increasing the counterfeiting safety, either only the applied lacquer 3 can be provided with fluorescence (nano) pigments or dyes, or both lacquer 3 and the printing ink of the microstructures 4 can be provided with different fluorescence or effect pigments. Therefore, For example, additional effects are generated under UV light, for example a blue-fluorescent microstructure (for example asterisks) on a yellow fluorescent background.

A further possibility is to provide the lacquer 3 with ablatable pigments, for example silver, so that the microstructures 4 are not printed but are "written" or negatively written into the lacquer 3 by means of ablation by laser technology.

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The louvres (lines and motif raster) of the microstructures 4 or 14 can be displayed both in the offset (direct and indirect) as well as in the flexographic printing process, as well as in the single-dot printing process. In contrast to the color, a negative representation of the microinformatics (letters, symbols) is possible due to the resolution fineness.

Since the effects produced by the micro-hollow mirrors are also based on the principle of a Moir6 magnifier, the structure of the grating fields corresponds to those from WO 2010/015382 A2 and WO 2011/015384 A1, the disclosure of which is hereby incorporated by reference in its entirety. In the magnification, this gives the number "50", for example, from the line field, the number being displayed positive or negative depending on the viewing angle, and the enlarged stars with a dynamic depth effect in the surroundings.

According to a further exemplary embodiment, the micro-hollow mirrors are arbitrarily arranged as an array in grids, for example square, hexagonal, parallelogram-like, or even only partially, for example in defined forms. The structuring / embossing can take place as hemispheres, ellipses, spherical as well as aspherical forms, or also pyramids, polygons, or in combination with different shapes and angles with one another.

FIG. 7 shows a pressure plate 15 with a depression 16 on the bottom of which are arranged structures which give recesses for micro hollow mirrors.

The surface of the recess 16 is lowered against the surface of the surrounding pressure plate 15 in order to avoid roughening of the metallization by the counter-pressure cloth during the pre-structuring of the micro hollow mirrors by the superimposition printing process and thus to optimize the mirroring effect. The recess 16 is particularly preferably laser-fed into the pressure plate 15 so that different forms of the recessed pre-structuring are possible.

A particular advantage of this is that the micro hollow mirrors can thus also be implemented in the case of a banknote with a one-sided front side imprinting pressure and a maximum gloss of the reflective coating in the mirrors is achieved. FIG. 8 shows a conventional milled die plate 17 with a pre-structure for the production of micro-hollow mirrors. Into the pressure plate 17, recesses 18 are milled, which result in elevations on the front side of the substrate during the shaping into a substrate. On the rear side of the substrate, recesses form, which form the micro-hollow mirrors. However, these micro-hollow mirrors have the disadvantage of a loss of gloss compared to the

micro-hollow mirrors which are produced by a pressure plate 15 according to FIG. 7 since the micro-hollow mirrors are not produced directly but indirectly.

FIG. 9 shows an arrangement of, for example, hemispherical micro hollow mirrors in a honeycomb grid. In this case, the base area of the micro hollow mirror is designed in the form of a honeycomb or in the form of a regular hexagon so that no interspaces occur between the individual micro hollow mirrors of the grid.

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CLAIMS WO2013056825

[3]

A method for producing micro hollow mirrors, comprising the steps of: providing a carrier substrate and pre-structuring the carrier substrate so that elevations are produced on a rear side of the carrier substrate, and depressions substantially corresponding to the elevations are formed on a front side of the carrier substrate opposite the rear, the step of applying a reflective coating to at least one side of the carrier substrate in the region of the elevations or recesses so that micro-hollow mirrors are formed by the depressions viewed from the front side of the substrate. 2, Method according to claim 1, characterized in that the pre-structuring of the carrier substrate is effected by embossing, in particular by embossing in the stitch printing process. 3, Method according to claim 1 or 2, characterized in that the carrier substrate is provided as a substrate comprising a paper and / or a carrier film, in particular a translucent carrier film.

Method according to claim 3, characterized in that in the case of an opaque carrier substrate, in particular of paper, the reflective coating is applied to the front side of the carrier substrate, and in the case of a translucent carrier substrate the reflective coating is applied to the front or rear side of the carrier substrate. Method according to at least one of the preceding claims, characterized in that the reflective coating is applied to the carrier substrate such that it is spatially interrupted between the micro-hollow mirrors or forms a continuous layer. Method according to at least one of the preceding claims, characterized in that the application of the reflective coating takes place by means of printing technology, preferably in screen printing, stitch printing, offset printing or

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flexographic printing, or by applying a prefabricated layer by means of transfer or laminating processes. Method according to at least one of Claims 2 to 6, characterized in that the embossing of the carrier substrate takes place by a gravure printing process with a gravure printing plate, the indentations having a gravure depth of about 20 µm to about 150 µm and an gravitational width of about 50 µm to about 500 µm, preferably from about 250 µm to about 300 µm.

[10]

8, Method according to Claim 7, characterized in that the depressions are produced in a regular, in particular raster-like, arrangement. 9, Method according to at least one of the preceding claims, characterized in that the depressions are filled with a transparent material and a microstructure is applied, preferably imprinted or embossed, on the side of the transparent material which opposes the depressions. 10, Method according to claim 9, characterized in that the thickness or the shape of the transparent material is chosen in such a way that the microstructure lies in the focal plane of the micro-hollow mirrors. Method according to at least one of Claims 1 to 8, characterized in that the carrier substrate with the micro hollow mirrors is applied to a data carrier which has at least one security element and at least one folding axis along which the data carrier can be folded, so that the micro hollow mirrors for verification with the safety element.

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VISUALLY VARIABLE SECURITY ELEMENT, AND METHOD FOR PRODUCTION THEREOF

Inventor(s): RAHM MICHAEL [DE]; DICHTL MARIUS [DE]; HEIM MANFRED [DE] ± (RAHM, MICHAEL, ; DICHTL, MARIUS, ; HEIM, MANFRED)

Applicant(s): GIESECKE & DEVRIENT GMBH [DE] ± (GIESECKE & DEVRIENT GMBH)

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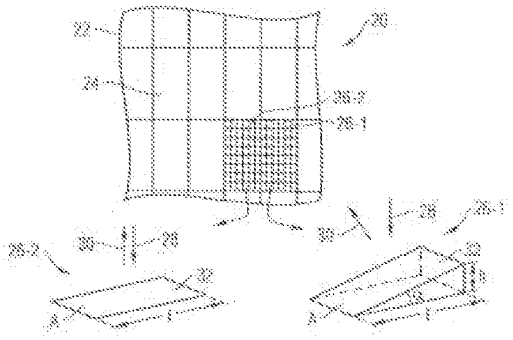
Application number: EP20060829388 20061207

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Abstract not available for EP1966769 (A1)
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An achromatic reflecting micro-structure takes the form of a mosaic (22) made from achromatic reflecting mosaic elements (26-1,26-2), which are characterized by parameters like size, outline shape, relief shape, reflecting capability and three-dimensional orientation and form a predefined motif. Independent claims are also included for the following: (1) A method for producing a security element; (2) A data carrier, especially a valuable document like a bank-note, an identity card, etc.



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Espacenet

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SECURITY ELEMENT HAVING AN OPTICALLY VARIABLE STRUCTURE COMPRISING MICRO-MIRRORS

Inventor(s): MAYER KARLHEINZ [DE]; HUYNH THANH-HAO [DE]; FRANZ PETER [DE]; ADAMCZYK ROGER [DE]; MEINDL KLAUS [DE] ± (MAYER, KARLHEINZ, ; HUYNH, THANH-HAO, ; FRANZ, PETER, ; ADAMCZYK, ROGER, ; MEINDL, KLAUS)

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- cooperative: **B42D25/00**; **B42D25/29**; **G02B5/04**; **G02B5/09**; B42D2033/18; B42D2033/24; B42D2035/20; B42D25/324

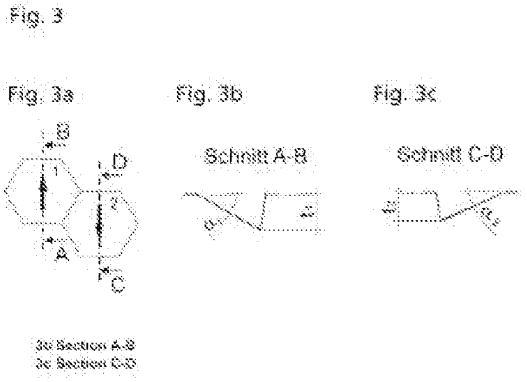
Application number: EP20120774924 20120920

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Abstract not available for EP2760677 (A1)
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The invention relates to a security element having an optically variable structure which comprises a plurality of embossed elements, each embossed element consisting of at least two flanks that extend toward one another in a specific angle and/or a specific direction. The surface of the embossed elements is designed to reflect light. Furthermore, the security element consists of at least two groups of embossed elements, wherein the at least two groups differ from each



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other only in the angle and/or the direction with which or by which the flanks of the embossed elements extend toward one another. According to the invention, each embossed element has a regular hexagonal base surface.

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WO2013045054

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Security element having an optically variable structure of micromirrors

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Publication type	Application
Application number	PCT/EP2012/003940
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Patent Citations (6), Classifications (12), Legal Events (2)

External Links: Patentscope, Espacenet

ABSTRACT

The invention relates to a security element having an optically variable structure which comprises a plurality of embossed elements, each embossed element consisting of at least two flanks that extend toward one another in a specific angle and/or a specific direction. The surface of the embossed elements is designed to reflect light. Furthermore, the security element consists of at least two groups of embossed elements, wherein the at least two groups differ from each other only in the angle and/or the direction with which or by which the flanks of the embossed elements extend toward one another. According to the invention, each embossed element has a regular hexagonal base surface

DESCRIPTION translated from German

Security element having an optically variable structure of micromirrors

The invention relates to a security element with an optically variable structure which has a plurality of embossing elements. Each of the embossing elements comprises at least two flanks which converge in an angle and / or a particular direction to one another, wherein the surface of the embossing elements is made reflective. Furthermore, the security element consists of at least two groups of Prägeele- elements, wherein the at least two groups which differ from each other only in the angle and / or direction, or with the run of the edges of the embossing elements to each other. The invention further relates to a tool for producing said security element. In order to protect against counterfeiting, particularly with color copiers or other reproduction process, are valuable documents such as banknotes, securities, credit or identification cards, passports, certificates and the like, labels, packaging or other elements for product protection with security elements with an optically variable structure off permitted. The counterfeit protection is based that the visually and easily and clearly recognizable optically variable effect is not or only insufficiently reproduced by the reproduction devices mentioned above. In particular, the security elements have a corresponding haptics on that are hard to copy, but is easy and unaided be checked fen.

WO 2010/100360 Al a generic security element for documents of value is known, in which in a grid-like arrangement of reflecting surfaces of the tilt angle of individual mirror is varied in small steps, so that when changing the viewing angle produces a information with a motion effect to a viewer.

The disadvantage here is in particular that the motion effect is only limited to the presentation of a single information.

The invention is therefore based on the object, a generic security element or a tool for making a generic security element in such a way that the disadvantages of the state of the art fixed and the protection against forgery is further increased.

This object is solved by the features of the independent claims. Further developments of the invention are the subject of the dependent claims.

CLAIMS (1) translated from German

1. P atentanspr ü che

A security element with an optically variable structure which has a plurality of embossing elements, each of said embossing elements comprises at least two flanks which converge in an angle and / or a particular direction, wherein the surface of the embossing elements is made reflective, and wherein the The security element of at least two groups of embossing elements, wherein the at least two groups only in the angle and / or direction, with the or run of the edges of the embossing elements to each other, differ from each other, characterized in that each embossing element a regular hexagonal base surface has.

The security element according to claim 1, characterized in that the base of all embossing elements is the same.

The security element according to claim 1 or 2, characterized in that the surface of the embossing elements is provided with a reflective or mirror coating, so that the surface of the incident light is reflected at least nearly specular.

The security element according to at least one of the preceding claims, characterized in that the surface of the embossing elements is provided with a reflective or metallic or metallically reflecting coating so that the surface of the incident light reflected nearly specular.

5. The security element according to at least one of the preceding claims, characterized in that the security element consists of a base element that is several times repeatedly arranged side by side, so that a two-dimensional array of a plurality of basic elements yields, each primitive least two embossing elements contains a regular hexagonal base with at least two pieces of information, wherein in each of these embossing elements, the mirror surfaces are aligned differently. 6. The security element according to claim 5,

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According to the invention, the base of each embossing element to a regular hexagonal geometry. The pattern of embossing elements with a regular hexagonal and thus honeycomb-örmigen geometry has the particular advantage that several embossing information contrast can be nested within each other, since the stamping surface is completely provided with embossing elements without gaps between the embossing elements remain. No surface so it will be given away by blank portions. This is particularly preferably the case, if the base surface of all embossing elements is equally large.

Nevertheless, it is of course possible that the embossing elements are slightly spaced apart. A slight distance in the sense of this invention, a distance which is smaller than the lateral dimensions of an embossing element. Short sections are arranged on plate level or in the plane of the non-shaped substrate between the respective embossing elements.

As a base of an embossing element the surface of the embossing element is understood in the context of this invention, the case of vertical projection of the embossed element arises on the substrate into which the embossing element is embossed. Those areas used for the reflection behavior of the pre- are essential geelements and converge in the specified angle above are called flanks. All other surfaces are, if present, referred to as side faces.

The term "honeycomb embossing element" is in the present and the following remarks to be equated with the term "embossing element having a regular hexagonal base", and these terms can be used interchangeably.

A honeycomb and hence also the base surface of the honeycomb element has Prägeele- known to a point of symmetry, so that an orientation of the mirror surfaces is possible in all directions. Thus both effects can be produced, which appear in the establishment and tilting of the security element, as well as effects that occur when rotating the security element. In this way, a wide variety of motion effects can be displayed.

A tool for producing such security elements or embossing elements, for example, a printing plate, in particular an intaglio printing plate, or die, in particular a blind embossed intaglio printing plate. A blind embossed intaglio plate here is an intaglio printing plate whose wells are not filled with color, so that the substrate merely stamped, but not acted on its surface with a color. The production of the embossing elements of the invention is particularly preferably possible in metal with the use of so-called direct laser engraving, be introduced directly in the corresponding recesses in a metallic master embossing plate by laser radiation. This thus produced, with further elements and / or other manufacturing steps, such as mechanical engraving, provided master stamper can then be reproduced on other galvanic process steps, which as a final step an intaglio printing plate is produced. Finally, the embossing plate is pressed during the embossing operation against a substrate so that the substrate deforms and accordingly the embossing elements are embossed in the single substrate. Particularly preferably, the embossing elements are produced with an intaglio printing.

Instead of raised embossing elements also deepened embossing elements are of course possible. Here, the embossing elements do not protrude out of the plane of the substrate surface, but instead form cavities in the substrate surface, the embossing elements thus project into the substrate. A corresponding embossing plate can not exhibit increases in relation to the die level, in this case, since this would impair the wiping operation, for example by means of a squeegee. Instead, increases in a recessed or depressed region of the die must in this case be introduced, so that the increases do not protrude above the die level. These structures thus correspond to structures, such as are known for example from WO 2010/075979 Ai. Thus, FIG. 2 of WO 2010/075979 Al a correspondingly embossed substrate and Fig. 3 shows a die for producing embossed structures in FIG. 2nd

By steeper flanks, which can be generated with the laser engraving in comparison to other engraving method, there is the possibility to manufacture embossing elements in high resolution, with the length of an embossing element, ie the size of its lower edge to its upper edge, 10 pm μm to 2000, preferably from 30 pm to 500 pm and more preferably from 50 pm to 300 pm is.

Preferably, the laser engraving means of an Ultra-short-pulse laser, the laser pulses with a duration in the range of picoseconds or femtoseconds done to deliver. Particularly preferably a picosecond or ps laser is used to write the laser pulses with a duration in the range of picoseconds.

Preferably, a security element of a base element, which is several times repeatedly arranged side by side, so that a two-dimensional arrangement results from a variety of primitives. Each basic element contains at least two honeycomb with at least two pieces of information, which in each of these honeycomb the mirror surfaces are oriented differently. Preferably, a base element from two to six honeycomb having two to six information. The outline shape of these planar array of a plurality of basic elements can be designed as desired and be configured for example three, four or polygonal or take the form of a graphic image. A particular advantage of the inventive security element is to create an embossed structure that contains at least two pieces of information that appear in different viewing angles. Another particular advantage of the

characterized in that a basic element from two to six embossing elements consists of two to six information.

7. The security element according to at least one of the preceding claims, character- ised in that the embossing elements of the basic element which does not contribute to the two to six information, are filled with a background embossing element which is oriented differently as the embossed elements of the base member. 8. The tool for producing a security element according to one of claims 1 to 7th

9. A tool according to claim 8, characterized in that the tool is a printing or embossing plate

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inventive security element is that not only two but also three or more information can be displayed with the best possible contrast.

The surface of the embossing elements is more preferably provided with a reflective border or metallic or metallic reflective coating so that the surface of the incident light is reflected almost specular. This coating, which may be applied to the substrate of the security element, before or after embossing with the embossing elements is preferably carried out as follows:

- As a metallic or metallic-looking screen printing ink,

- As a paint with optically variable pigments, preferably so-called OVI pigments,

- As a paint with optically variable pigments which are additionally magnetically alignable, preferably so-called OVMI pigments,

- As a paint with optically variable pigments Iriodin example from Bayer, which is applied in the flexographic printing or screen printing and is preferably combined with an applied in offset printing underground.

- As a film in the form of a strip or patch that is applied to the substrate,

- As a brilliant offset ink, which preferably has a shiny metallic surface, as brilliant intaglio printing ink, which preferably has a black color or colorless or may have a shiny metallic appearance, such as gold or silver. The stamping and printing of the substrate are particularly preferably carried out in a single operation, for example by an ink-carrying intaglio printing is used. Here, the wells of a gravure printing plate are at least partially filled with one or more different colors, so that the printing of the printing material printing material not only deformed or stamped, but is loaded with color.

The substrate preferably comprises paper, and / or a film, in particular a translucent foil. In the simplest case the substrate consists completely of either paper or plastic. The substrate may, however, also partially consist of different materials, and in particular in a range of paper and at the same time in a different area from plastic, preferably from a translucent foil. This makes it possible to characterize various materials as a substrate in a single operation to be used. Under translucent film here either a transparent or semi-transparent film is understood, for example, a translucent film containing, for example polyamide, polyester, polyethylene or biaxially oriented polypropylene (BOPP). According to a preferred embodiment, the embossing elements are incorporated in a translucent film. This translucent film can cover, for example an opening in an opaque value document at least partially. According to a preferred embodiment, some of the not line-shaped embossed elements is at least designed tactile, so that the viewer can not only visually recognize, but also for example, feel with your fingertips.

The security element according to the invention can of course be combined with other known from the prior art security features, thereby protecting against counterfeit is increased further. For example, at least portions of the Si cherheitselements invention having a security element according to EP 1317346 Bl, WO 97/17211, WO 02/20280 Al or Al are combined.

By the following examples and additional figures, the advantages of the invention will be explained. The single features described and embodiments described below are taken inventive in itself, but also in combination inventive. The examples represent preferred embodiments to which, however, the invention should be restricted in any way. The proportions shown in the figures do not correspond to the relations existing in reality and serve only to improve clarity.

In detail, schematically:

Fig. 1 shows two honeycomb-shaped embossed elements of the invention in top view,

Fig. 2 shows the definition of the mirror direction,

Fig. 3 shows an embodiment of the invention two honeycomb embossing elements in plan view in Fig. 1, Fig. 4 shows an embodiment of a Hintergrundwabe H,

Fig. 5 shows an embodiment with a rectangular outline form, Fig. 6 shows an embodiment with an outline shape in the form of a free-form,

Fig. 7 shows an exemplary reaction with the two pieces of information A and B, Fig. 8 shows an embodiment with three pieces of information,

Fig. 9 shows an embodiment with six information,

FIG. 10 is a concrete example of the orientation of the mirror surfaces at six information shown in FIG. 9,

FIG. 11 is another concrete example of the orientation of the mirror surfaces at six information shown in FIG. 9, FIG. 12 an embodiment with an arched appearance of a letter A

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Fig. 13 two embodiments of a printing plate for producing inventive embossing elements (above) as well as one verprägtes with this printing plate substrate (below)

Fig. 14 shows an embodiment of an inventive honeycomb-shaped embossed element, which is embodied as a depression in the substrate, in an oblique top view. FIG. 1 shows an embodiment in which the honeycomb embossing element with the number 1 information 1 and the honeycomb embossing element with the number 2 is assigned 2 information. The length A of a honeycomb embossing element is impressed by intaglio printing in a paper substrate is between 10

µm

µm and 2000, preferably between 30 and 500 µm µm and particularly preferably between 50 and 300 µm µm. Each honeycomb-örmige embossing element is designed as tilted in a certain direction mirror surface that reflects light in one direction. The information a different direction is chosen so that the embossing elements of a first information light from a different direction than reflect the embossing elements of a second to nth information. Honeycomb-örmige embossed elements that are not associated with a specific piece of information, are referred to as background honeycomb H and received all a common mirror direction, are left as original surface not engraved or have no embossing or to show an angle profile which is perceived as a vault.

Below the mirror directions in FIG. 2 are symbolized by arrows, circulate the counter-clockwise from the horizontal from. The designated 0 ° horizontal arrow to the right in this case means a mirror surface, the surface normal is tilted to the right by α a mirror angle relative to a surface normal, which is perpendicular to the surface of the die. This mirror surface thus has on its right side a greater depth relative to the die surface than her left side. The designated 90 ° vertical upward arrow represents a mirror surface, the surface normal is tilted α up to a mirror angle relative to a surface normal, which is perpendicular to the surface of the die. This mirror surface thus has on its upper side has a greater depth relative to the die surface than its lower side. The arrows that are denoted by 180 ° or 270 °, mirror surfaces that are tilted with respect to the arrows denoted by 0 ° or 90 ° in the other direction means.

The term "bottom" or "top", "bottom" and "top" and "lower portion" and "upper portion" of the embossing elements is here and hereinafter related to the schematic illustration of embossing elements in the figures. Thus, for example referred to the underside or the lower portion of an embossing element is not the side facing the die, in which the embossing element is embossed, but a certain side of the embossing element in relation to the schematic illustration. Instead of the term "bottom" could alternatively be called "southern" side or instead of the word "top" the term "northern" side are used.

Angles that are indicated ben within a honeycomb embossing element, do not relate to the direction of the tilt of the mirror surfaces, but at the mirror angle a by which the mirror surfaces are tilted with respect to the die surface.

Fig. 3 shows in Fig. 3a is an example of a mirror arrangement in which a goods benförmiges embossing element 1 with the information 1 αι a mirror direction of 90 °, a mirror angle and has a depth t. The mirror angle is in this case based on the level of the die surface into which the embossing elements are imprinted using a mirror angle of 0 °, a non-independent substrate or a mirror means the mirror plane is oriented parallel to the die surface level. The honeycomb embossing element 2 with a Release 2 has a mirror direction of 270 °, a mirror angle ci2 and a depth t2. The depth, in preparation by intaglio between 0 pm and 350 pm are varied, preferably in the range 10 pm to 120 pm. Depending on the length A of the embossing pattern results from a certain angle a mirror. The mirror angle A varies between 0 ° and 80 °, preferably between 10 ° and 70 °.

Fig. 3b and Fig. 3c show a cross-sectional view taken along the designated in FIG. 3a with section lines AB and CD of the embossing plate. The contrast of the information in this case depends inter alia on the steepness of the flank from Rücksprung-, ie. The angle of inclination of the edge shown in Fig. 3b and right in Fig. 3c left The steeper the return flank and the closer it comes so an angle of 90 °, the contrast, the information is emerging. The recessed structures of the die result after embossing according sublime mirror surfaces in the substrate, a substrate dependent on the loss of embossing height arises.

Embossing elements of the invention are particularly preferably with a die, such as an intaglio printing plate, manufactured in the respective wells are introduced with an ultra-short pulse lasers or picosecond or ps-laser, the ps-laser laser pulses with a duration in the range of picoseconds emits. Only with the use of ps-laser will flank angle greater than 60 ° stable and reproducible and can be produced in high resolution without finishing. Of course, the steepness of the flanks and the engraving depth must be adapted to the possibilities of the substrate used, so this is not inadmissible weakened still injured, such as torn or cut. The structures can be alternatively be made with a nanosecond or ns laser, but a reworking of the engraving by etching, electropolishing, irradiation with COVSchnee or mechanical polishing is required. Fig. 4 shows an embodiment of a Hintergrundwabe H. Such background honeycomb H surrounded example, the embossed elements 1 with the information 1 and the embossing elements 2 with the information 2. In this embodiment, the Hintergrundwabe H with a mirror direction of 180 ° and a mirror angle of 20 ° occupied. The important thing is a good contrasting of the generated by the H Hintergrundwabe information to information 1 and 2 of the honeycomb. 1 and 2

The defined basic cell is then repeated until a desired base is filled. The outline shape of the base may be of any desired shape, they may be rectangular, round, oval or assume any freeform.

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Fig. 5 this 6 shows an embodiment with a rectangular outline shape and Fig.. An embodiment with an outline shape in the form of a free-form.

Fig. 7 shows an exemplary implementation of the two pieces of information A and B. The area with the information A is filled with honeycomb embossing elements of type 1, the area with the information B with honeycomb embossing elements of type 2. The areas that neither of the two information A or B members are filled with the background honeycomb type H. If the basic cell as shown in FIG. 3 executed, information A and B appear alternately in the establishment and tilting of the security element. The unfilled with embossing elements areas within the two pieces of information A and B, for example,

• have no embossing elements or

• filled with embossing element of type 1 or type 2, so that a further increase in contrast between the two gives information or

• be filled with background honeycomb type H, thus resulting in a more uniform appearance. However, it can also be more than two pieces of information are integrated into the embossing pattern. Fig. 8 shows an embodiment with three pieces of information, and FIG. 9, an embodiment with six information.

Fig. 10 and Fig. 11 show concrete embodiments for the orientation of the mirror surfaces at six information shown in FIG.. 9

In the embodiment shown in FIG. 10, the information 1 to 4, for example a motion effect is that each object of the movement effect are visible in sequence with the up and down by tilting. Turning the security element by 90 ° to the right or left, the information is 5 or 6 visible.

In the embodiment shown in FIG. 11 to change each piece of information on rotation of the embossing substrate by 60 °.

In the previous examples showed how more information can be alternately interleaved in the honeycomb embossing elements. But there is also the possibility, within a partial area that represents a particular object or part of object, the mirror direction and / or the mirror angle of the honeycomb embossing elements to change This can be done in small increments as the course, so that ect a certain 3D Eff arises , One can in this subarea indeed then be no more than information, receives a greater brilliance of the effect. In Fig. 12 an example with a curved appearance of the letter A is shown. This embodiment and this method can also be combined with the embodiments and methods described above. So more information in the manner described above can be introduced outside the letter A.

Fig. 13 shows two exemplary embodiments of a pressure plate 7 for the production according to the invention the embossing elements and a respective verprägtes with this printing plate substrate 8. The pressure plates 7 have recesses, whose geometry and dimensions correspond to the embossed structures in the substrate 8.

Fig. 14 shows an embodiment for an inventive honeycomb-Miges embossing element which is designed as a depression in the substrate, in an oblique plan view from the right front. A corresponding embossing plate for the production of this molding element, in contrast to the die of FIG. 13 increases, which are inserted in a recessed or depressed region of the die. The increases must not protrude over the die level, otherwise they will affect the wiping process or affected by the wiping operation itself or damaged would here.

PATENT CITATIONS

Cited Patent	Filing date	Publication date	Applicant	Title
WO1997017211A1	Nov 2, 1996	May 15, 1997	Giesecke & Devrient Gmbh	Data carrier with an optically variable element
WO2002020280A1	Sep 6, 2001	Mar 14, 2002	Giesecke & Devrient Gmbh	Data support with an optically variable element
WO2003081983A1 *	Jan 24, 2003	Jul 31, 2003	Nanoventions, Inc.	Micro-optics for article identification
WO2006095181A2 *	Mar 7, 2006	Sep 14, 2006	De La Rue International Limited	Article and security device based on customised microprism film
WO2008008835A2 *	Jun 28, 2007	Jan 17, 2008	Visual Physics, Llc	Micro-optic security and image presentation system
WO2010075979A1	Dec 17, 2009	Jul 8, 2010	Giesecke & Devrient Gmbh	Security element having optically variable structure
WO2010100360A1	Feb 19, 2010	Sep 10, 2010	Oberthur Technologies	Security element for a value document
EP1317346B1	Sep 6, 2001	Jun 30, 2004	Giesecke & Devrient GmbH	Data carrier, method for the production thereof and gravure printing plate

* Cited by examiner

CLASSIFICATIONS

International Classification	G02B5/09, B42D15/10, B42D15/00, G02B5/04
Cooperative Classification	B42D25/00, B42D25/29, B42D25/324, B42D2033/18, B42D2035/20, B42D2033/24, G02B5/04, G02B5/09

LEGAL EVENTS

Date	Code	Event	Description

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Date	Code	Event	Description
May 29, 2013	121	Ep: the epo has been informed by wipo that ep was designated in this application	Ref document number: 12774924 Country of ref document: EP Kind code of ref document: A1
Mar 31, 2014	NENP	Non-entry into the national phase in:	Ref country code: DE

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Electronic Acknowledgement Receipt	
EFS ID:	42466188
Application Number:	17152623
International Application Number:	
Confirmation Number:	9833
Title of Invention:	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES
First Named Inventor/Applicant Name:	MARK A. RAYMOND
Customer Number:	166539
Filer:	Kent Alan Lembke./Kayleigh Sandoval
Filer Authorized By:	Kent Alan Lembke.
Attorney Docket Number:	79897.01436
Receipt Date:	15-APR-2021
Filing Date:	19-JAN-2021
Time Stamp:	16:20:12
Application Type:	Utility under 35 USC 111(a)

Payment information:

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	79897-01436_IDS.pdf	1035472 cfe6cb205faa9752ebd24ffdf23040bf5ebd6875	no	6
Warnings:					

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Information:					
2	Foreign Reference	WO2012048847.pdf	2688960 f68db55d787c508bedda03e8f32b681be38c801b	no	69
Warnings:					
Information:					
3	Foreign Reference	WO2012048847_Eng_Machine_Translation.pdf	1184086 0553c10a6f4e35d64f25700c0b5262c56d9991d8	no	33
Warnings:					
Information:					
4	Foreign Reference	WO2011012460_Machine_Translation.pdf	281684 aa2adc371239ff158fbe16299e52b0bb969eb003	no	17
Warnings:					
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5	Foreign Reference	WO2013056825_Machine_Translation.pdf	269830 cc72901da10d7978bb84467055b60f08ae6f271a	no	19
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6	Foreign Reference	WO2012000669A1.pdf	2131559 8de3b1b59d3e1b34be374d9be9d8b6a78a9a76b5	no	50
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7	Foreign Reference	WO2012000669_Eng-Trans.pdf	69818 45422a996493f2a083ebe5355a5272f1c9c8f79c	no	3
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8	Foreign Reference	DE102010048262A1.pdf	1639979 7c971844e89248addc419042f72ec2cae24c5b2c	no	26
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9	Foreign Reference	DE102010048262_Eng-Trans.pdf	165148 16cf1e49f4ab764707b3d82c5e54cc2e67f256ba	no	42
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10	Foreign Reference	EP1966769_Abstract.pdf	109251 226620f7f5331a0da907a8a7bdc40441c6d6b019	no	1
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11	Foreign Reference	EP2760677_Abstract.pdf	110196 2e05c3fd00b374b531225c38e7a87d52e9f7a721	no	2
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12	Foreign Reference	WO2013045054.pdf	173679 65e9a025c5f1198fd3d030a626c803a82e6dec5f	no	6
Warnings:					
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13	Non Patent Literature	EP-Search-Report_00122.pdf	229413 6709a155381db0135b68de1360910fb0ca880a0f	no	8
Warnings:					
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14	Non Patent Literature	ISR_50875-00121.pdf	518353 686b6256e2a45d5c818755f5c097dec005e92646	no	16
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15	Non Patent Literature	ISR-WO_00105.pdf	300383 a81a861a86f525e160f86c786bec0bcce331b077	no	7
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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(71) Anmelder *(für alle Bestimmungsstaaten mit Ausnahme von US)*: **GIESECKE & DEVRIENT GMBH** [DE/DE]; Prinzregentenstraße 159, 81677 München (DE).

(72) Erfinder; und

(75) Erfinder/Anmelder *(nur für US)*: **FUHSE, Christian** [DE/DE]; Bahnhofstraße 22, 83624 Otterfing (DE). **RAHM, Michael** [DE/DE]; Akeleistraße 27, 83646 Bad Tölz (DE). **RAUCH, Andreas** [DE/DE]; Hochwiesenweg 8, 82441 Ohlstadt (DE).

(74) Gemeinsamer Vertreter: **GIESECKE & DEVRIENT GMBH**; Patent- und Lizenzabteilung, Prinzregentenstraße 159, 81677 München (DE).

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Erklärungen gemäß Regel 4.17:

— *hinsichtlich der Berechtigung des Anmelders, ein Patent zu beantragen und zu erhalten (Regel 4.17 Ziffer ii)*

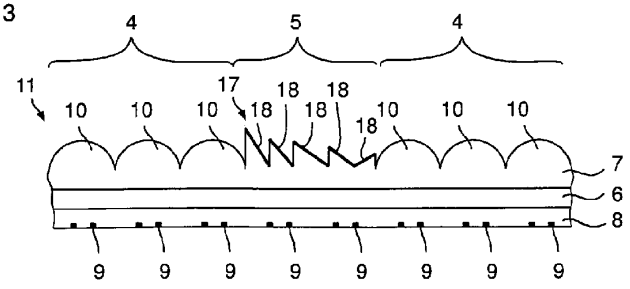
— *hinsichtlich der Berechtigung des Anmelders, die Priorität einer früheren Anmeldung zu beanspruchen (Regel 4.17 Ziffer iii)*

[Fortsetzung auf der nächsten Seite]

(54) **Title**: SECURITY ELEMENT, AND VALUE DOCUMENT COMPRISING SUCH A SECURITY ELEMENT

(54) **Bezeichnung** : SICHERHEITSELEMENT SOWIE WERTDOKUMENT MIT EINEM SOLCHEN SICHERHEITSELEMENT

Fig. 3



(57) **Abstract**: The invention relates to a security element for a security paper, value document or the like, comprising a support having a motif region (3), which provides a visually perceptible motif having a first and a second motif part (4, 5), wherein the motif region (3) comprises a first micro-optical representation arrangement (11), (e.g. microlenses (10) and microstructures (9), forming a moire magnification arrangement; a partially demetallized perforated screen (31); or a diffractive structure), which presents at least two different images as the first motif part in a manner dependent on the viewing angle, and a second micro-optical representation arrangement (17) (e.g. a plurality of reflecting facets (or embossed structures such as reflective fresnel structures, diffraction structures, or mat structures) which can also be partially demetallized), which presents a reflective surface as the second motif part (5), said reflective surface appearing curved relative to the actual macroscopic spatial form of the second micro-optical representation arrangement (17). Special effects appear in transmitted light.

(57) **Zusammenfassung**:

[Fortsetzung auf der nächsten Seite]

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Veröffentlicht:

— *mit internationalem Recherchenbericht (Artikel 21 Absatz 3)*

— *vor Ablauf der für Änderungen der Ansprüche geltenden Frist; Veröffentlichung wird wiederholt, falls Änderungen eingehen (Regel 48 Absatz 2 Buchstabe h)*

Die Erfindung betrifft ein Sicherheitselement für ein Sicherheitspapier, Wertdokument oder dergleichen, mit einem Träger, der einen Motivbereich (3) aufweist, der ein visuell wahrnehmbares Motiv mit einem ersten und einem zweiten Motivteil (4, 5) bereitstellt, wobei der Motivbereich (3) eine erste mikrooptische Darstellungsanordnung (11) (z.B. Mikrolinsen (10) und Mikrostrukturen (9), was eine Moire -Vergrösserungsanordnung bildet; z.B. ein Lochraster (31) mit einer partiellen Demetallisierung; oder z.B. eine diffraktive Struktur), die als ersten Motivteil betrachtungswinkelabhängig zumindest zwei verschiedene Bilder darbietet, und eine zweite mikrooptische Darstellungsanordnung (17) (z.B. eine Vielzahl von verspiegelten Facetten (oder geprägte Strukturen wie reflektive Fresnel - Strukturen, Beugungsstrukturen oder Mattstrukturen), die auch teilweise demetallisiert sein können) umfasst, die als zweiten Motivteil (5) eine reflektive Oberfläche darbietet, die gegenüber der tatsächlichen makroskopischen Raumform der zweiten mikrooptischen Darstellungsanordnung (17) gewölbt erscheint. Im Durchlicht sind besondere Effekte vorhanden.

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Sicherheitselement sowie Wertdokument mit einem solchen Sicherheitselement

Die vorliegende Erfindung betrifft ein Sicherheitselement für ein Sicherheitspapier, Wertdokument oder dergleichen, sowie ein Wertdokument mit einem solchen Sicherheitselement.

Zu schützende Gegenstände werden häufig mit einem Sicherheitselement ausgestattet, das die Überprüfung der Echtheit des Gegenstandes erlaubt und sogleich als Schutz vor unerlaubter Reproduktion dient.

Zu schützende Gegenstände sind beispielsweise Sicherheitspapiere, Ausweis- und Wertdokumente (wie z.B. Banknoten, Chipkarten, Pässe, Identifikationskarten, Ausweiskarten, Aktien, Anlagen, Urkunden, Gutscheine, Schecks, Eintrittskarten, Kreditkarten, Gesundheitskarten, etc.) sowie Produktsicherungselemente (wie z.B. Etiketten, Siegel, Verpackungen, etc.).

Es sind Sicherheitselemente bekannt, die eine mikrooptische Darstellungsanordnung in Form einer Moiré-Vergrößerungsanordnung, wie sie z.B. in der WO 2007/076952 A2 beschrieben ist, oder in Form einer Modulo-Vergrößerungsanordnung, wie sie z.B. in der WO 2009/000528 A1 beschrieben ist, aufweisen, um einen dreidimensionalen Bildeindruck zu erzeugen, der einprägsam ist. Gleichzeitig ist ein solches Sicherheitselement schwer nachzuahmen, da der mikrooptische Aufbau schwierig zu kopieren oder nachzubilden ist. Da jedoch Fälscher stets daran arbeiten, bekannte Sicherheitselemente zu fälschen, besteht ein Bedarf an Sicherheitselementen mit erhöhter Fälschungssicherheit.

Davon ausgehend liegt der vorliegenden Erfindung die Aufgabe zugrunde, ein Sicherheitselement für ein Sicherheitspapier, Wertdokument oder dergleichen bereitzustellen, das schwieriger zu kopieren oder nachzubilden ist.

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Erfindungsgemäß wird die Aufgabe gelöst durch ein Sicherheitselement für ein Sicherheitspapier, Wertdokument oder dergleichen, mit einem Träger, der einen Motivbereich aufweist, der ein visuell wahrnehmbares Motiv mit einem ersten und einem zweiten Motivteil bereitstellt, wobei der Motivbereich eine erste mikrooptische Darstellungsanordnung, die als ersten Motivteil betrachtungswinkelabhängig zumindest zwei verschiedene Bilder darbietet, und eine zweite mikrooptische Darstellungsanordnung umfasst, die als zweiten Motivteil eine reflektive Oberfläche darbietet, die gegenüber der tatsächlichen makroskopischen Raumform der zweiten mikrooptischen Darstellungsanordnung gewölbt erscheint.

Bei dem erfindungsgemäßen Sicherheitselement weist der Motivbereich den ersten und zweiten Motivteil auf, der unterschiedliche mikrooptische Darstellungsanordnungen umfasst, die in der Regel deutlich unterschiedliche Anforderungen an ihre Herstellungsprozesse, insbesondere Origination, stellen. Das bedeutet, dass ein Fälscher beide Herstellungsprozesse beherrschen muss, wodurch die Fälschungssicherheit erhöht wird.

Ferner weist das erfindungsgemäße Sicherheitselement aufgrund der beiden mikrooptischen Darstellungsanordnungen eine sehr hohe optische Attraktivität und somit einen besonders hohen Wiedererkennungswert auf. Dadurch wird der Benutzer, wenn es sich bei den Sicherheitselementen beispielsweise um ein Sicherheitselement für eine Banknote handelt, die Banknote bevorzugt anhand dieses attraktiven Sicherheitselementes auf Echtheit überprüfen. Als Folge sind die Anforderungen an einen Fälscher erhöht, da er beide mikrooptische Darstellungsanordnungen in hoher Qualität nachahmen oder kopieren muss, was sehr aufwendig ist, um eine Fälschung herzustellen, die vom Benutzer nicht als solche erkannt wird.

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Die beiden Motivteile sind bevorzugt (räumlich) zusammenhängend angeordnet, so dass die von beiden mikrooptischen Darstellungsanordnungen dargebotenen Bilder von dem Benutzer als ein einziges Motiv wahrgenommen werden können.

Unter der zusammenhängenden Anordnung wird insbesondere verstanden, dass der Abstand der beiden Motivteile bevorzugt kleiner als 1 mm und insbesondere bevorzugt kleiner als 0,2 mm ist. Ferner können beide Motivteile direkt aneinander grenzen.

Für den Benutzer ist daher zumindest in einer bestimmten Betrachtungs- bzw. Beleuchtungssituation bevorzugt nicht erkennbar, dass zwei verschiedene mikrooptische Darstellungsanordnungen vorhanden sind. Er erkennt nur die optisch verschieden dargestellten Motivteile, sieht dies aber quasi als ästhetisches Stilmittel der Darstellung des Motivs. Er wird daher zumindest in der bestimmten Betrachtungs- bzw. Beleuchtungssituation das gesamte Motiv als solches wahrnehmen.

Das Sicherheitselement kann bevorzugt so ausgebildet sein, dass einer der beiden Motivteile den anderen der beiden Motivteile zumindest teilweise umgibt. Insbesondere kann der umgebende Motivteil den anderen Motivteil vollständig in Art eines Rahmens umgeben.

Ferner ist es möglich, dass sich beide Motivteile zumindest teilweise überlappen und/oder zumindest bereichsweise ineinander verschachtelt sind.

Eine Umrahmung bzw. die Anordnung des ersten und zweiten Motivteils in sehr geringen Abständen erhöht die Fälschungssicherheit insbesondere

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dann, wenn die beiden mikrooptischen Darstellungen mit unterschiedlichen Origination-Verfahren hergestellt werden müssen und/oder nicht gleichzeitig geprägt werden können. Ein Fälscher muss dann nicht nur zwei Origination- und/oder Prägeverfahren beherrschen, sondern die damit hergestellten Motive auch noch in exaktem Passer zueinander positionieren. Insbesondere verschachtelte Motivteile sind dann äußerst schwer zu fälschen.

Eine eventuell vorhandene unterschiedliche Abhängigkeit des optischen Erscheinungsbilds der beiden mikrooptischen Darstellungsanordnungen von der vorliegenden Betrachtungs- oder Beleuchtungssituation kann auch gezielt für weitere Effekte eingesetzt werden. Insbesondere kann das erfindungsgemäße Sicherheitselement mit Vorteil so ausgebildet sein, dass je nach Betrachtungs- und/ oder Beleuchtungssituation die Darstellung einer der mikrooptischen Darstellungsanordnungen dominiert, während sich die Darstellungen der ersten bzw. zweiten mikrooptischen Darstellungsanordnung in einer anderen Betrachtungs- bzw. Beleuchtungssituation zu einem Gesamtmotiv ergänzen.

In einer weiteren vorteilhaften Ausgestaltung, die nachfolgend noch im Detail beschrieben wird, liefert die erste mikrooptische Darstellungsanordnung bei konstantem Betrachtungswinkel eine von der Beleuchtungsrichtung unabhängige Darstellung, während die Darstellung der zweiten mikrooptischen Darstellungsanordnung abhängig von der Beleuchtungsrichtung variiert.

Das Sicherheitselement kann ferner so ausgebildet sein, dass eine der beiden mikrooptischen Darstellungsanordnungen einen Hintergrund darstellt, vor dem die andere der beiden mikrooptischen Darstellungsanordnungen ein

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Objekt zeigt, so dass insgesamt eine dreidimensional erscheinende Gesamtansicht als Motiv wahrnehmbar ist.

Bei dem erfindungsgemäßen Sicherheitselement kann die erste mikrooptische Darstellungsanordnung die zumindest zwei verschiedenen Bilder betrachtungswinkelabhängig so darbieten, dass sich die Bilder zumindest bereichsweise überlappen und/ oder ineinander verschachtelt sind.

Die erste mikrooptische Darstellungsanordnung kann mit besonderem Vorteil zwei unterschiedliche Ansichten desselben Objekts als die zumindest zwei verschiedenen Bilder darbieten.

Ferner ist es möglich, dass die zumindest zwei verschiedenen Bilder so dargeboten werden, dass sich für einen Betrachter eine stereographische Darstellung eines Objektes mit einer absoluten Tiefeninformation ergibt. Für den Betrachter ist somit das Objekt scheinbar vor oder hinter dem Träger positioniert, wobei der scheinbare Abstand vom Träger und somit die Tiefeninformation durch die Ausbildung der ersten mikrooptischen Darstellungsanordnung festgelegt ist.

Insbesondere können mehr als zwei verschiedene Bilder desselben Objektes mittels der ersten mikrooptischen Darstellungsanordnung so dargeboten werden, dass sich eine Parallaxe ergibt. Damit kann erreicht werden, dass sich bei einer Änderung des Betrachtungswinkels Bildbestandteile des ersten Motivteiles im Vordergrund relativ zu Bildbestandteilen des ersten Motivteiles im Hintergrund bewegen. Dies kann sogar dazu führen, dass man quasi hinter ein im Vordergrund des ersten Motivteiles dargestelltes Objekt schauen kann.

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In einer vorteilhaften Ausgestaltung kann die erste mikrooptische Darstellungsanordnung ein Hologramm aufweisen. Das Hologramm kann beispielsweise ein Prägehologramm sein. Insbesondere kann es sich um ein Volumenhologramm handeln. Ferner kann das Hologramm in klassischer Weise ein direkt belichtetes Hologramm oder auch ein computergeneriertes Stereogramm sein.

In einer anderen vorteilhaften Ausgestaltung kann die erste mikrooptische Darstellungsanordnung Mikrostrukturen sowie Mikroabbildungselemente, um die Mikrostrukturen vergrößert abzubilden, umfassen. Insbesondere kann die erste mikrooptische Darstellungsanordnung als Mikrolinsen-Kippbild, als Moiré-Vergrößerungsanordnung oder als Modulo-Vergrößerungsanordnung ausgebildet sein.

Die Mikroabbildungselemente können als fokussierende Elemente ausgebildet sein. Sie können als eindimensional fokussierende Elemente (beispielsweise Zylinderlinsen oder entsprechende Mikrohohlspiegel) oder auch als zweidimensional fokussierende Elemente (beispielsweise sphärische oder asphärische Linsen oder entsprechende Mikrohohlspiegel) ausgebildet sein. Ferner ist es möglich, dass die Mikroabbildungselemente als Lochraster ausgebildet sind.

Die Mikrostrukturen und/ oder die Mikroabbildungselemente können in einem ein- oder zweidimensionalen Raster angeordnet sein, wobei die Rasterweite bevorzugt kleiner als 300 µm, insbesondere kleiner als 100 µm und besonders bevorzugt kleiner als 40 µm ist.

Bei dem erfindungsgemäßen Sicherheitselement kann die erste mikrooptische Darstellungsanordnung mittels der zumindest zwei verschiedenen Bil-

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der ein Kippbild mit mindestens zwei unterschiedlichen Ansichten desselben Objekts darbieten. Die unterschiedlichen Ansichten können dabei dasselbe Objekt so zeigen, dass sich ein stereographischer Tiefeneindruck ergibt. Die unterschiedlichen Ansichten können jedoch auch eine von der für eine absolute Tiefeninformation notwendigen Parallaxe leicht abweichende Parallaxe aufweisen, so dass zusätzlich zu einem dreidimensionalen Eindruck noch eine Bewegung des dargestellten Objektes bei Änderung des Betrachtungswinkels für den Betrachter dargeboten wird. Ferner ist es möglich, die mindestens zwei unterschiedlichen Ansichten orthoparallaktisch darzustellen, wie dies z.B. in der WO 2007/076952 A2 beschrieben ist. Dabei lassen die Darstellungen für das linke und rechte Auge des Betrachters streng genommen keine Zuordnung einer Tiefe zu, da sich die Blickrichtungen, unter denen der Betrachter das Objekt mit dem linken und rechten Auge sieht, nicht schneiden.

Die erste mikrooptische Darstellungsanordnung kann daher auch so ausgebildet sein, dass sie einen betrachtungswinkelabhängigen Bewegungseffekt bereitstellt, wobei dieser mit oder ohne absolute Tiefeninformation relativ zum Träger bewirkt werden kann. Insbesondere sind orthoparallaktische Darstellungen möglich.

Die zweite mikrooptische Darstellungsanordnung ist insbesondere so ausgebildet, dass die gewölbt erscheinende reflektive Oberfläche einen reliefartigen Eindruck darbietet. Dieser Eindruck ist insbesondere so, dass unabhängig vom Betrachtungswinkel stets der gleiche reliefartige Eindruck vermittelt wird. Der Betrachter hat den Eindruck, auf eine gewölbte, reflektive Oberfläche zu blicken, obwohl die makroskopische Raumform der zweiten mikrooptischen Darstellungsanordnung in der Regel plan ist.

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Mit Vorteil weist die zweite mikrooptische Darstellungsanordnung geprägte mikroskopische Strukturen auf, die mit einer reflexionserhöhenden Beschichtung versehen sind.

Insbesondere kann die zweite mikrooptische Darstellungsanordnung eine Vielzahl von reflektiven Facetten mit variierenden Orientierungen aufweisen. Die Orientierungen sind bevorzugt so gewählt, dass aufgrund der dadurch vorgegebenen Reflexionsrichtungen für einen Betrachter die gewölbte Oberfläche imitiert bzw. nachgestellt wird. Unter „reflektiven" Facetten werden hier nicht nur Facetten verstanden, die einen Reflexionsgrad von nahezu 100% aufweisen, sondern auch Facetten, die semitransparent (z. B. mit einer sehr dünnen oder gerasterten Metallschicht) oder sogar weitgehend transparent (z. B. mit einer hochbrechenden dielektrischen Beschichtung) ausgebildet sind. Bilden die Facetten die Grenzfläche zwischen Schichten mit unterschiedlichen Brechungsindizes, kann die nachgestellte gewölbte Oberfläche durch Brechung auch in Durchsicht sichtbar werden. Die Facetten können hierzu beispielsweise in einen hochbrechenden Prägelack geprägt und in einen niedrig brechenden Schutzlack eingebettet werden. Ferner ist es bevorzugt, dass die Facetten eine maximale Größe aufweisen, die unterhalb des Auflösungsvermögens eines Betrachters (ohne optische Hilfsmittel) liegt. So sind die lateralen Abmessungen bevorzugt kleiner als 300 µm, insbesondere kleiner als 100 µm und besonders bevorzugt kleiner als 20 µm. Die Facettenhöhe ist bevorzugt kleiner als 20 µm, insbesondere kleiner als 10 µm und besonders bevorzugt nicht größer als 5 µm.

Ferner ist es möglich, dass die zweite mikrooptische Darstellungsanordnung eine reflektive Fresnel-Struktur mit variierender Gitterperiode aufweist. Des Weiteren kann die zweite mikrooptische Darstellungsanordnung asymmetrische Beugungsstrukturen oder Mattstruktur-Gitterbilder aufweisen.

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Die Ausbildung mit einer Vielzahl von reflektiven Facetten kann insbesondere mittels einer sägezahnartigen Ausbildung einer Oberfläche z.B. einer Prägelackschicht sowie einer entsprechenden Verspiegelungsbeschichtung realisiert sein. Die Breite solcher Sägezähne ist bevorzugt kleiner als 300 µm, insbesondere kleiner als 100 µm und besonders bevorzugt kleiner als etwa 20 µm. Die Höhe der Sägezähne ist bevorzugt kleiner als 20 µm, insbesondere kleiner als 10 µm und besonders bevorzugt nicht größer als 5 µm.

Bei dem erfindungsgemäßen Sicherheitselement kann das visuell wahrnehmbare Motiv ausschließlich den ersten und zweiten Motivteil aufweisen. Natürlich ist es auch möglich, dass das visuell wahrnehmbare Motiv mehr als zwei Motivteile aufweist, beispielsweise drei, vier, etc. In diesem Fall ist es bevorzugt, dass in den weiteren Motivteilen entsprechende mikrooptische Darstellungsanordnungen vorhanden sind, mit denen eine dreidimensionale Darstellung mit absoluter Tiefeninformation, eine reflektive Oberfläche, die gegenüber der tatsächlich makroskopischen Raumform gewölbt erscheint, oder ein betrachtungswinkelabhängiger Bewegungs-, Kipp- und/oder Wechseleffekt mit oder ohne dreidimensionale Wirkung bereitgestellt wird.

Bei dem erfindungsgemäßen Sicherheitselement kann der Träger eine Folie aufweisen und zumindest Teile der beiden mikrooptischen Darstellungsanordnungen können mittels derselben Folie realisiert sein.

Das Sicherheitselement kann als mehrschichtiger Schichtverbund ausgebildet sein.

Das Sicherheitselement kann insbesondere eine erste und zweite Prägelackschicht aufweisen, zwischen denen bevorzugt eine Trägerschicht angeordnet

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ist. Die erste und zweite Prägelackschicht und die eventuell vorgesehene Trägerschicht können den Träger des Sicherheitselementes bilden.

In einer vorteilhaften Ausgestaltung sind in der ersten Prägelackschicht Mikroabbildungselemente der ersten mikrooptischen Darstellungsanordnung und mikroskopische Strukturen, beispielsweise Sägezahnstrukturen oder Fresnel-Strukturen, der zweiten mikrooptischen Darstellungsanordnung geprägt, wobei die mikroskopischen Strukturen mit einer reflexionserhöhenden Beschichtung versehen sind. In der zweiten Prägelackschicht sind Mikrostrukturen der ersten mikrooptischen Darstellungsanordnung geprägt, die mittels der Mikroabbildungsoptik vergrößert abgebildet werden, um die betrachtungswinkelabhängig zumindest zwei verschiedenen Bilder darzubieten. Bei den Mikroabbildungselementen kann es sich um refraktive oder reflektive Elemente handeln. Falls es sich um reflektive Elemente handelt, sind diese auch bevorzugt mit einer reflexionserhöhenden Beschichtung versehen. Bevorzugt wird das Aufbringen der Beschichtung in einem Schritt für die Mikroabbildungselemente und die mikroskopischen Strukturen durchgeführt.

Ferner ist es möglich, die mikroskopischen Strukturen der zweiten mikrooptischen Darstellungsanordnung nicht in der ersten Prägelackschicht, sondern in der zweiten Prägelackschicht (einschließlich der reflexionserhöhenden Beschichtung) auszubilden.

Alternativ kann noch eine dritte Prägelackschicht vorgesehen sein, in der die mikroskopischen Strukturen geprägt sowie mit der entsprechenden reflexionserhöhenden Beschichtung versehen sind. Die dritte Prägelackschicht kann über eine zweite Trägerschicht mit der zweiten Prägelackschicht verbunden sein.

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Ferner können die abzubildenden Mikrostrukturen nicht nur im Bereich des ersten Motivteils, sondern auch im Bereich des zweiten Motivteils geprägt sein. Dies erleichtert die Herstellung und führt zu weiteren interessanten optischen Effekten, die schwer nachzuahmen sind.

Der mehrschichtige Schichtverbund des Sicherheitselementes weist bevorzugt eine Gesamtdicke von kleiner 500 µm, insbesondere kleiner als etwa 100 µm und besonders bevorzugt von kleiner als 50 µm auf.

Die Erfindung umfasst auch ein Wertdokument mit einem Sicherheitselement der eben genannten Art einschließlich seiner Weiterbildungen.

Das Sicherheitselement kann insbesondere als Sicherheitsfaden, Aufreißfaden, Sicherheitsband, Sicherheitsstreifen, Patch oder als Etikett zum Aufbringen auf ein Sicherheitspapier, Wertdokument oder dergleichen ausgebildet sein. Insbesondere kann das Sicherheitselement transparente oder zumindest transluzente Bereiche oder Ausnehmungen überspannen.

Unter dem Begriff Sicherheitspapier wird hier insbesondere die noch nicht umlauffähige Vorstufe zu einem Wertdokument verstanden, die neben dem erfindungsgemäßen Sicherheitselement auch weitere Echtheitsmerkmale aufweisen kann. Unter Wertdokumenten werden hier einerseits aus Sicherheitspapieren hergestellte Dokumente verstanden. Andererseits können Wertdokumente auch sonstige Dokumente und Gegenstände sein, die mit dem erfindungsgemäßen Sicherheitselement versehen werden können, damit die Wertdokumente nicht kopierbare Echtheitsmerkmale aufweisen, wodurch eine Echtheitsprüfung möglich ist und zugleich unerwünschtes Kopieren verhindert wird.

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Es versteht sich, dass die vorstehend genannten und die nachstehend noch zu erläuternden Merkmale nicht nur in den angegebenen Kombinationen, sondern auch in anderen Kombinationen oder in Alleinstellung einsetzbar sind, ohne den Rahmen der vorliegenden Erfindung zu verlassen.

Nachfolgend wird die Erfindung beispielshalber anhand der beigefügten Zeichnungen, die auch erfindungswesentliche Merkmale offenbaren, noch näher erläutert. Zur besseren Anschaulichkeit wird in den Figuren auf eine maßstabs- und proportionsgetreue Darstellung verzichtet. Es zeigen:

Figur 1	eine Draufsicht einer Banknote mit einem erfindungsgemäßen Sicherheitselement;
Figur 2	eine vergrößerte Draufsicht des Sicherheitselementes von Figur 1;
Figur 3	eine Querschnittsansicht des Sicherheitselementes von Figur 2;
Figur 4	eine schematische Ansicht zur Erläuterung der Funktionsweise der ersten mikrooptischen Darstellungsanordnung;
Figur 5	eine schematische Ansicht zur Erläuterung der Funktionsweise der zweiten mikrooptischen Darstellungsanordnung;

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Figuren 6A – 6C Darstellungen des erfindungsgemäßen Sicherheitselementes unter unterschiedlichen Betrachtungsrichtungen;

Figuren 7A – 7C Ansichten des erfindungsgemäßen Sicherheitselementes unter gleichem Betrachtungswinkel aber mit unterschiedlichen Beleuchtungsrichtungen;

Figur 8 eine Schnittansicht einer weiteren Ausführungsform des erfindungsgemäßen Sicherheitselementes;

Figur 9 eine Schnittansicht einer noch weiteren Ausführungsform des erfindungsgemäßen Sicherheitselementes;

Figur 10 eine Schnittansicht einer anderen Ausführungsform des erfindungsgemäßen Sicherheitselementes;

Figur 11 eine Vorderansicht einer weiteren Ausführungsform des erfindungsgemäßen Sicherheitselementes, und

Figur 12 eine Rückansicht des erfindungsgemäßen Sicherheitselementes von Figur 11.

Bei der in Figur 1 gezeigten Ausführungsform ist das erfindungsgemäße Sicherheitselement 1 so in einer Banknote 2 integriert, dass das Sicherheitselement 1 von der in Figur 1 gezeigten Vorderseite der Banknote 2 sichtbar ist.

Das Sicherheitselement 1 ist als reflektives Sicherheitselement 1 mit einem rechteckigen Motivbereich 3 ausgebildet, der in einen ersten Motivteil 4 und einen zweiten Motivteil 5 aufgeteilt ist.

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Der erste Motivteil 4 umgibt hier den zweiten Motivteil 5, wie z.B. der vergrößerten Darstellung in Figur 2 zu entnehmen ist.

Wie insbesondere in der schematischen Schnittansicht des Motivbereiches 3 in Figur 3 gezeigt ist, weist der Motivbereich 3 eine Trägerfolie 6 (die beispielsweise eine PET-Folie sein kann) sowie eine obere und untere Prägelackschicht 7, 8 auf. In der unteren Prägelackschicht 8 sind Mikrostrukturen 9, die insbesondere mit Farbe gefüllt sein können, in einer Ebene senkrecht zur Zeichenebene von Figur 3 in einem Raster mit fester Geometrie (hier beispielsweise ein hexagonales Raster) und somit flächig in einem ersten Mikrostrukturmuster angeordnet. Alternativ zur Erzeugung in einer Prägelackschicht können die Mikrostrukturen 9 auch auf andere Art und Weise auf der Trägerfolie 6 realisiert werden. Insbesondere sind auch gedruckte Mikrostrukturen denkbar. Daneben können die Mikrostrukturen 9, wie in der WO2009/083151 A1 angegeben, auch durch metallisierte Subwellenlängenstrukturen, insbesondere Subwellenlängengitter oder Mottenaugenstrukturen gebildet sein oder durch Transfer metallischer Strukturen erzeugt werden, wie dies beispielsweise in der deutschen Patentanmeldung DE 102010019766.1 beschrieben ist.

Die obere Prägelackschicht 7 ist so ausgebildet, dass sie im ersten Motivteil 4 eine Vielzahl von Mikrolinsen 10 aufweist. Die Mikrolinsen 10 sind in einer Ebene senkrecht zur Zeichenebene von Figur 3 in einem Raster mit fester Geometrie (hier beispielsweise ein hexagonales Raster) und somit flächig in einem ersten Muster angeordnet, wobei das erste Muster im Ausführungsbeispiel so an das erste Mikrostrukturmuster angepasst und beide Muster so zueinander ausgerichtet sind, dass bei Betrachtung des Sicherheitselementes 1 die Mikrolinsen 10 zusammen mit den Mikrostrukturen 9 eine Moiré-

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Vergrößerungsanordnung bilden. Das Grundprinzip einer Moiré-Vergrößerungsanordnung ist beispielsweise in der WO 2007/076952 A2 beschrieben, deren gesamter Inhalt hiermit aufgenommen wird.

Die Moiré-Vergrößerungsanordnung in dem Bereich des ersten Motivteiles 4 bildet eine erste mikrooptische Darstellungsanordnung 11, mit der hier, wie nachfolgend noch im Detail beschrieben wird, mehrfach die Zahl 105 dem Betrachter so dargestellt wird, dass sie hinter der Ebene der Banknote 2 erscheint. Dies wird dadurch erreicht, dass dem linken und rechten Auge LA und RA des Betrachters unterschiedliche Ansichten des darzustellenden Objektes (hier die Zahl 105) dargeboten werden, die das Objekt jeweils aus der entsprechenden Richtung betrachtet zeigen. In Figur 4 ist das Objekt zur Vereinfachung der Darstellung als Punkt eingezeichnet, wobei das rechte Auge RA des Benutzers das Objekt an der Position 12 sieht und das linke Auge LA des Benutzers das Objekt an der Position 13 sieht. Somit sieht der Betrachter mit seinen beiden Augen das Objekt unter den unterschiedlichen Richtungen 14, 15, die sich an der Position 16 schneiden, so dass sich für den Betrachter das Objekt an der Position 16 und daher im Abstand d1 hinter der Banknote 2 befindet. Für den Betrachter ergibt sich somit für das Objekt eine absolute Tiefeninformation.

Im Bereich des zweiten Motivteiles 5 ist eine zweite mikrooptische Darstellungsanordnung 17 ausgebildet, die im Ausführungsbeispiel eine Vielzahl von verspiegelten Facetten 18 in der oberen Prägelackschicht 7 aufweist. Anstelle von verspiegelten Facetten 18 kann die Prägelackschicht jedoch auch andere geprägte Strukturen, insbesondere reflektive Fresnel-Strukturen mit variierender Gitterperiode, asymmetrische Beugungsstrukturen oder gewölbt erscheinende Mattstruktur-Gitterbilder, enthalten. Mit der zweiten mikrooptischen Darstellungsanordnung 17 wird dem Betrachter eine reflek-

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tive Oberfläche dargeboten, die gegenüber der tatsächlichen makroskopischen Raumform der zweiten mikrooptischen Darstellungsanordnung 17 gewölbt erscheint. Wie der schematischen Darstellung in Figur 5 zur Erläuterung des Prinzips der zweiten mikrooptischen Darstellungsanordnung 17 zu entnehmen ist, wird einfallendes Licht an den Facetten 18 in die gleichen Richtungen reflektiert, in die eine gewölbte Oberfläche 19 das Licht reflektieren würde.

So wird der einfallende Lichtstrahl 20 in die Richtung 21 reflektiert, die parallel zur Richtung 21' ist, die der Richtung bei Reflexion an der Oberfläche 19 entspräche. Gleiches gilt für die Lichtstrahlen 22 und 24, die in die Richtungen 23 und 25 reflektiert werden. Diese Richtungen 23 und 25 sind parallel zu den Richtungen 23' und 25', welches die Reflexionsrichtungen bei Reflexion an der Oberfläche 19 wären.

Die Facetten 18 sind so bemessen, dass ein Beobachter sie ohne Hilfsmittel nicht auflösen kann. So können die Facetten 18 in Richtung senkrecht zur Zeichenebene Abmessungen von beispielsweise 15 µm und eine Höhe von beispielsweise 5 µm aufweisen.

Aus dem Reflexionsverhalten der zweiten mikrooptischen Darstellungsanordnung 17 schließt ein Betrachter, dass im zweiten Motivteil 5 die gewölbte Oberfläche 19 mit der Tiefe d2 vorliegt. So spricht beispielsweise für den Lichtstrahl 20 das Reflexionsverhalten dafür, dass die lokale Flächennormale in Richtung 26 weist, was deutlich verschieden ist zu der makroskopischen Flächennormalen (Pfeil 27) der zweiten mikrooptischen Darstellungsanordnung 17 in diesem Bereich. Mittels der zweiten mikrooptischen Darstellungsanordnung 17 wird somit durch gerichtete Reflexion eine Wölbung imitiert, wodurch sich erst indirekt ein Tiefeneindruck bzw. ein 3D-Eindruck

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ergibt. Man kann diesen Eindruck daher auch als "2½"-dimensionale Darstellung oder reliefartige Darstellung bezeichnen.

Insbesondere wird mittels der zweiten mikrooptischen Darstellungsanordnung 17 keine Parallaxe erzeugt, so dass der Tiefeneindruck im Wesentlichen auf der Erfahrung des Betrachters beruht, der implizit weitere Informationen voraussetzt. Erscheint einem Betrachter eine Fläche nach vorne gewölbt, schließt der Betrachter daraus, dass der mittlere Bereich der gewölbten Fläche aus seiner Perspektive weiter vorne liegen muss als der Randbereich.

Bei dem hier beschriebenen Ausführungsbeispiel wird mittels der zweiten mikrooptischen Darstellungsanordnung 17 ein Kopf einer Frau dargestellt.

In Figuren 6A, 6B und 6C wird das Sicherheitselement 1 gezeigt, wie es einem Betrachter unter unterschiedlichen Betrachtungswinkeln erscheint, wobei vorausgesetzt ist, dass das Sicherheitselement 1 so beleuchtet wird, dass der Betrachter jeweils im Spiegelreflex der Lichtquelle steht. Unter dieser Annahme bleibt die Ansicht des Frauenportraits im zweiten Motivteil 5 stets gleich, während sich die in der Tiefe liegende Darstellung der Zahlen 105 aufgrund der Parallaxe horizontal von links nach rechts verschiebt. So ist bei der Ansicht von links gemäß Figur 6A die mit dem Pfeil P1 bezeichnete Zahl 105 links neben dem Hals des Frauenportraits. Bei der zentralen Ansicht gemäß Figur 6B fängt die Zahl 105 gerade an, hinter dem Frauenportrait zu verschwinden. Bei der Ansicht von rechts gemäß Figur 6C ist die Ziffer 5 der Zahl 105 schon nicht mehr sichtbar.

Somit liefert die erste mikrooptische Darstellungsanordnung 11 in Abhängigkeit des Betrachtungswinkels verschiedene Bilder, während die Darstellung der zweiten mikrooptischen Darstellungsanordnung 17 bezüglich ihrer

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räumlichen Wirkung nicht vom Betrachtungswinkel abhängt. Die erste mikrooptische Darstellungsanordnung 11 liefert mehr als zwei unterschiedliche Ansichten der Zahlen 105 in der Art und Weise, dass sich die beschriebene Bewegung der Zahlen 105 relativ zum Frauenportrait bei Änderung der Betrachtungsrichtung ergibt. Es liegt somit eine Parallaxe vor.

In Figuren 7A, 7B und 7C ist das erfindungsgemäße Sicherheitselement 1 jeweils in derselben Blickrichtung von vorne gezeigt, wobei jedoch die Position der Lichtquelle und somit die Beleuchtungsrichtung variiert. In Figur 7A wird das Sicherheitselement 1 von links beleuchtet. In Figur 7B wird das Sicherheitselement 1 von vorne beleuchtet und in Figur 7C wird das Sicherheitselement 1 von rechts beleuchtet. Aus den Darstellungen von Figur 7A - 7C ist klar ersichtlich, dass das Frauenportrait und somit der zweite Motivteil 5 das Licht entsprechend der Wölbung des nachgestellten Kopfes reflektiert. Die Positionen der in der Tiefe liegenden Zahlen 105 (Pfeil P1) ändern sich jedoch nicht, da die Betrachtungsrichtung und somit der Betrachtungswinkel nicht geändert wurden. In der Praxis wird die Position der Lichtquelle fest sein und ein Beobachter schließt aus der Lage der Lichtreflexe und deren Bewegung beim Kippen des Sicherheitselements auf die Form der nachgestellten Wölbung.

Die erste mikrooptische Darstellungsanordnung 11 liefert somit in diesem Ausführungsbeispiel bei konstantem Betrachtungswinkel eine von der Beleuchtungsrichtung unabhängige Darstellung, während die Darstellung der zweiten mikrooptischen Darstellungsanordnung 17 gemäß der imitierten reflektiven und reliefartigen Ausbildung des Frauenportraits variiert.

Bei dem beschriebenen Ausführungsbeispiel wird somit mittels der Moiré-Vergrößerungsanordnung 11 ein absoluter Tiefeneffekt erreicht, bei dem für

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den Betrachter die in der Tiefe d1 liegende, periodisch wiederkehrende Zahl 105 dargestellt wird. Die Mikrostrukturen 9 können, wie bereits erwähnt, bevorzugt mit Farbe gefüllt sein, so dass die Zahlen 105 einerseits und der restliche Bereich des ersten Motivteils 4 andererseits matt, aber unterschiedlich farbig erscheinen. Vor diesem ersten Motivteil 4 befindet sich der zweite Motivteil 5, bei dem über eine Anordnung metallisierter mikroskopischer Sägezahngitter das gewölbt erscheinende und metallisch glänzende Frauenportrait gezeigt wird.

Die erste mikrooptische Vergrößerungsanordnung 11 kann nicht nur als Moiré-Vergrößerungsanordnung ausgebildet sein, sondern beispielsweise auch als Modulo-Vergrößerungsanordnung, wie sie z.B. in der WO 2009/000528 A1 beschrieben ist. Der Inhalt bezüglich der Ausbildung einer Modulo-Vergrößerungsanordnung der WO 2009/000528 A1 wird hiermit in die vorliegende Anmeldung aufgenommen. Mit einer Modulo-Vergrößerungsanordnung muss sich das darzustellende Bild im Gegensatz zu einer Moiré-Vergrößerungsanordnung nicht zwangsläufig aus einem Gitter periodisch wiederholender Einzelmotive zusammensetzen. Es kann ein komplexes Einzelbild mit hoher Auflösung dargestellt werden. Bei der Moiré-Vergrößerungsanordnung besteht das darzustellende Bild in der Regel aus Einzelmotiven (hier Mikrostrukturen 9), die in einem Gitter periodisch angeordnet sind und die durch die Linsen 10 vergrößert dargestellt werden, wobei die jedem Einzelmotiv zugeordnete Fläche maximal etwa der Fläche der entsprechenden Linsenzelle entspricht.

Bei der beschriebenen Ausführungsform können die Mikrolinsen 10 sowie die Sägezahnstruktur für die reflektiven Facetten mittels nur einer einzigen Prägung der Prägeschicht 7 gleichzeitig nebeneinander hergestellt werden.

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Anschließend sind lediglich die Facetten zu metallisieren, damit sie reflektiv wirken. Der Aufbau gemäß Figur 3 ist daher schnell herzustellen.

Statt der beschriebenen Sägezahnanordnung können bei der zweiten mikrooptischen Darstellungsanordnung 17 auch Fresnel-Strukturen oder Reliefnachstellungen durch diffraktive Strukturen oder Mattstruktur-Gitterbilder benutzt werden.

In Figur 8 ist eine Abwandlung des erfindungsgemäßen Sicherheitselementes 1 gezeigt, bei der die erste mikrooptische Darstellungsanordnung 11 statt der Mikrolinsen 10 Hohlspiegel 28 aufweist, die durch Prägen der unteren Prägelackschicht 8 und Aufbringen einer spiegelnden Beschichtung gebildet sind.

Auch die im Ausführungsbeispiel als Facetten 18 ausgebildete zweite mikrooptische Darstellungsanordnung 17 ist auf der unteren Prägelackschicht 8 ausgebildet. Die Facetten 18 können in gleicher Weise wie die Mikrohohlspiegel 28 durch Prägen und Verspiegeln gebildet sein.

Die Mikrostrukturen 9 können nicht nur im Bereich des ersten Motivteils 4, sondern auch im Bereich des zweiten Motivteiles 5 und somit oberhalb der Facetten 18 vorgesehen sein. Dies erleichtert die Herstellung des Sicherheitselementes 1.

Falls die Mikrostrukturen 9 im Bereich des zweiten Motivteiles 5 vorgesehen und mit einer Farbe gefüllt sind, erscheint die gewölbte spiegelnde Oberfläche, die durch die Facetten 18 nachgestellt ist, ebenfalls leicht farbig. Ist die Einfärbung der gewölbten spiegelnden Oberflächen nicht erwünscht, können die Mikrostrukturen 9 in diesem Bereich jedoch auch weggelassen werden.

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In Figur 9 ist ein Aufbau des Sicherheitselementes 1 gezeigt, bei dem die Mikrohohlspiegel 28, die Mikrostrukturen 9 und die Facetten 18 jeweils für sich in eine eigenen Prägelackschicht 8, 7 und 29 geprägt sind. Zwischen den Prägelackschichten 8 und 7 ist eine erste Trägerfolie 6 und zwischen den Prägelackschichten 7 und 29 ist eine zweite Trägerfolie 30 vorgesehen.

Dieser Aufbau erfordert zwar mehr Arbeitsschritte zur Herstellung im Vergleich zu den Varianten gemäß Figuren 3 und 8, bietet jedoch den Vorteil, dass die Origination der Mikrohohlspiegel 28 und der Facetten 18 getrennt voneinander erfolgen kann. Die Mikrohohlspiegel 28 können sogar bei unterschiedlichen Designs dieselben sein, da immer nur eine homogene, mit Mikrohohlspiegeln 28 bedeckte Fläche benötigt wird. Hat man einmal ein Original mit sehr guten Abbildungseigenschaften hergestellt, kann man es für die Herstellung vieler verschiedener Sicherheitselemente 1 nutzen. Darüber hinaus kann für die Herstellung entsprechender Sicherheitselemente mit unterschiedlichen Motiven in den jeweils ersten und zweiten mikrooptischen Darstellungsanordnungen 11, 17 dasselbe Prägewerkzeug zur Prägung der Mikrohohlspiegel 28 benutzt werden, so dass auch dieses nur einmal hergestellt werden muss. Ferner können die Mikrohohlspiegel 28 und die Facetten 18 unterschiedlich metallisiert sein, beispielsweise mit unterschiedlichen Metallen oder Beschichtungen mit farbkippenden Effekten (z.B. Dünnschichtsysteme, bei denen die Farbe in Abhängigkeit des Betrachtungswinkels variiert).

Ein besonderer Vorteil des Aufbaus aus Figur 8 liegt darin, dass sowohl die Mikrohohlspiegel 28 als auch die Facetten 18 verspiegelt werden, während beispielsweise bei dem in Figur 9 gezeigten Aufbau eine bereichsweise Demetallisierung in den an die zweite mikrooptische Darstellungsanordnung 17 angrenzenden Bereichen nötig ist. Die Schärfe der Grenze zwischen den

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beiden Motivteilen 4, 5 ist dann durch die entsprechenden Toleranzen der Demetallisierung gegeben. Diese Limitierung liegt bei dem Aufbau gemäß Figur 8 nicht vor, so dass die gewölbte Oberfläche im zweiten Motivteil 5 mit besonders filigranem Umriss vor dem Hintergrund der Moiré- oder Modulo-Vergrößerungsanordnung im ersten Motivteil 4 erscheinen kann.

Bei den Varianten gemäß Figuren 8 und 9 mit Mikrohohlspiegeln kann ferner vorteilhaft auf der Oberseite und/ oder Unterseite des Sicherheitselementes 1 eine weitere Schutzlackschicht (nicht gezeigt) vorgesehen sein, so dass die Beständigkeit sowie der Schutz vor Abformungen durch Fälscher erhöht werden kann.

Insbesondere bei der Betrachtung des Sicherheitselementes 1 in Durchlicht vor einer hellen Lichtquelle kann die erste mikrooptische Darstellungsanordnung 11 statt eines Mikrofokussierelementerasters (Raster aus den Mikrolinsen 10 oder Raster aus den Mikrohohlspiegeln 28) auch lediglich ein Lochraster 31 aufweisen, wie in Figur 10 gezeigt ist. Ein solches Lochraster 31 kann beispielsweise durch periodisch angeordnete Löcher oder Schlitze in einer opaken, beispielweise spiegelnd metallisierten Schicht realisiert werden. Die Löcher können dabei kleine Aussparungen sein. In diesem Fall können die Löcher als positive Löcher bezeichnet werden. Es können auch sogenannte negative Löcher vorgesehen werden, bei denen die Löcher kleine, nicht-transparente oder nicht-spiegelnde Bereiche sind.

Bei der in Figur 10 gezeigten Ausführungsform erstreckt sich das Lochraster auch in den zweiten Motivbereich 5, so dass sich im zweiten Motivbereich eine Überlagerung der Darstellungen ergibt. Natürlich kann das Sicherheitselement auch so ausgebildet sein, dass im zweiten Motivbereich 5 kein Lochraster vorhanden ist.

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Ferner kann bei dem erfindungsgemäßen Sicherheitselement 1 sowohl die erste mikrooptische Darstellungsanordnung 11 als auch die zweite mikrooptische Darstellungsanordnung 17 mittels diffraktiver Strukturen verwirklicht werden. So kann im ersten Motivteil 4 beispielsweise ein Hologramm mit einer stereographischen 3D-Darstellung vorgesehen werden, das aus mikroskopisch kleinen Sinusgittern aufgebaut ist. Im zweiten Motivteil 5 werden bevorzugt asymmetrische Beugungsgitter so angeordnet, dass das Reflexionsverhalten einer gewölbten Oberfläche (möglichst) achromatisch nachgestellt ist, wie dies z.B. in der WO 2006/013215 A1 beschrieben ist, deren diesbezüglicher Offenbarungsgehalt hiermit aufgenommen wird.

Wie bereits in Verbindung mit Figur 10 beschrieben ist, können die beiden Motivteile 4 und 5 zumindest teilweise überlappen. Alternativ oder zusätzlich können die beiden Motivteile 4 und 5 auch bereichsweise ineinander verschachtelt sein. Dabei können die Flächen der beiden Motivteile 4, 5 beispielsweise in komplementäre Flächenelemente zerlegt und anschließend zu einem Gesamtmotiv vereint werden. Dabei verliert jeder Motivteil einen Teil seiner Bildinformation, der in den betroffenen Flächenelementen durch die Bildinformation des jeweils anderen Flächenelements ersetzt wird. Liegen die Abmessungen der Flächenelemente unterhalb des Auflösungsvermögens des Auges, nimmt der Betrachter die individuellen Eindrücke der beiden Motivteile gleichzeitig wahr und verarbeitet sie zu einem Gesamtmotiv. Die Flächenanteile der von beiden Motivteilen stammenden Flächenelemente können dabei lokal und/ oder global gleich oder unterschiedlich verteilt sein. Liegt eine Ungleichverteilung vor, so kann der Motivteil mit dem größeren Flächenanteil gegenüber dem Motivteil mit dem geringeren Anteil visuell dominieren. Generell ist es aber auch möglich, Flächenelemente zu verwenden, die über dem Auflösungsvermögen des Auges liegen. In diesem

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Fall kann der Betrachter die einzelnen Motivteile lokal getrennt wahrnehmen.

Bei einer Ausführungsform, bei der die erste mikrooptische Darstellungsanordnung 11 als Moiré-Vergrößerungsanordnung mit Mikrolinsen 10 ausgebildet ist und die zweite mikrooptische Darstellungsanordnung 17 die reflektiven Facetten 18 aufweist, kann z.B. im verschachtelten Bereich jede zweite Mikrolinse 10 der ersten mikrooptischen Darstellungsanordnung 11 durch eine oder mehrere reflektive Facetten 18 der zweiten mikrooptischen Darstellungsanordnung 17 ersetzt werden.

Ferner kann der Motivbereich 3 des Sicherheitselementes 1 z.B. in kleine Kacheln oder dünne Streifen aufgeteilt sein, die jeweils mit Elementen der ersten oder zweiten mikrooptischen Darstellungsanordnung 11, 17 belegt sind. Damit ergibt sich ein interessanter Effekt, da die Darstellung des zweiten Motivteiles 5 nicht mehr rein metallisch spiegelnd ist, sondern teilweise transparent, so dass man durch die zweite mikrooptische Darstellungsanordnung 17 hindurch ein beispielsweise in der Tiefe liegendes Bild des ersten Motivteiles 4 sieht. Alternativ kann das mittels der ersten mikrooptischen Darstellungsanordnung 11 dargestellte Objekt auch scheinbar vor der gewölbt erscheinenden Oberfläche der zweiten mikrooptischen Darstellungsanordnung 17 liegen bzw. schweben.

Je nach Flächenanteil der ersten und zweiten mikrooptischen Darstellungsanordnungen 11, 17 kann man von einer metallisch glänzenden undurchsichtigen Wölbung kontinuierlich auf eine immer durchsichtiger werdende und letztlich eher glasartig erscheinende Darstellung wechseln.

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Die erste und/oder zweite mikrooptische Darstellungsanordnung(en) 11, 17 können/kann ganz oder teilweise mit einer farbkippenden Beschichtung, insbesondere einem Dünnfilmsystem mit Reflektor/Dielektrikum/Absorber versehen sein. Damit lässt sich die optische Attraktivität weiter steigern und die Fälschungssicherheit weiter erhöhen.

Das erfindungsgemäße Sicherheitselement 1 kann auf der Banknote 2 so angeordnet sein, dass es nicht nur von der in Figur 1 gezeigten Vorderseite, sondern auch von der Rückseite der Banknote sichtbar ist. Dabei müssen jedoch nicht zwangsweise alle generierten Wölb- oder Tiefeneffekte von beiden Seiten sichtbar sein.

Eine vorteilhafte Ausführungsform ist in Figuren 11 (Vorderansicht) und 12 (Rückansicht) dargestellt. Das Sicherheitselement 1 weist im ersten Motivteil 4 eine erste mikrooptische Darstellungsanordnung 11 gemäß Figur 8 auf, die hier die Zahl 105 periodisch wiederholt in der Tiefe darstellt. Im zweiten Motivteil 5 ist eine gewölbt erscheinende Darstellung eines Portraits sichtbar, wobei die Darstellung von beiden Seiten (also auch von der Rückseite gemäß Figur 12) gewölbt erscheint. Dies kann z.B. mittels Facetten 18 gemäß Figur 8 realisiert sein. Von der Rückseite schaut der Betrachter jedoch im Bereich des ersten Motivteiles 4 auf die Rückseite der Mikrohohlspiegel 28 der ersten mikrooptischen Darstellungsanordnung 11, so dass er dort lediglich einen matten metallisierten Bereich wahrnehmen kann (in Figur 12 sind daher im ersten Motivteil 4 die Zahlen 105 nicht eingezeichnet).

Um das erfindungsgemäße Sicherheitselement 1 von der Rückseite aus betrachtet attraktiver zu machen, kann daher beispielsweise in einem an den Motivbereich 3 anschließenden zweiten Motivbereich 32 eine weitere gewölbte Darstellung (hier die Zahl 1452) mittels reflektiver Facetten in glei-

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cher Weise wie in Figur 8 verwirklicht werden. Der zweite Motivbereich 32 und somit die Zahl 1452 ist hier nur von der Rückseite aus sichtbar (von der Vorderseite würde die Zahl seitenverkehrt erscheinen). Dies kann insbesondere dadurch erreicht werden, dass das Sicherheitselement 1 in einem Fensterbereich der Banknote angeordnet ist, der nur so groß ist wie der Motivbereich 3, so dass der zweite Motivbereich 32 verdeckt ist und daher nur von der Rückseite aus gesehen werden kann.

In vorteilhafter Weise können gezielt nur bestimmte Bereiche im ersten und zweiten Motivbereich 3 und 32 mit einem farbkippenden Dünnfilmsystem überzogen sein. So können z.B. der zweite Motivteil 5 sowie der Motivbereich 32 auf der Rückseite (Figur 12) mit einem farbkippenden Dünnfilmsystem überzogen sein, so dass diese Elemente dann mit wechselnder Farbe vor dem metallisch matten und farblosen Hintergrund der Mikrohohlspiegelrückseiten im ersten Motivbereich 4 erscheinen.

Natürlich kann das erfindungsgemäße Sicherheitselement 1 so weitergebildet werden, dass sowohl der Wölb- als auch der Tiefeneffekt von beiden Seiten des Sicherheitselementes 1 gesehen werden können.

Bei den bisher beschriebenen Ausführungsbeispielen war die erste mikrooptische Darstellungsanordnung 11 im ersten Motivteil 4 jeweils so ausgebildet, dass eine stereographische Darstellung mit Tiefeninformationen erreicht wird. Darunter werden hier Darstellungen verstanden, bei denen ein dreidimensionaler Effekt dadurch generiert wird, dass das Sicherheitselement 1 dem linken und rechten Auge des Betrachters unterschiedliche Ansichten eines Objektes liefert, die das Objekt jeweils aus der entsprechenden Richtung betrachtet zeigen. Aus diesen unterschiedlichen Ansichten ergibt sich für einen Betrachter dann eine absolute Tiefeninformation, woraus insgesamt

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ein dreidimensionaler Eindruck resultiert. Die verwendeten Darstellungen in dieser Klasse können oft mehr als nur zwei unterschiedliche Ansichten aufweisen, womit sich meist auch eine Parallaxe ergibt (d.h. beim Drehen bzw. Ost-West-Kippen bewegen sich die Bildbestandteile im Vordergrund relativ zu den Bildbestandteilen im Bildhintergrund). Unter Umständen kann man beispielsweise durch Drehen auch hinter ein im Vordergrund stehendes Objekt schauen.

Technisch realisiert werden kann dies durch dreidimensionale Hologramme, beispielsweise direkt belichtete Hologramme oder computergenerierte Stereogramme. Weitere Beispiele sind Mikrolinsen-Kippbilder und Moiré-Vergrößerungsanordnungen mit Tiefeneffekt und/ oder Bewegungseffekt, wie dies z.B. in WO 2007/076952 A2oder WO 2009/000527 A1 beschrieben ist.

Bei der zweiten mikrooptischen Darstellungsanordnung 17 im zweiten Motivteil 5 wird durch gerichtete Reflexion eine Wölbung imitiert, aus der sich erst indirekt ein Tiefeneffekt bzw. ein dreidimensionaler Effekt ergibt. Bei dieser Art der Darstellungen zeigt sich keine Parallaxe, so dass eine Darstellung vor oder hinter einer Bezugsebene ohne weiteres nicht möglich ist. Zu dieser Klasse der Darstellungsart kann man beispielsweise linsenartig gewölbt erscheinende reflektive Fresnel-Strukturen (z.B. EP 1 570 422 B1, EP 1 562 758 B1), diffraktive achromatische Elemente mit Wölbeffekt (z.B. WO 2006/013215 A1), gewölbt erscheinende Mattstruktur-Gitterbilder (z.B. WO2010/034420A1) oder insbesondere auch reliefartig erscheinende Sicherheitselemente auf Basis mikrooptischer Sägezahngitter zählen, wie sie im Zusammenhang mit Figur 5 beispielsweise in der vorliegenden Anmeldung beschrieben sind. All diesen Ausgestaltungen ist gemein, dass eine zumindest teilweise verspiegelte und auf größerer Längenskala praktisch ebene

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Oberfläche das vom Betrachter implizit vorausgesetzte Gesetz, dass Einfallswinkel gleich Ausfallswinkel bei Reflexionen ist, auf größerer Längenskala verletzt, indem beispielsweise lokal durch mit bloßem Auge nicht erkennbaren Mikrospiegeln die Ausrichtung der jeweiligen Oberflächennormalen von der dem Betrachter sichtbaren Bezugsebene des Sicherheitselementes abweicht und/oder das einfallende Licht durch Beugungseffekte in vom Betrachter unerwartete Richtungen gebeugt wird.

Man kann nun in einer weiteren Ausgestaltung die erste mikrooptische Darstellungsanordnung 11 so ausbilden, dass im ersten Motivteil 4 die Parallaxe nicht exakt der Parallaxe eines in der Tiefe liegenden Objektes entspricht. Dies kann beispielsweise durch Moiré-Vergrößerungsanordnungen oder Modulo-Vergrößerungsanordnungen verwirklicht werden. Dadurch kann erreicht werden, dass beim Kippen oder Drehen des Sicherheitselementes 1 ein zusätzlicher Bewegungseffekt im ersten Motivteil 4 auftritt. Dabei kann es sich um eine orthoparallaktische Bewegung handeln, wie sie z.B. in der WO 2007/076952 A2 beschrieben ist, wobei die Darstellungen für das linke und rechte Auge des Betrachters streng genommen keine Zuordnung einer Tiefe zulassen, da sich die Blickrichtungen, unter denen der Beobachter das Objekt mit dem linken und rechten Auge sieht, nicht schneiden. In einer bevorzugten Variante liegt nur ein relativ kleiner Fehler der Parallaxe vor, so dass sich die Blickrichtungen (14 und 15 in Fig. 4) fast schneiden und der Betrachter ein sich beim Kippen oder Drehen des Sicherheitselementes 1 bewegendes Objekt sieht, das er aber trotz des Parallaxenfehlers eindeutig z.B. in einer hinter der Ebene des Sicherheitselementes 1 liegenden Tiefe einordnet.

Im A-Matrix-Formalismus der Anmeldung WO 2009/000528 A1 entspricht eine Darstellung mit korrekter Parallaxe einer Darstellung mit einer A-Matrix, die nur auf der Hauptdiagonalen besetzt ist. Bei einer orthoparallak-

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tischen Darstellung ist die A-Matrix nur an den nicht auf der Hauptdiagonalen liegenden Stellen besetzt. Ein kleiner Fehler der Parallaxe im Sinne der vorliegenden Erfindung liegt dann vor, wenn die A-Matrix sowohl auf der Hauptdiagonalen als auch daneben besetzt ist.

Ähnlich wie bei den vorstehend beschriebenen speziellen Ausgestaltungen von Moiré- oder Modulo-Vergrößerungsanordnungen die Parallaxe nicht exakt der Parallaxe eines in der Tiefe liegendes Objektes entspricht, so dass im Extremfall eine orthoparallaktische Bewegung entsteht, kann auch die zweite mikrooptische Darstellungsanordnung „Fehler" in den Orientierungen der mikroskopischen Strukturen im Vergleich zur Orientierung der nachgestellten Oberfläche aufweisen. Ein solcher Effekt liegt beispielsweise bei einer sogenannten imaginären Fläche vor. Darunter wird hier die Ausbildung eines Reflexions- bzw. Transmissionsverhaltens verstanden, das mit einer realen gewölbten reflektierenden bzw. transmittierenden Oberfläche nicht erzeugt werden kann. Dreht man beispielsweise die Azimutwinkel aller Facetten um 90° nach rechts, so sieht ein von oben beleuchtetes Relief so aus, als wäre es von rechts beleuchtet. Ferner wandern die Lichtreflexe beim Kippen in diesem Fall nicht so, wie man es beim nachgestellten Relief erwarten würde, sondern ebenfalls „orthoparallaktisch", was ein sehr überraschender Effekt sein kann. Einem Betrachter erscheinen auch solche Darstellungen jedoch auf den ersten Blick gewölbt. Für den erfindungsgemäßen Eindruck einer Wölbung kommt es hier also nicht darauf an, dass die Orientierung der Mikrostrukturen zwingend tatsächlich das Reflexionsverhalten einer realen gewölbten Oberfläche exakt nachbildet.

In einer weiteren Ausgestaltung des Sicherheitselementes 1 kann die Darstellung mittels der ersten mikrooptischen Darstellungsanordnung 11 im ersten Motivteil 4 bei einem Ost-West-Kippen oder Drehen des Sicherheitselemen-

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tes 1 von einem ersten Bild in ein zweites Bild wechseln. So könnte beispielsweise eine in der Tiefe liegendes Bild eines ersten Symbols A beim Kippen des Sicherheitselementes 1 in mindestens eine andere Darstellung, beispielsweise ein Symbol B, kippen.

Die erste mikrooptische Darstellungsanordnung 11 kann neben einem dreidimensionalen Effekt auch zusätzliche Effekte realisieren, beispielsweise neben den vorstehend erwähnten Kippbildern auch kinematische Effekte (Bewegungen, Pumpeffekt, etc.). Bei den bereits erwähnten Modulo-Vergrößerungsanordnungen kann sich die dreidimensionale Darstellung im ersten Motivteil 4 beim Kippen des Sicherheitselementes 1 bewegen. Alternativ könnte die Darstellung auch ab einem bestimmten Kippwinkel in die Darstellung eines völlig anderen, nicht zwangsweise ebenfalls dreidimensional erscheinenden Objektes kippen (beispielsweise kann eine in der Tiefe liegende Zahl in eine andere Darstellung, beispielsweise ein sich beim weiteren Kippen dann bewegendes Symbol, wechseln).

Die Qualität bzw. das Erscheinungsbild der beiden mikrooptischen Darstellungsanordnungen können jeweils eine unterschiedliche Abhängigkeit von der verwendeten Betrachtungs- oder Beleuchtungssituation zeigen. So ist beispielsweise ein durch Hologrammgitter realisiertes Stereogramm nur bei nahezu paralleler Beleuchtung aus der richtigen Richtung gut zu erkennen, während es bei diffuser Beleuchtung verschwommen oder gar nicht wahrgenommen wird. Die erfindungsgemäß gewölbt erscheinende zweite mikrooptische Darstellungsanordnung ist jedoch auch bei diffuser Beleuchtung aus einem weiten Winkelbereich sehr gut erkennbar. Andere Kombinationen können in Aufsicht bzw. Durchsicht unterschiedlich gut erkennbare erste und zweite mikrooptische Darstellungsanordnungen zeigen. Die erste mikrooptische Darstellungsanordnung kann beispielsweise aus einer Moiré-

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Vergrößerungsanordnung auf Basis eines Mikrolinsenrasters bestehen, die in Auf- und Durchsicht beispielsweise einen Tiefeneffekt zeigt, während eine durch metallisierte Sägezahnstrukturen gebildete zweite mikrooptische Darstellungsanordnung in Aufsicht den gewünschten Wölbeffekt zeigen und in Durchsicht nur opak erscheinen kann. Das erfindungsgemäße Sicherheitselement kann folglich so ausgebildet sein, dass je nach Betrachtungs- und/oder Beleuchtungssituation die Darstellung einer der beiden mikrooptischen Darstellungsanordnungen dominiert, während sich die Darstellungen in einer anderen Betrachtungs- bzw. Beleuchtungssituation zu einem Gesamtmotiv ergänzen.

Das erfindungsgemäße Sicherheitselement 1 kann z.B. auch als Sicherheitsstreifen 33 ausgebildet sein, wie in Figur 1 gezeigt ist. Ferner kann das Sicherheitselement 1 nicht nur, wie beschrieben, auf einer Trägerfolie ausgebildet werden, von der es in bekannter Weise auf das Wertdokument 2 übertragen werden kann. Es ist auch möglich, das Sicherheitselement 1 direkt auf dem Wertdokument auszubilden. So kann ein direkter Druck auf ein Polymersubstrat mit anschließender Prägung des Sicherheitselementes durchgeführt werden, um beispielsweise bei Kunststoffbanknoten ein erfindungsgemäßes Sicherheitselement auszubilden. Das erfindungsgemäße Sicherheitselement kann in verschiedensten Substraten ausgebildet werden. Insbesondere kann es in oder auf einem Papiersubstrat, einem Papier mit Synthesefasern, d.h. Papier mit einem Anteil x polymeren Materials im Bereich von $0 < x < 100$ Gew.-%, einer Kunststofffolie, z. B. einer Folie aus Polyethylen (PE), Polyethylenterephthalat (PET), Polybutylenterephthalat (PBT), Polyethylennaphthalat (PEN), Polypropylen (PP) oder Polyamid (PA), oder einem mehrschichtigem Verbund, insbesondere einem Verbund mehrerer unterschiedlicher Folien (Kompositverbund) oder einem Papier-Folien-Verbund (Folie/Papier/Folie oder Papier/Folie/Papier), wobei das Sicherheitselement in

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oder auf oder zwischen jeder der Schichten eines solchen mehrschichtigen Verbunds vorgesehen werden kann, ausgebildet werden.

Bei den bisher beschriebenen Ausführungsbeispielen wurde stillschweigend vorausgesetzt, dass sich die mikrooptischen Darstellungsanordnungen auf ebenen Substraten befinden. Die erfindungsgemäßen Gestaltungen können jedoch auch bei gekrümmten oder flexiblen Substraten, wie etwa Etiketten, Wertpapieren oder Banknoten, vorteilhaft eingesetzt werden.

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Bezugszeichenliste

1	Sicherheitselement	25	Richtung
2	Banknote	25'	Richtung
3	Motivbereich	26	lokale Flächennormale
4	erster Motivteil	27	makroskopische Flächennormale
5	zweiter Motivteil	28	Mikrohohlspiegel
6	Trägerfolie	29	Prägelackschicht
7	obere Prägelackschicht	30	zweite Trägerfolie
8	untere Prägelackschicht	31	Lochraster
9	Mikrostrukturen	32	Motivbereich
10	Mikrolinsen	33	Sicherheitsstreifen
11	erste mikrooptische Darstellung	P1	Pfeil
12	Position	d1	Abstand
13	Position	d2	Abstand
14	Richtung		
15	Richtung		
16	Position		
17	zweite mikrooptische Darstellung		
18	Facetten		
19	Oberfläche		
20	Lichtstrahl		
21	Richtung		
21'	Richtung		
22	Lichtstrahl		
23	Richtung		
23'	Richtung		
24	Lichtstrahl		

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Patentansprüche

1. Sicherheitselement für ein Sicherheitspapier, Wertdokument oder dergleichen, mit
einem Träger, der einen Motivbereich (3) aufweist, der ein visuell wahrnehmbares Motiv mit einem ersten und einem zweiten Motivteil (4, 5) bereitstellt, wobei der Motivbereich (3)
eine erste mikrooptische Darstellungsanordnung (11), die als ersten Motivteil betrachtungswinkelabhängig zumindest zwei verschiedene Bilder darbietet, und eine zweite mikrooptische Darstellungsanordnung (17) umfasst, die als zweiten Motivteil (5) eine reflektive Oberfläche darbietet, die gegenüber der tatsächlichen makroskopischen Raumform der zweiten mikrooptischen Darstellungsanordnung (17) gewölbt erscheint.

2. Sicherheitselement nach Anspruch 1, bei dem die beiden Motivteile zusammenhängend angeordnet sind, wobei die beiden Motivteile (4, 5) bevorzugt unmittelbar aneinander grenzen.

3. Sicherheitselement nach einem der obigen Ansprüche, bei dem einer der beiden Motivteile (4, 5) den anderen der beiden Motivteile (4, 5) zumindest teilweise umgibt.

4. Sicherheitselement nach einem der obigen Ansprüche, bei dem sich die beiden Motivteile (4, 5) zumindest teilweise überlappen und/ oder zumindest bereichsweise ineinander verschachtelt sind.

5. Sicherheitselement nach einem der obigen Ansprüche, bei dem die erste mikrooptische Darstellungsanordnung (11) die zumindest zwei verschiedenen Bilder so darbietet, dass sich die Bilder zumindest bereichsweise überlappen und/ oder ineinander verschachtelt sind.

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6. Sicherheitselement nach einem der obigen Ansprüche, bei dem die erste mikrooptische Darstellungsanordnung (11) als die zumindest zwei verschiedenen Bilder unterschiedliche Ansichten desselben Objektes darbietet.

7. Sicherheitselement nach einem der obigen Ansprüche, bei dem die erste mikrooptische Darstellungsanordnung (11) die zumindest zwei verschiedenen Bilder so darbietet, dass sich für einen Betrachter eine stereographische Darstellung eines Objektes mit einer absoluten Tiefeninformation ergibt.

8. Sicherheitselement nach einem der obigen Ansprüche, bei dem die erste mikrooptische Darstellungsanordnung (11) als Hologramm ausgebildet ist.

9. Sicherheitselement nach einem der Ansprüche 1 bis 7, bei dem die erste mikrooptische Darstellungsanordnung (11) Mikrostrukturen (9) sowie Mikroabbildungselemente (10, 28), um die Mikrostrukturen (9) vergrößert abzubilden, umfasst.

10. Sicherheitselement nach einem der obigen Ansprüche, bei dem die erste mikrooptische Darstellungsanordnung (11) eine orthoparallaktische Darstellung erzeugt.

11. Sicherheitselement nach einem der obigen Ansprüche, bei dem die zweite mikrooptische Darstellungsanordnung (17) die reflektive Oberfläche in einem reliefartigen Eindruck darbietet.

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12. Sicherheitselement nach einem der obigen Ansprüche, bei dem die zweite mikrooptische Darstellungsanordnung (17) geprägte mikroskopische Strukturen aufweist, die mit einer reflexionserhöhenden Beschichtung versehen sind.

13. Sicherheitselement nach Anspruch 12, bei dem die zweite mikrooptische Darstellungsanordnung (17) eine Vielzahl von reflektiven Facetten (18) mit zueinander unterschiedlichen Orientierungen aufweist.

14. Sicherheitselement nach Anspruch 12, bei dem die zweite mikrooptische Darstellungsanordnung (17) eine reflektive Fresnel-Struktur mit variierender Gitterperiode aufweist.

15. Sicherheitselement nach Anspruch 12, bei dem die zweite mikrooptische Darstellungsanordnung (17) asymmetrische Beugungsstrukturen oder Mattstruktur-Gitterbilder aufweist.

16. Sicherheitselement nach einem der Ansprüche 12 bis 15, bei dem die Mikroabbildungselemente der ersten mikrooptischen Darstellungsanordnung und die mikroskopischen Strukturen der zweiten mikrooptischen Darstellungsanordnung in derselben Prägelackschicht geprägt sind.

17. Sicherheitselement nach einem der obigen Ansprüche, bei dem das Sicherheitselement (1) als mehrschichtiger Schichtverbund ausgebildet ist.

18. Wertdokument mit einem Sicherheitselement nach einem der obigen Ansprüche.

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Fig. 1

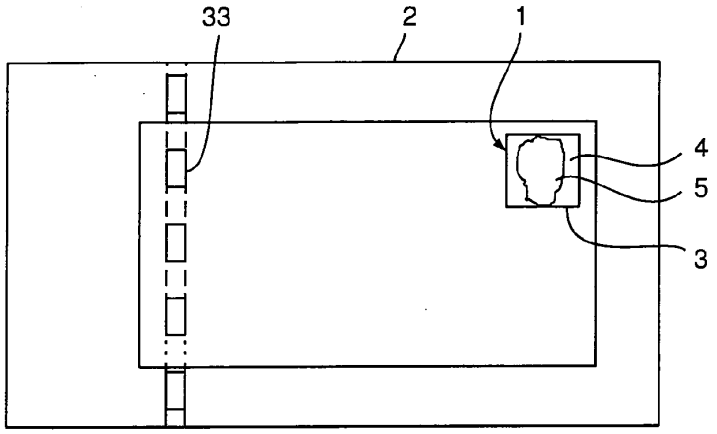


Fig. 2

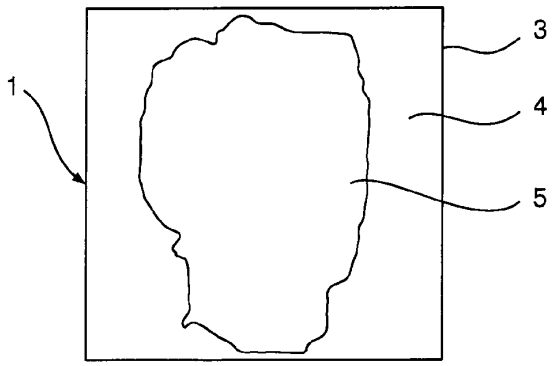
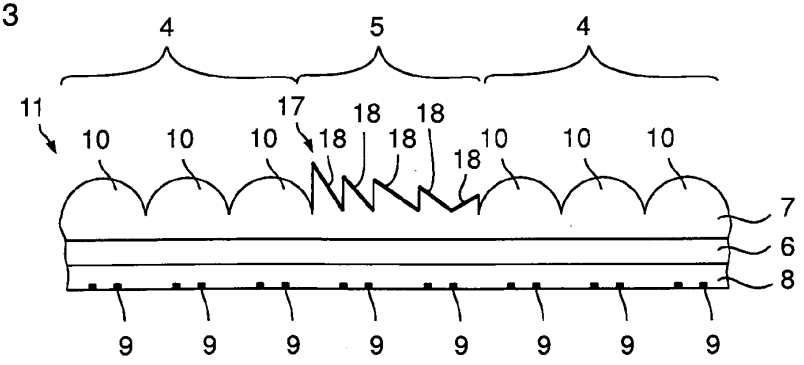


Fig. 3



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Fig. 4

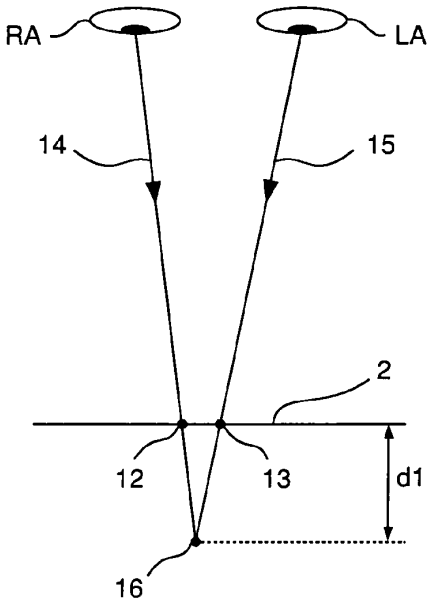
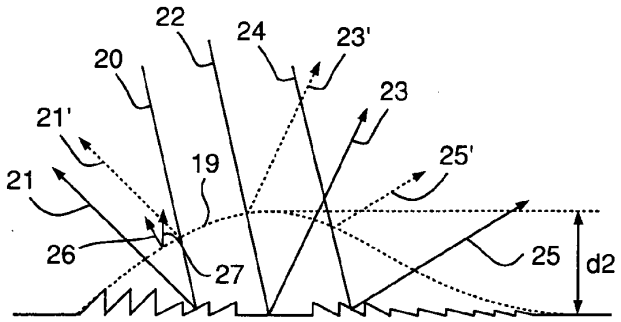


Fig. 5



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Fig. 6A

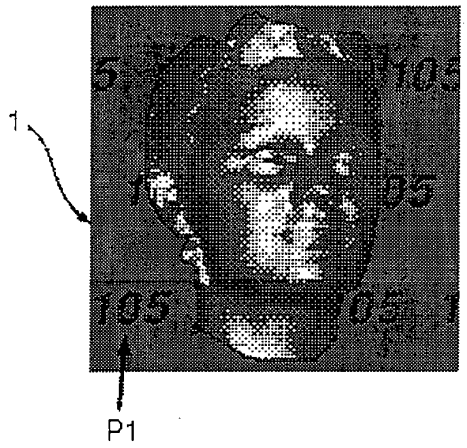


Fig. 6B

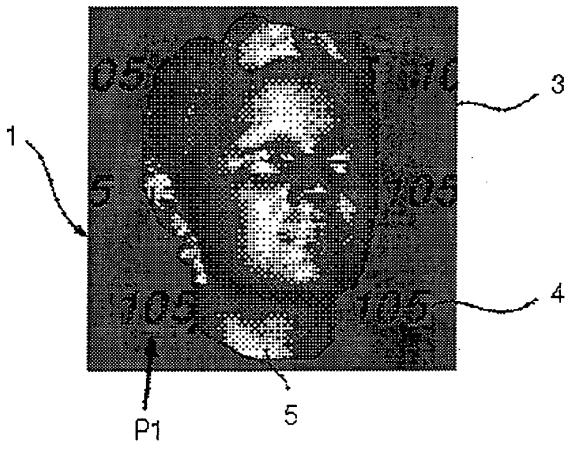
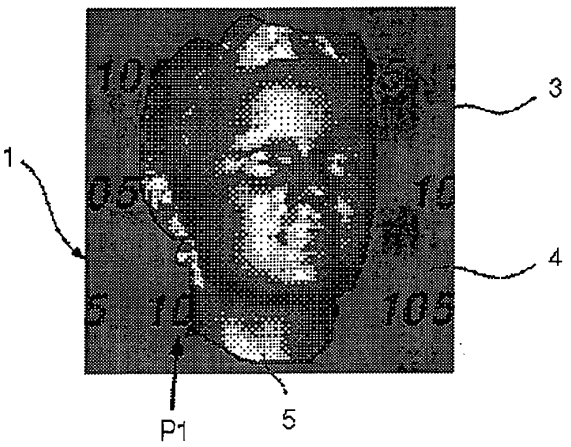


Fig. 6C



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Fig. 7A

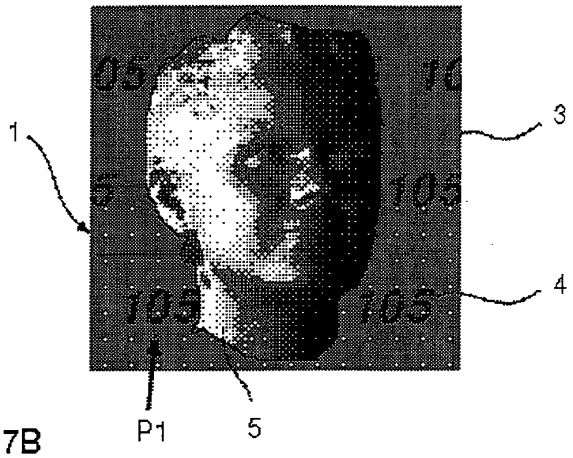


Fig. 7B

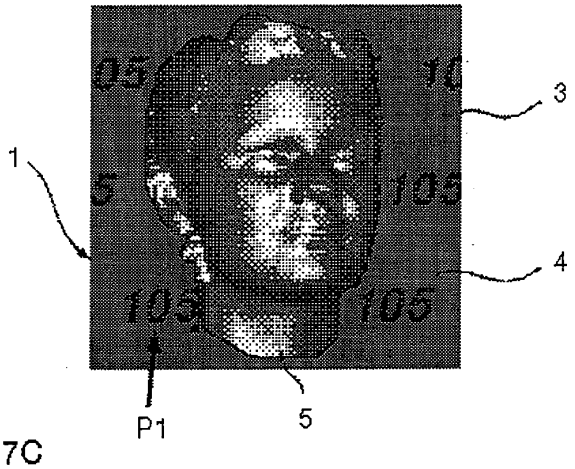
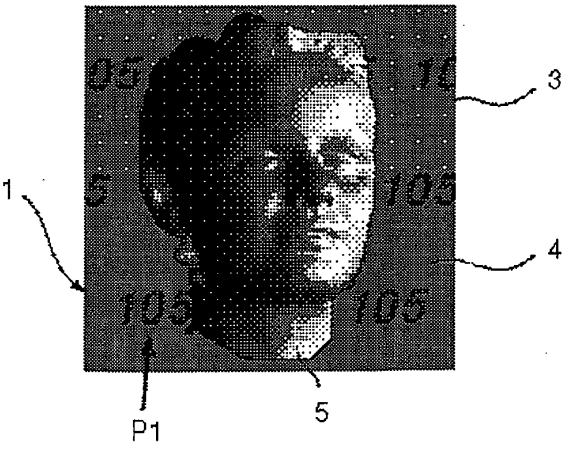


Fig. 7C



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Fig. 8

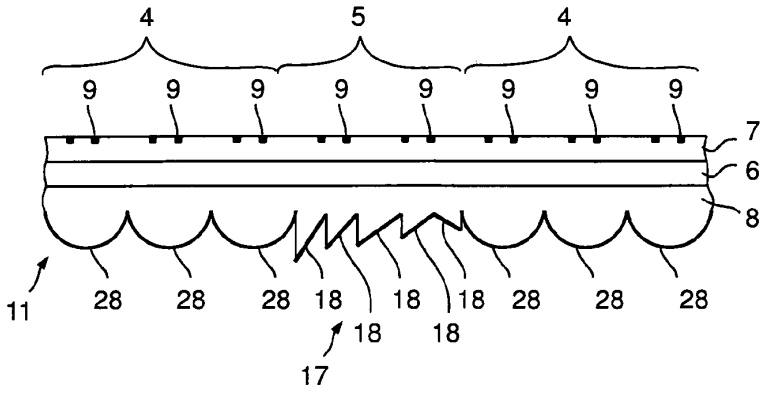
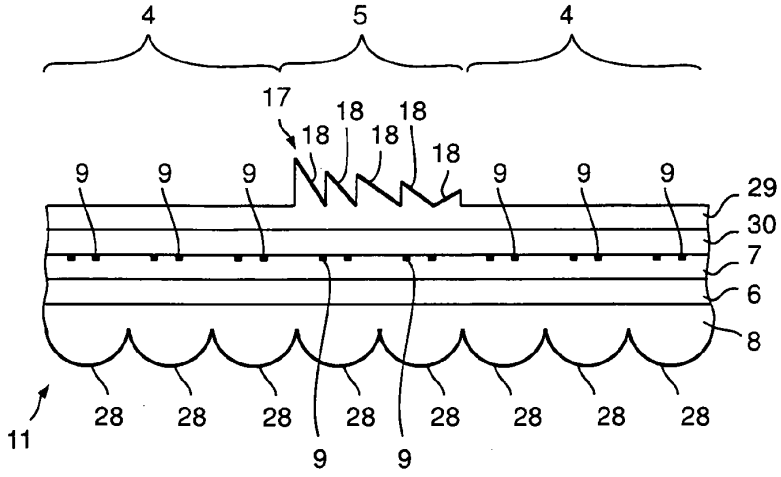


Fig. 9



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Fig. 10

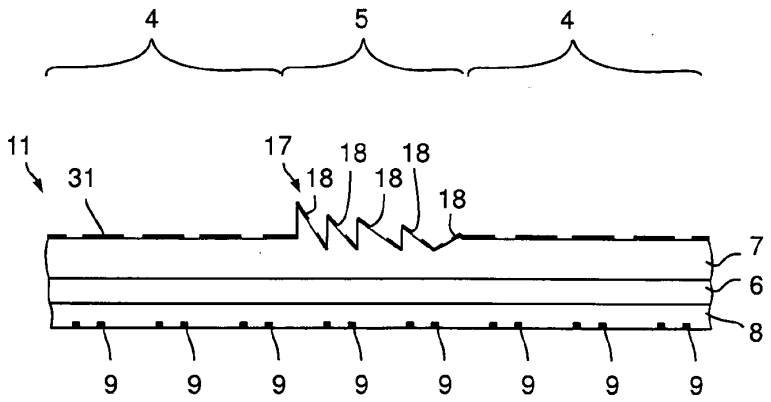


Fig. 11

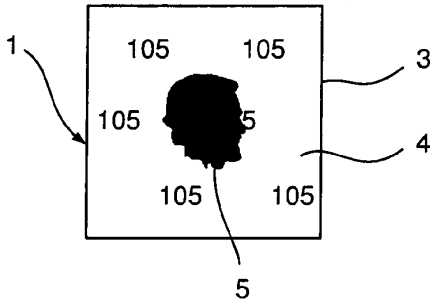
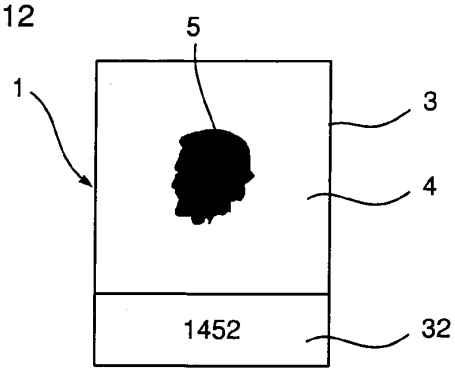


Fig. 12



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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/003220

A. CLASSIFICATION OF SUBJECT MATTER
INV. B42D15/00 B42D15/10 B44F7/00 G02B5/18 G02B27/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B42D B44F G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/034420 A1 (GIESECKE & DEVRIENT GMBH [DE]; DICHTL MARIUS [DE]; GERHARDT THOMAS [DE) 1 April 2010 (2010-04-01) cited in the application page 3, line 13 - page 4, line 13 page 9, line 18 - line 19 page 10, line 1 - line 15 page 20, line 11 - line 14; figure 6 ----- -/--	1-8, 10-15, 17,18

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 October 2011	18/11/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Achermann, Didier

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/008635 A2 (NANOVENTIONS INC [US]; STEENBLIK RICHARD A [US]; HURT MARK J [US]; JOR) 17 January 2008 (2008-01-17) paragraphs [0009], [0010], [0015], [0016], [0019], [0113], [0132], [0135] paragraph [0149]; figure 1 paragraph [0203]; figure 11A paragraph [0204]; figure 12B paragraph [0217]; figures 16d,e paragraph [0281] - paragraph [0296]; figures 34, 35 paragraphs [0251], [0277], [0280] paragraph [0388]; figure 46 -----	1-18

1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/003220

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010034420 A1	01-04-2010	DE 102008049513 A1	01-04-2010
		EP 2335100 A1	22-06-2011
WO 2008008635 A2	17-01-2008	AU 2007272705 A1	17-01-2008
		CA 2656528 A1	17-01-2008
		CN 101563640 A	21-10-2009
		EP 2038692 A2	25-03-2009
		JP 2009543138 A	03-12-2009
		KR 20090029818 A	23-03-2009
		RU 2009101282 A	10-08-2010
		US 2008037131 A1	14-02-2008

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2011/003220

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
INV. B42D15/00 B42D15/10 B44F7/00 G02B5/18 G02B27/22
ADD.

Nach der Internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
B42D B44F G02B

Recherchierte, aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	WO 2010/034420 A1 (GIESECKE & DEVRIENT GMBH [DE]; DICHTL MARIUS [DE]; GERHARDT THOMAS [DE) 1. April 2010 (2010-04-01) in der Anmeldung erwähnt Seite 3, Zeile 13 - Seite 4, Zeile 13 Seite 9, Zeile 18 - Zeile 19 Seite 10, Zeile 1 - Zeile 15 Seite 20, Zeile 11 - Zeile 14; Abbildung 6 ----- -/--	1-8, 10-15, 17,18

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen [X] Siehe Anhang Patentfamilie

* Besondere Kategorien von angegebenen Veröffentlichungen :
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Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
27. Oktober 2011	18/11/2011

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Achermann, Didier

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2011/003220

C. (Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	WO 2008/008635 A2 (NANOVENTIONS INC [US]; STEENBLIK RICHARD A [US]; HURT MARK J [US]; JOR) 17. Januar 2008 (2008-01-17) Absätze [0009], [0010], [0015], [0016], [0019], [0113], [0132], [0135] Absatz [0149]; Abbildung 1 Absatz [0203]; Abbildung 11A Absatz [0204]; Abbildung 12B Absatz [0217]; Abbildungen 16d,e Absatz [0281] - Absatz [0296]; Abbildungen 34, 35 Absätze [0251], [0277], [0280] Absatz [0388]; Abbildung 46 -----	1-18

1

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INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/EP2011/003220

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
WO 2010034420 A1	01-04-2010	DE 102008049513 A1	01-04-2010
		EP 2335100 A1	22-06-2011
WO 2008008635 A2	17-01-2008	AU 2007272705 A1	17-01-2008
		CA 2656528 A1	17-01-2008
		CN 101563640 A	21-10-2009
		EP 2038692 A2	25-03-2009
		JP 2009543138 A	03-12-2009
		KR 20090029818 A	23-03-2009
		RU 2009101282 A	10-08-2010
		US 2008037131 A1	14-02-2008

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CLAIMS WO2012000669

P a t e n t a n s p o rt h e 1. A security element for a security paper, document of value or the like, comprising a support having a motif area (3) providing a visually perceptible motif with a first and a second motif part (4, 5), the motif area (3) being a first microoptical representation (11), which as a first motif part presents at least two different images depending on the viewing angle, and a second microoptical representation arrangement (17) which presents as a second motif part (5) a reflective surface which is opposite to the actual macroscopic spatial form of the second microoptical representation arrangement (17). arched appears.

2.
Security element according to Claim 1, in which the two motif parts are arranged in a coherent manner, wherein the two motif parts (4, 5) preferably adjoin one another directly.

3.
Security element according to one of the above claims, in which one of the two motif parts (4, 5) at least partially surrounds the other of the two motif parts (4, 5).

4.
Security element according to one of the above claims, in which the two motif parts (4, 5) overlap at least partially and / or are at least partially interleaved with each other.

5.
Security element according to one of the above claims, wherein the first micro-optical representation arrangement (11) presents the at least two different images in such a way that the

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images overlap at least in regions and / or are nested one inside the other.

6.
A security element according to any one of the preceding claims, wherein the first micro-optical representation (11) presents as the at least two different images different views of the same object.

7.
A security element as claimed in any one of the preceding claims, wherein the first micro-optical representation (11) presents the at least two different images so as to give a viewer a stereographic representation of an object having absolute depth information.

8.
A security element according to any one of the preceding claims, wherein the first micro-optical representation arrangement (11) is formed as a hologram.

9.
A security element according to any one of claims 1 to 7, wherein the first microoptical representation arrangement (11) comprises microstructures (9) and microimage elements (10, 28) to image the microstructures (9) in an enlarged manner.

10.
A security element as claimed in any one of the preceding claims, wherein the first micro-optical representation (11) produces an ortho-parallax representation.

11.
A security element according to any one of the preceding claims, wherein the second micro-optical representation (17) presents the reflective surface in a relief-like impression.

12.
A security element according to any one of the preceding claims, wherein the second micro-optic display assembly (17) has embossed microscopic structures provided with a reflection-enhancing coating.

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13.
A security element according to claim 12, wherein the second micro-optic display assembly (17) comprises a plurality of reflective facets (18) having mutually different orientations.

14.
A security element according to claim 12, wherein the second micro-optical display device (17) comprises a reflective grating-period Fresnel structure.

15.
The security element of claim 12, wherein the second micro-optic display device (17) comprises asymmetric diffraction patterns or matt-structured grating images.

16.
A security element according to any one of claims 12 to 15, wherein the microimage elements of the first microoptical representation array and the microscopic structures of the second microoptical representation array are embossed in the same embossing lacquer layer.

17.
Security element according to one of the above claims, wherein the security element (1) is designed as a multilayer composite layer.

18.
Security document with a security element according to one of the above claims.

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and Papierfabrik Louisenthal GmbH. - Ex. 1002

(19) Deutsches Patent- und Markenamt

(10) **DE 10 2010 048 262 A1** 2012.04.12

(12) # Offenlegungsschrift

(21) Aktenzeichen: **10 2010 048 262.5**
(22) Anmeldetag: **12.10.2010**
(43) Offenlegungstag: **12.04.2012**

(51) Int Cl.: ***G09F 3/03*** (2006.01)
G02B 5/124 (2006.01)
G02B 5/09 (2006.01)
G02B 5/10 (2006.01)

(71) Anmelder:
Giesecke & Devrient GmbH, 81677, München, DE

(72) Erfinder:
Fuhse, Christian, Dr., 83624, Otterfing, DE; Kaule, Wittich, Dr., 82275, Emmering, DE

(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:

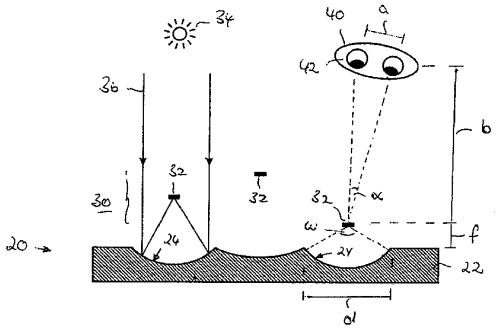
DE	**199 15 943**	**A1**
DE	**10 2005 061 749**	**A1**
WO	**90/ 08 338**	**A1**
WO	**2009/ 000 530**	**A2**

Rechercheantrag gemäß § 43 Abs. 1 Satz 1 PatG ist gestellt.

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Darstellungselement**

(57) Zusammenfassung: Die Erfindung betrifft ein Darstellungselement (20) mit einem Substrat (22) mit einem Flächenbereich, in dem eine Mehrzahl optischer Elemente (24) angeordnet ist. Erfindungsgemäß ist das Darstellungselement (20) ausgelegt und bestimmt, bei Beleuchtung (34) ein Lichtfleckenbild (30) aus einer Mehrzahl von Lichtflecken (32) zu erzeugen, die für einen Betrachter (40) oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind, wobei die optischen Elemente durch refraktive und/oder reflektive optische Elemente (24) gebildet sind und jedem Lichtfleck (32) des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element (24) zugeordnet ist, welches bei Beleuchtung (34) des Darstellungselements (20) zur Erzeugung des ihm zugeordneten Lichtflecks (32) beiträgt.



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Beschreibung

[0001] Die Erfindung betrifft ein Darstellungselement mit einem Substrat mit einem Flächenbereich, in dem eine Mehrzahl optischer Elemente angeordnet ist. Die Erfindung betrifft ferner ein Verfahren zur Herstellung eines derartigen Darstellungselements und einen Datenträger mit einem solchen Darstellungselement.

[0002] Datenträger, wie Wert- oder Ausweisdokumente, aber auch andere Wertgegenstände, wie etwa Markenartikel, werden zur Absicherung oft mit Sicherheitselementen versehen, die eine Überprüfung der Echtheit des Datenträgers gestatten und die zugleich als Schutz vor unerlaubter Reproduktion dienen.

[0003] Besondere Beachtung erfahren dabei gegenwärtig Sicherheitselemente mit dreidimensional wirkenden Bildern, da diese einerseits auch für den Laien leicht erkenn- und prüfbar sind und sie andererseits mit gängigen Kopierverfahren nicht originalgetreu reproduziert werden können.

[0004] Dabei sind mehrere Techniken bekannt, mit denen bei beidäugiger Betrachtung flacher Bilder ein dreidimensionaler Bildeindruck erzeugt werden kann. Bei Anaglyphenbildern sind etwa zwei stereoskopische Halbbilder einander überlagert. Bei Betrachtung mit einem Hilfsmittel, wie einer Rot-Grün-Brille oder einer Polarisationsbrille werden die beiden Halbbilder für die beiden Augen getrennt.

[0005] Eine andere Technik verwendet Linsen- oder Spiegelrasterbilder, die aus einem Mehrschichtaufbau mit Motivschicht und von der Motivschicht beabstandeter Linsen- bzw. Spiegelschicht bestehen. Ein Beispiel dieser Technik sind die 3D-Moiré-Magnifier, wie sie in der Druckschrift WO 2009/000530 A2 beschrieben sind.

[0006] Ein weiterer Ansatz, wie er etwa in der Druckschrift WO 90/08338 A1 beschrieben ist, besteht darin, das Motiv als flaches Relief ausbilden, wobei sich die Oberfläche des Motivs nachgeahmt und/oder gestückelt in der Oberfläche des Bildes wiederfindet.

[0007] Schließlich werden für Sicherheitselemente seit längerem Hologramme, holographische Stereogramme und hologrammartige Gitterbilder eingesetzt, um einen dreidimensionalen Bildeindruck zu erzeugen. Bei dieser Technik spielt Lichtbeugung und Interferenz an den holographischen Strukturen und Beugungsgittern eine entscheidende Rolle.

[0008] Davon ausgehend davon liegt der Erfindung die Aufgabe zugrunde, ein Darstellungselement der eingangs genannten Art zu schaffen, das ein attraktives visuelles Erscheinungsbild aufweist. Für Sicherheitsanwendungen soll das Darstellungselement zudem eine hohe Fälschungssicherheit aufweisen und darüber hinaus auch für Laien einfach auf Echtheit zu prüfen sein.

[0009] Diese Aufgabe wird durch das Darstellungselement mit den Merkmalen des Hauptanspruchs gelöst. Ein Verfahren zur Herstellung eines derartigen Darstellungselements, ein mit einem solchen Darstellungselement ausgestatteter Datenträger und eine mit einem solchen Darstellungselement ausgestattete Anzeigeeinrichtung sind in den nebengeordneten Ansprüchen angegeben. Weiterbildungen der Erfindung sind Gegenstand der Unteransprüche.

[0010] Gemäß der Erfindung enthält ein gattungemäßes Darstellungselement ein Substrat mit einem Flächenbereich, in dem eine Mehrzahl optischer Elemente angeordnet ist. Das Darstellungselement ist dabei ausgelegt und bestimmt, bei Beleuchtung ein Lichtfleckenbild aus einer Mehrzahl von Lichtflecken zu erzeugen, die für einen Betrachter oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind. Dazu sind die genannten optischen Elemente durch refraktive und/oder reflektive optische Elemente gebildet, wobei jedem Lichtfleck des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element zugeordnet ist, welches bei Beleuchtung des Darstellungselements zur Erzeugung des ihm zugeordneten Lichtflecks beiträgt.

[0011] Die Erfindung beruht somit auf dem Gedanken, ein dreidimensionales Motiv vorzugeben, das aus über oder unter dem Darstellungselement schwebenden Lichtflecken besteht. Um die Lichtflecke bei Beleuchtung zu erzeugen, weist das Darstellungselement nebeneinander liegende oder verschachtelte Teile von Spiegeln, Linsen oder Prismen auf, die so ausgelegt sind, dass sie in einem Bildraum bei geeigneter Beleuchtung schwebende Lichtreflexe erzeugen, die zusammengenommen das vorgegebene dreidimensionale Motiv darstellen. Die schwebenden Lichtreflexe sind im physikalischen Sinne reelle Bilder oder virtuelle Bilder der beleuchtenden Lichtquellen, wie nachfolgend genauer erläutert. Der visuelle Eindruck ist dabei besonders gut, wenn das Darstellungselement mit parallelem Licht, beispielsweise einer weit entfernten Lichtquelle, beleuchtet wird.

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[0012] Das durch die Beleuchtung entstehende dreidimensionale Lichtfleckenbild bietet dem Betrachter einen ungewöhnlichen und visuell ansprechenden dreidimensionalen Bildeindruck, der dem Darstellungselement einen hohen Aufmerksamkeits- und Wiedererkennungswert verleiht. Das Vorliegen oder Nichtvorliegen des Effekts ist für jeden Benutzer leicht festzustellen, das Darstellungselement also einfach verifizierbar. Dennoch ist die Spiegel- bzw. Linsenanordnung aufgrund des erforderlichen Know-how und der benötigen Technologie für einen potentiellen Fälscher nur schwer nachzustellen.

[0013] Nachfolgend werden die refraktiven und/oder reflektiven optischen Elemente der kürzeren Benennung halber meist nur als "optische Elemente" bezeichnet. Es versteht sich jedoch, dass damit im Rahmen der Erfindung stets refraktive und/oder reflektive optische Elemente gemeint sind. Die optischen Elemente können entweder rein refraktiv sein, wie etwa eine Linse oder ein Mikroprisma, rein reflektiv, wie etwa ein Spiegel oder ein Mikrospiegel, oder sowohl refraktiv als auch reflektiv, wie etwa eine mit einer semitransparenten Beschichtung versehene Linse oder ein mit einer semitransparenten Beschichtung versehenes Mikroprisma. In jedem Fall spielen Beugungs- und Interferenzeffekte bei den erfindungsgemäßen refraktiven und/oder reflektiven optischen Elementen keine Rolle und können stets vernachlässigt werden.

[0014] In einer bevorzugten Ausgestaltung sind die optischen Elemente und die Schwebehöhen der Lichtflecke so ausgelegt, dass für die Lichtflecke und die zugeordneten optischen Elemente jeweils die Bedingung $f/d < 5$ gilt, wobei f die Schwebehöhe eines Lichtflecks oberhalb oder unterhalb des Flächenbereichs bezeichnet und d den Durchmesser der zu diesem Lichtfleck beitragenden optischen Elemente angibt. Dadurch ist sichergestellt, dass die Lichtflecke bei normalem Betrachtungsabstand von etwa 30 cm für beide Augen des Betrachters innerhalb der Öffnung des zugehörigen optischen Elements liegen.

[0015] Gemäß einer vorteilhaften Erfindungsvariante schweben die Lichtflecken des Lichtfleckenbilds in mehreren verschiedenen Schwebehöhen oberhalb oder unterhalb des Flächenbereichs, um ein dreidimensionales Motiv zu bilden. Nach einer alternativen, ebenfalls vorteilhaften Erfindungsvariante schweben die Lichtflecken des Lichtfleckenbilds bereichsweise alle in derselben Schwebehöhe oberhalb oder unterhalb des Flächenbereichs, um ein Kulissenmotiv zu bilden. Mit Vorteil kann in dem Lichtfleckenbild auch ein dreidimensionales Motiv mit einem zweidimensionalen Motiv kombiniert sein, da dann auch bei schlechten Lichtverhältnissen noch ein Lichtfleckenbild erkennbar und damit eine Echtheitsprüfung möglich ist.

[0016] Die optischen Elemente umfassen zweckmäßig gewölbte Spiegel, insbesondere Hohlspiegel (konkav gewölbte Spiegel) oder Wölbspiegel (konvex gewölbte Spiegel). Die gewölbten Spiegel können sphärisch, elliptisch, rotationssymmetrisch asphärisch, nichtrotationssymmetrisch asphärisch oder rinnenförmig ausgebildet sein, wobei im letzteren Fall die Rinnen geradlinig oder krummlinig verlaufen können. Elliptische Spiegel weisen in x- und y-Richtung eine unterschiedliche Spiegelkrümmung auf, bei asphärischen Spiegeln weicht die Spiegelfläche von einer Kugelform ab. Asphärische Spiegel können rotationssymmetrisch oder im allgemeinsten Fall auch nichtrotationssymmetrisch sein. Gradlinige rinnenförmige Spiegel können als Sonderfall elliptischer Spiegel angesehen werden, bei denen der Krümmungsradius in einer Raumrichtung unendlich groß ist. Um eine geringe Strukturhöhe zu verwirklichen, können die gewölbten Spiegel auch zumindest teilweise durch Fresnelspiegel gebildet sein.

[0017] Alternativ oder zusätzlich können die optischen Elemente auch Linsen umfassen, insbesondere sphärische, elliptische, rotationssymmetrisch asphärische, nichtrotationssymmetrisch asphärische oder zylindrische Linsen. Elliptische Linsen weisen in x- und y-Richtung eine unterschiedliche Krümmung auf, bei asphärischen Linsen weicht die lichtbrechende Linsenfläche von einer Kugelform ab. Asphärische Linsen können rotationssymmetrisch oder im allgemeinsten Fall auch nichtrotationssymmetrisch sein. Zylindrische Linsen können als Sonderfall elliptischer Linsen angesehen werden, bei denen der Krümmungsradius in einer Raumrichtung unendlich groß ist. Auch die Linsen können zumindest teilweise durch Fresnellinsen gebildet sein, um zu einer geringeren Strukturhöhe zu gelangen.

[0018] In einer vorteilhaften Erfindungsvariante ist jedem Lichtfleck des Lichtfleckenbilds genau ein optisches Element zugeordnet.

[0019] Nach einer alternativen, ebenfalls vorteilhaften Erfindungsvariante ist jedem Lichtfleck des Lichtfleckenbilds nicht nur ein optisches Element, sondern eine Mehrzahl von optischen Elementen zuordnet. Zuordnung bedeutet dabei, dass das optische Element bei Beleuchtung durch Spiegelung (Reflexion) und/oder Lichtbrechung (Refraktion) zur Erzeugung dieses Lichtflecks beiträgt. Die optischen Elemente sind bevorzugt beabstandet auf dem Flächenbereich verteilt. Durch die entstehenden Zwischenräume zwischen den einzelnen optischen Elementen können dann mehrere Gruppen von optischen Elementen, die jeweils verschiedenen

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Lichtflecken zugeordnet sind, im selben Flächenbereich ineinander verschachtelt angeordnet sein. Auf diese Weise kann eine besonders hohe räumliche Auflösung im Lichtfleckenbild erreicht werden, wie weiter unten genauer erläutert.

[0020] Als weiterer Vorteil der Zuordnung einer Mehrzahl von optischen Elementen zu einem Lichtfleck hat sich herausgestellt, dass aufgrund der dann möglichen geringeren Abmessungen der einzelnen optischen Elemente Elemente mit ebenen Begrenzungsflächen eingesetzt werden können, die einfacher zu berechnen und herzustellen sind als ein einziges gekrümmtes, optisches Element gleicher optischer Wirkung.

[0021] Um ein Lichtfleckenbild zu erzeugen, in dem die Lichtflecken unterschiedliche Helligkeiten aufweisen, ist vorteilhaft jedem Lichtfleck des Lichtfleckenbilds eine solche Anzahl von optischen Elementen zugeordnet, die der Helligkeit des Lichtflecks innerhalb des von den Lichtflecken gebildeten Motivs entspricht. Sind die optischen Elemente unterschiedlich groß, kann auch jedem Lichtfleck eine solche Gesamtfläche von optischen Elementen zugeordnet werden, die der Helligkeit des Lichtflecks innerhalb des von den Lichtflecken gebildeten Motivs entspricht.

[0022] Besonders bevorzugt sind die optischen Elemente durch ebene Mikrospiegel oder durch kleine Mikroprismen gebildet.

[0023] Das vorbestimmte Motiv kann auch ein Wechselbild sein, das aus unterschiedlichen Betrachtungsrichtungen unterschiedliche Bilder zeigt. Ein konkretes Beispiel für die Erzeugung eines solchen Wechselbilds ist weiter unten beschrieben. Es versteht sich, dass der Begriff "Wechselbilder" auch solche Bilder umfasst, bei denen nur Bildteile dem Wechsel unterworfen sind.

[0024] Bei Wechselbildern ändern sich Bilder oder Bildpartien bei Änderung der Betrachtungsrichtung, insbesondere beim Kippen des Bildes; weswegen solche Bilder auch Kippbilder genannt werden. Der Wechsel kann beim waagrechten oder senkrechten Kippen erfolgen, oder beim Kippen in einer Richtung, die zwischen waagrecht und senkrecht liegt.

[0025] Wenn der Wechsel beim Bildinhalt abrupt erfolgt, spricht man von Flipbildern. Erfolgt der Wechsel über Zwischenstufen spricht man von Morphing-Bildern.

[0026] Weiterhin können auch 2D-3D-Bilder als Lichtfleckenbild ausgebildet werden. Dabei hat man neben 3-dimensional wirkenden Partien (die vor oder hinter der Ebene des Darstellungselements zu sehen sind oder die Ebene des Darstellungselements zu durchdringen scheinen) auch 2-dimensional wirkende Partien in oder nahe der Ebene des Darstellungselements (in der Höhenstufe 0 oder nahe der Höhenstufe 0)

[0027] Bei einem 2D-3D-Bild können 2D- und 3D-Partien nebeneinander liegen und/oder bei Änderung der Betrachtungsrichtung wechselweise am gleichen Ort erscheinen. Bei einem solchen 2D-3D-Wechselbild kann z. B. ein zweidimensionaler Bildinhalt (z. B. eine Schrift oder ein Logo) richtungsabhängig in ein 3D-Bild ein- und ausgeblendet werden.

[0028] Gemäß einer Weiterbildung der Erfindung kann der Flächenbereich, in dem die Mehrzahl optischer Elemente angeordnet ist, auch gekrümmt sein, beispielsweise zylindrisch oder sphärisch gekrümmt.

[0029] Bei einer weiteren Erfindungsvariante erzeugt eine Teilmenge der optischen Elemente eine versteckte Bildinformation, die ohne Hilfsmittel nicht erkennbar ist. Die versteckte Bildinformation steht dabei im Gegensatz zu der durch das oben beschriebene Lichtfleckenbild gebildeten offenen Bildinformation, die bei normaler Beleuchtung ohne weitere Hilfsmittel mit bloßem Auge erkennbar ist. Die versteckte Bildinformation ist dagegen bei normaler Beleuchtung nicht ohne weiteres mit bloßem Auge erkennbar, sondern wird beispielsweise nur bei gerichteter Beleuchtung mit Laserlicht sichtbar oder benötigt einen besonderen Auffangschirm.

[0030] In einer vorteilhaften Variante der Erfindung umfassen die optischen Elemente eine periodische Anordnung von Mikrospiegeln, die jeweils einen Abstand zum nächsten Nachbarn von 2 mm oder weniger, insbesondere von 1 mm oder weniger aufweisen. Ein Betrachter erkennt dann nicht mehr die Spiegelbilder der Spiegel, sondern sieht pro Spiegel nur einen Lichtpunkt, dessen Form von der Ausleuchtung der Umgebung abhängt. Kippt der Betrachter das Darstellungselement, so wandern die Lichtpunkte der Spiegel etwas zur Seite, und zwar je nach Auslegung der Spiegel als Hohl- oder Wölbspiegel so, als ob die Lichtpunkte vor oder vorzugsweise hinter der Ebene des Darstellungselements liegen würden. Durch die periodische Anordnung der Mikrospiegel sieht der Betrachter somit ein regelmäßiges Gitter von Lichtpunkten, die sich beim Kippen des

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Darstellungselements vorzugsweise so zu bewegen scheinen, als würden sie sich in einer weiter hinten liegenden Ebene befinden. Das Lichtpunkt-Gitter kann daher den Hintergrund für ein weiteres Motiv bilden, beispielsweise für den in der ebenfalls anhängigen deutschen Patentanmeldung DE 10 2009 056 934.0 beschriebenen Wölbeffekt, oder für eine Sägezahndarstellung mit kinematischen Effekt, wie etwa die Hologrammstrukturen der Druckschrift EP 0 868 313 B1 (dortiger Absatz [0034] bzw. Fig. 8 mit reflektierenden Sägezahnstrukturen).

[0031] Um die optischen Elemente einerseits vor Verschmutzung und Abrieb zu schützen und um anderseits eine unbefugte Nachstellung durch Abprägen der Oberflächenstruktur wirksam zu verhindern, werden die optischen Elemente vorteilhaft in eine Umgebungsschicht oder einen Umgebungsschichtverbund, insbesondere in eine Schutzschicht eingebettet. Eine solche Einbettung verändert in der Regel die Schwebehöhe der Lichtflecken, da ein Brechungsindexunterschied zwischen Einbettungsmaterial und Luft bzw. Einbettungsmaterial und Linsenmaterial den optischen Strahlengang verändert. Eine solche Änderung des optischen Strahlengangs kann jedoch ohne weiteres bei der Auslegung der optischen Elemente entsprechend berücksichtigt werden, so dass nach der Einbettung die gewünschten Schwebehöhen verwirklicht werden.

[0032] In einer vorteilhaften Gestaltung sind die optischen Elemente als Prägestrukturen in einer Prägelackschicht ausgebildet. Ist das Darstellungselement zumindest teilweise reflektierend ausgebildet, so sind die Prägestrukturen vorzugsweise mit einer reflexionserhöhenden Beschichtung versehen. Als reflexionserhöhende Beschichtung kommt insbesondere eine vollflächige oder gerasterte Metallisierung, eine hochbrechende Beschichtung, ein Dünnschichtelement mit Farbkippeffekt oder eine cholesterische Flüssigkristallschicht in Betracht.

[0033] Die Strukturhöhen der Prägestrukturen liegen vorzugsweise unterhalb von 100 µm, bevorzugt unterhalb von 20 µm, besonders bevorzugt unterhalb von 5 µm.

[0034] Die erfindungsgemäßen Darstellungselemente können mit anderen Sicherheitsmerkmalen kombiniert werden, beispielsweise mit diffraktiven Strukturen, mit Hologrammstrukturen in allen Ausführungsvarianten, metallisiert oder nicht metallisiert, mit Subwellenlängenstrukturen, metallisiert oder nicht metallisiert, mit Subwellenlängengittern, mit Schichtsystemen, die beim Kippen einen Farbwechsel zeigen, semitransparent oder opak, mit diffraktiven optischen Elementen, mit refraktiven optischen Elementen, wie etwa Prismenstrahlformern, mit speziellen Lochformen, mit Sicherheitsmerkmalen mit gezielt eingestellter elektrischer Leitfähigkeit, mit eingearbeiteten Stoffen mit magnetischer Codierung, mit Stoffen mit phosphoreszierender, fluoreszierender oder lumineszierender Wirkung, mit Sicherheitsmerkmalen auf Grundlage von Flüssigkristallen, mit Mattstrukturen, mit zusätzlichen Mikrospiegelelementen, mit Elementen mit Jalousie-Effekt oder mit Sägezahnstrukturen. Weitere Sicherheitsmerkmale, mit denen die erfindungsgemäßen Darstellungselemente kombiniert werden können, sind in der Druckschrift WO 2005/052650 A2 auf Seiten 71 bis 73 angegeben; diese werden insoweit in die vorliegende Beschreibung aufgenommen.

[0035] Die Erfindung enthält auch ein Verfahren zum Herstellen eines refraktiven Darstellungselements der beschriebenen Art, welches ausgelegt und bestimmt ist, bei Beleuchtung ein Lichtfleckenbild aus einer Mehrzahl von Lichtflecken zu erzeugen, die für einen Betrachter oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind. Bei dem Verfahren wird ein Substrat bereitgestellt und wird in einem Flächenbereich des Substrats eine Mehrzahl refraktiver und/oder reflektiver optischer Elemente angeordnet, wobei jedem Lichtfleck des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element zugeordnet wird, welches bei Beleuchtung des Darstellungselements zur Erzeugung des ihm zugeordneten Lichtflecks beiträgt.

[0036] Gemäß einer vorteilhaften Verfahrensvariante wird

– ein gewünschtes dreidimensionales Motiv mit Bildpunkten Pj und Höhenwerten Zj über einer xy-Ebene vorgegeben, wobei die Bildpunkte den bei Beleuchtung entstehenden Lichtflecken entsprechen,
– wird für jeden Bildpunkt P_j eine Helligkeit I_j zwischen 0% und 100% festgelegt,
– werden den Bildpunkten P_j Öffnungskegel zugeordnet, die ein Öffnungsverhältnis > 0,2 aufweisen,
– wird für jeden Bildpunkt Pj durch einen Schnitt des von dem Bildpunkt ausgehenden Öffnungskegels mit der xy-Ebene ein Einzugsbereich Ej bestimmt,
– wird die xy-Ebene in eine Anzahl von Grobfeldern und die Grobfelder jeweils in eine Anzahl von Feinfeldern aufgeteilt,
– werden für jeden Bildpunkt P_j auf Grundlage des festgelegten Höhenwerts Z_j und des festgelegten Helligkeitswerts I_j eine Anzahl an zu füllenden Feinfeldern bestimmt,

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– werden die für den Bildpunkt P_j bestimmten, zu füllenden Feinfelder im Wesentlichen gleichmäßig auf die Grobfelder im Einzugsbereich E_j des Bildpunkts P_j verteilt, und
– werden die zu füllenden Feinfelder mit refraktiven und/oder reflektiven optischen Elementen belegt, die bei Beleuchtung des Darstellungselements zur Erzeugung des dem Bildpunkt P_j entsprechenden Lichtflecks beitragen.

[0037] Die Erfindung enthält schließlich auch einen Datenträger mit einem Darstellungselement der beschriebenen Art, wobei das Darstellungselement insbesondere als ein reflektierendes Sicherheitselement in einem opaken Bereich des Datenträgers, oder als zumindest teilweise durchsichtiges Sicherheitselement in oder über einem transparenten Fensterbereich oder einer durchgehenden Öffnung des Datenträgers angeordnet sein kann. Bei dem Datenträger kann es sich insbesondere um ein Wertdokument, wie eine Banknote, insbesondere eine Papierbanknote, eine Polymerbanknote oder eine Folienverbundbanknote handeln, aber auch um eine Ausweiskarte, wie etwa eine Kreditkarte, eine Bankkarte, eine Barzahlungskarte, eine Berechtigungskarte, einen Personalausweis oder eine Passpersonalisierungsseite handeln.

[0038] Die Erfindung enthält weiter eine Anzeigeeinrichtung mit einer Steuereinrichtung und einem Darstellungselement der oben beschriebenen Art, wobei die räumliche Ausrichtung der optischen Elemente des Darstellungselements durch die Steuereinrichtung einstellbar ist. Auf diese Weise kann das Darstellungselement je nach Ansteuerung unterschiedliche Lichtfleckenbilder zeigen. Die Änderung der räumlichen Ausrichtung der optischen Elemente kann dabei sehr rasch erfolgen, so dass für den Betrachter der Eindruck einer fortlaufenden Bildfolge entsteht. Die Anzeigeeinrichtung kann somit als 3D-Display für unterschiedlichste Anwendungen eingesetzt werden.

[0039] Weitere Ausführungsbeispiele sowie Vorteile der Erfindung werden nachfolgend anhand der Figuren erläutert, bei deren Darstellung auf eine maßstabs- und proportionsgetreue Wiedergabe verzichtet wurde, um die Anschaulichkeit zu erhöhen.

[0040] Es zeigen:

[0041] Fig. 1 eine schematische Darstellung einer Banknote mit einem erfindungsgemäßen Sicherheitselement,

[0042] Fig. 2 schematisch ein erster Ausführungsbeispiel der Erfindung mit Hohlspiegeln als reflektive optische Elemente,

[0043] Fig. 3 ein anderes Ausführungsbeispiel der Erfindung mit Wölbspiegeln als reflektive optische Elemente,

[0044] Fig. 4 ein vorgegebenes Lichtflecken-Motiv in Form einer dreidimensionalen Lichtpyramide,

[0045] Fig. 5 in (a) einen Wölbspiegel und in (b) der durch einen Fresnel-Spiegel ersetzte Wölbspiegel von (a),

[0046] Fig. 6 eine Aufsicht auf eine Mehrzahl von gewölbten Spiegeln, in (a) mit Spiegeln mit quadratischer Grundfläche und in (b) mit rinnenförmig ausgebildeten Spiegeln verschiedener Orientierung,

[0047] Fig. 7 ein weiteres Ausführungsbeispiel der Erfindung, bei dem die refraktiven optischen Elemente durch Linsen gebildet sind,

[0048] Fig. 8 in (a) bis (d) vier Ausführungsbeispiele, bei denen ein gekrümmter Hohlspiegel in Mikrooptikelemente mit quadratischer Grundfläche und ebener Spiegelfläche zerlegt ist,

[0049] Fig. 9 die Belegung einer schachbrettartigen Anordnung nach **Fig.** 8(b) mit Mikrospiegeln, wobei (a) einen Zwischenschritt mit nur einer Mikrospiegelgruppe und (b) die vollständige Belegung mit zwei Mikrospiegelgruppen für zwei nahe benachbarte Lichtflecken zeigt,

[0050] Fig. 10 veranschaulicht die Berechnung der ebenen Spiegelflächen der Mikrospiegel der Fig. 8 und Fig. 9,

[0051] Fig. 11 veranschaulicht die Berechnung von Mikroprismen, die bei der Zerlegung einer Sammellinse entstehen, und

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[0052] Fig. 12 zeigt schematisch ein Sicherheitselement mit eingebetteten Mikrospiegeln.

[0053] Die Erfindung wird nun am Beispiel von Sicherheitselementen für Banknoten erläutert. Fig. 1 zeigt dazu eine schematische Darstellung einer Banknote **10**, die mit einem erfindungsgemäßen Sicherheitselement **12** versehen ist. Das Sicherheitselement **12** kann als reflektierendes Sicherheitselement ausgebildet sein, das in einem opaken Bereich der Banknote **10** vorliegt, oder kann als Durchsichtssicherheitselement ausgebildet sein, das beispielsweise über einem transparenten Fensterbereich der Banknoten **10** angeordnet ist.

[0054] Bei Beleuchtung, beispielsweise durch Sonnenlicht oder eine Deckenlampe, erzeugt das Sicherheitselement **12** für einen Betrachter ein dreidimensionales Lichtfleckenbild aus einer Mehrzahl von Lichtflecken, die für einen Betrachter jeweils oberhalb oder unterhalb der Ebene des Sicherheitselements **12** zu schweben scheinen. Verschiedene Lichtflecken weisen dabei unterschiedliche Schwebehöhen auf, so dass die Lichtflecken zusammen ein dreidimensionales Motiv, beispielsweise eine aus der Banknote herausragende Lichtpyramide, bilden.

[0055] Diese durch die Beleuchtung entstehenden und aus der Banknote vor- oder zurückspringenden Lichtfleckenbilder bieten dem Betrachter einen ungewöhnlichen, visuell ansprechenden dreidimensionalen Bildeindruck, der auch für Laien leicht zu prüfen und zu memorieren ist.

[0056] Zur Erläuterung des Erfindungsprinzips zeigt Fig. 2 ein erstes Ausführungsbeispiel eines Sicherheitselements **20**, bei dem das dreidimensionale Motiv **30** vereinfacht durch drei Bildpunkte **32** dargestellt ist. Das Sicherheitselement **20** enthält ein Substrat **22**, das in einem Flächenbereich eine Mehrzahl von kleinen Hohlspiegeln **24** enthält. Da in der Figur vereinfacht nur drei Bildpunkte **32** des Motivs dargestellt sind, sind entsprechend auch nur drei Hohlspiegel **24** gezeigt. Es versteht sich jedoch, dass ein Sicherheitselement **20** in der Praxis typischerweise eine große Zahl, beispielsweise einige Zehn, einige Hundert oder sogar mehrere Tausend refraktiver und/oder reflektiver optischer Elemente **24** aufweisen wird. Konkrete Beispiele für Sicherheitselemente mit einer großen Zahl an optischen Elementen sind weiter unten beschrieben.

[0057] Zurückkommend auf die Darstellung der Fig. 2 ist die Brennweite f der in der Ebene des Substrats **22** angeordneten Hohlspiegel **24** jeweils so gewählt, dass die Hohlspiegel **24** bei Beleuchtung mit einer weit entfernten Lichtquelle **34** die vorgegebenen Bildpunkte als Lichtflecken **32** erzeugen. Genauer gesagt stellen die Lichtflecken **32** reelle Bilder der Lichtquelle dar, wie im linken Bildteil der Fig. 2 durch den geometrischen Strahlengang **36** angedeutet.

[0058] Ein dreidimensionaler Bildeindruck, also die Wahrnehmung des Betrachters **40**, dass die Lichtflecken **32** in einer bestimmten Höhe über der Fläche des Substrats **22** schweben, entsteht erst durch beidäugiges Sehen. Dazu muss durch die Auslegung der Hohlspiegelanordnung sichergestellt sein, dass die reellen Bilder **32** der Lichtquelle **34** jeweils für beide Augen **42** innerhalb der Öffnung des maßgeblichen optischen Systems, hier also eines Holspiegels **24**, liegen.

[0059] Wie im rechten Bildteil von Fig. 2 illustriert, liegt ein Lichtfleck **32** genau dann für beide Augen **42** innerhalb der Öffnung des Hohlspiegels **24**, wenn vom Lichtfleck **32** aus gesehen der Öffnungswinkel ω des Hohlspiegels **24** größer ist als der Betrachtungswinkel α des Betrachters **40**. Der Öffnungswinkel ω ist dabei durch das Verhältnis von Spiegeldurchmesser d und Brennweite f gegeben, $\omega = d/f$ und der Betrachtungswinkel α durch das Verhältnis von Augenabstand a und Betrachtungsabstand b, also $\alpha = a/b$. Für einen typischen Augenabstand $a \approx 6{,}5$ cm und einen typischen Betrachtungsabstand $b \approx 30$ cm erhält man so die Bedingung

$$f/d < b/a \approx 5,$$

also die Bedingung, dass das Verhältnis der Schwebehöhe f eines Lichtflecks **32** zum Durchmesser des den Lichtfleck erzeugenden Hohlspiegels **24** kleiner als etwa 5 sein muss. Beträgt der Durchmesser der Hohlspiegel **24**, wie im Ausführungsbeispiel der Fig. 2, beispielsweise d = 0,5 mm, so lassen sich Schwebehöhen bis zu 2,5 mm mit dreidimensionalem Bildeindruck realisieren.

[0060] Die refraktiven und/oder reflektiven optischen Elemente können Abmessungen von einigen 100 µm oder sogar einigen Millimeter aufweisen, können aber auch deutlich kleiner ausgebildet sein. Beispielsweise kann ein Hohlspiegel in eine Vielzahl von Mikrospiegeln zerlegt und diese über einen bestimmten Flächenbereich des Substrats **22** verteilt sein, wie weiter unten näher erläutert. In jedem Fall liegt die Abmessung eines erfindungsgemäß eingesetzten optischen Elements jedoch deutlich oberhalb der Lichtwellenlänge, so dass

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Beugungs- und Interferenzeffekte vernachlässigt werden können. Insbesondere liegt die Abmessung der optischen Elemente daher vorteilhaft oberhalb von 2 µm, vorzugsweise sogar oberhalb von 5 µm.

[0061] Die Lichtflecken **32** des vorgegeben Motivs **30** können für den Betrachter **40** nicht nur oberhalb, sondern auch unterhalb der Oberfläche **22** des Substrats schweben. Mit Bezug auf Fig. 3 sind dazu in einem Flächenbereich des Substrats **22** eine Mehrzahl kleiner Wölbspiegel **26** angeordnet, deren Brennweiten so gewählt sind, dass die Wölbspiegel **26** bei Beleuchtung mit einer weit entfernten Lichtquelle **34** die vorgegebenen Bildpunkte als Lichtflecken **32** erzeugen. Genauer gesagt stellen die Lichtflecken **32** in diesem Fall virtuelle Bilder der Lichtquelle **34** dar, die für den Betrachter unterhalb der Oberfläche des Substrats zu schweben scheinen, wie im rechten Bildteil der Fig. 3 durch den geometrischen Strahlengang **38** angedeutet.

[0062] Hohl- und Wölbspiegel können auch beide im selben Sicherheitselement vorgesehen sein, wenn Teile des Motivs vorspringen, andere Teile hinter die Substratoberfläche zurücktreten sollen. Zur Illustration zeigt Fig. 4 ein vorgegebenes Motiv in Form einer dreidimensionalen Lichtpyramide **50** aus einer Mehrzahl von Lichtflecken **52**, die in verschiedenen Schwebehöhen über bzw. unterhalb der Oberfläche des Substrats **22** schweben.

[0063] Im Ausführungsbeispiel der Fig. 4 sind alle gewölbten Spiegel mit einem Durchmesser von 0,5 mm ausgeführt. Die Brennweite f wird bei Hohlspiegeln positiv angegeben (Schwebehöhe über der Substratoberfläche), bei Wölbspiegeln negativ (Schwebehöhe unter der Substratoberfläche). Mit dieser Konvention weist der Lichtfleck **52-1** der Pyramidespitze eine Schwebehöhe von f = +2 mm auf, während die Lichtflecke **52-2** und **52-3** der Pyramidenkanten in einer Höhe f = +1,2 mm bzw. f = +0,4 mm schweben. Die Lichtflecke **52-1** bis **52-3** mit ihren positiven Schwebehöhen werden durch Hohlspiegel erzeugt, wie grundsätzlich bereits bei Fig. 2 erläutert.

[0064] In der Pyramide **50** weiter nach außen gehend weisen die Lichtflecken **52-4** und **52-5** eine Schwebehöhe von f = –0,4 mm bzw. f = –1,2 mm auf, schweben für den Betrachter also unterhalb der Substratoberfläche **22**. Die Pyramidenbasis ist schließlich aus Lichtflecken **52-6** gebildet, die eine Schwebehöhe von f = –2 mm aufweisen und damit 4 mm unterhalb der Pyramidenspitze **52-1** liegen.

[0065] Für alle Lichtflecken **52** ist die Bedingung $|f|/d < 5$ erfüllt, so dass die Pyramide **50** für den Betrachter bei normalem Betrachtungsabstand echt dreidimensional erscheint und die Substratebene von unten nach oben zu durchstoßen scheint.

[0066] Die Schwebehöhe der Lichtflecken wird durch den Krümmungsradius der gewölbten Spiegel bestimmt, wie in **Fig.** 5(a) beispielhaft für einen Wölbspiegel **60** gezeigt. Bei einem Durchmesser d und einem Krümmungsradius r hat der Wölbspiegel **60** eine Brennweite von f = r/2. Beispielsweise ist bei einem Spiegeldurchmesser d = 0,5 mm für eine Brennweite bzw. Schwebehöhe von f = 2 mm ein Krümmungsradius von r = 4 mm erforderlich. Die Strukturhöhe des Wölbspiegels ergibt sich in diesem Fall über die Beziehung $h \cdot (2r - h) = (d/2)^2$ zu h = 7,8 µm.

[0067] Je nach gewünschter Schwebehöhe können dabei Spiegelstrukturen entstehen, deren Höhe h für eine gewünschte Anwendung zu groß ist, beispielsweise weil eine maximal zulässige Prägehöhe oder Prägetiefe in einer geprägten Schicht überschritten wird. In diesem Fall kann der Wölbspiegel **60** der **Fig.** 5(a) durch einen entsprechenden Fresnel-Spiegel **62** ersetzt werden, der eine wesentlich geringere Strukturhöhe h_f aufweist, wie in **Fig.** 5(b) gezeigt. Die Zonenbreiten z der Fresnel-Zonen **64** können dabei beliebig gewählt werden, solange sie groß gegen die Lichtwellenlänge sind, insbesondere solange z > 2 µm ist. Ansonsten spielt die Breite z der Fresnel-Zonen **64** für die optische Wirksamkeit des Fresnel-Spiegels **62** keine Rolle.

[0068] Haben die gewölbten Spiegel eines Sicherheitselements mehrere verschiedene Brennweiten, weisen die Lichtflecken des Lichtfleckenbilds also mehrere verschiedene Schwebehöhen oberhalb und/oder unterhalb der Substratoberfläche auf, so entsteht ein echt dreidimensionales Motiv. In manchen Gestaltungen kann es sich jedoch auch anbieten, alle gewölbten Spiegel mit derselben Brennweite auszubilden, so dass alle Lichtflecken des Lichtfleckenbilds dieselbe Schwebehöhe aufweisen. Auf diese Weise entstehe ein Kulissenmotiv, das in einer bestimmten Höhe oberhalb oder unterhalb der Substratoberfläche schwebt.

[0069] Die gewölbten Spiegel müssen nicht sphärisch gekrümmt sein. Als erfindungsgemäße optische Elemente können beispielsweise auch elliptische Hohl- oder Wölbspiegel eingesetzt werden, die in x- und y-Richtung eine unterschiedliche Spiegelkrümmung aufweisen. Da die Brennweite f eines gewölbten Spiegels nach

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dem oben Gesagten proportional zum Krümmungsradius r ist, verändert sich beim Drehen eines elliptisch gewölbten Spiegels die Schwebehöhe f des zugehörigen Lichtflecks für den Betrachter.

[0070] Enthält ein vorgegebenes Motiv zumindest teilweise elliptische Hohl- oder Wölbspiegel, so erheben sich die Lichtflecken in den Brennebenen der jeweiligen Partien beim Drehen der Anordnung vor dem Hintergrund bzw. senken sich in den Hintergrund ab. Dieser Effekt tritt besonders auffällig hervor, wenn die beim Drehen aufsteigenden bzw. absinkenden Lichtflecken mit sich bei Drehen nicht verändernden Lichtflecken kombiniert werden, die für das Auge einen ruhenden Bezugspunkt darstellen.

[0071] Mit Bezug auf die Aufsicht der **Fig.** 6(a) kann die Mehrzahl an gewölbten Spiegeln **70** beispielsweise mit rechteckiger oder quadratischer Grundfläche in einem Flächenbereich **72** des Sicherheitselements angeordnet sein.

[0072] Für einen dreidimensionalen Bildeindruck für einen Betrachter genügt bereits eine seitliche Parallaxe, also eine Parallaxe entlang der Verbindungslinie der beiden Augen **42** des Betrachters **40**. Die gewölbten Spiegel **74**, **76**, **78** können daher auch rinnenförmig ausgebildet sein, wie der Aufsicht der **Fig.** 6(b) gezeigt. Rinnenförmige gewölbte Spiegel weisen nur in einer Richtung, nämlich senkrecht zur Rinne, eine von Null verschiedene Krümmung auf, während die Krümmung in Rinnenrichtung verschwindet.

[0073] Mit einem aus rinnenförmigen gewölbten Spiegeln **74**, **76**, **78** aufgebauten Bild lassen sich ebenfalls attraktive visuelle Effekte verwirklichen. Die Lichtflecke erscheinen dabei bei geeignetem Betrachtungswinkel über oder unter der Substratoberfläche schwebend in Form von in der Luft hängenden leuchtenden Strichen.

[0074] Wegen der nebeneinander liegenden Augen ergibt sich bei einem 3D-Rinnenbild bei senkrecht zur Verbindungslinie der Augen **42** verlaufenden Rinnen **74** die stärkste räumliche Wirkung. Jedoch haben auch schräg verlaufende Rinnen **76** einen senkrechten Anteil und erzeugen damit ebenfalls ein Lichtfleckenbild mit dreidimensionaler Wirkung.

[0075] Wenn man ein Bild mit schräg in der Bildebene liegenden Rinnen **76** so dreht (**80**), dass die Rinnen senkrecht stehen, verstärkt sich die dreidimensionale Wirkung. Dreht der Betrachter die Rinnen **76** dagegen in die Waagrechte, so reduziert sich der dreidimensionale Eindruck. Bei einem Sicherheitselement, das wie in **Fig.** 6(b) gezeigt, Teilbereiche mit verschiedener Orientierung der Rinnen **74**, **76**, **78** enthält, erheben sich die Lichtflecken der jeweiligen Teilbereiche beim Drehen (**80**) der Anordnung vor dem Hintergrund bzw. senken sich in den Hintergrund ab.

[0076] Unter rinnenförmigen gewölbten Spiegeln sind dabei sowohl rinnenförmige Hohlspiegel als auch rinnenförmige Wölbspiegel zu verstehen. Rinnenförmige Hohlspiegel erzeugen Lichtflecke, die über der Substratoberfläche schweben, während rinnenförmige Wölbspiegel Lichtflecke erzeugen, die unterhalb der Substratoberfläche schweben.

[0077] Weiter müssen die rinnenförmigen gewölbten Spiegel nicht gradlinig verlaufen, wie in **Fig.** 6(b) gezeigt, sondern sie können auch krummlinig angelegt sein. Auch durch eine solche Gestaltung lassen sich attraktive visuelle Effekte verwirklichen.

[0078] Bei einer weiteren, in Fig. 7 illustrierten Erfindungsvariante sind die optischen Elemente anstelle von reflektierenden Spiegeln durch lichtbrechende (refraktive) Linsen gebildet. Das refraktive Sicherheitselement **90** stellt in diesem Fall ein Durchsichtssicherheitselement dar, das vom Betrachter **40** in Durchsicht gegen eine idealerweise weit entfernte Lichtquelle **95** auf Echtheit geprüft wird.

[0079] Als Linsen kommen sowohl Sammellinsen **92** als auch Zerstreuungslinsen **96** in Betracht, wobei, vom Betrachter **40** aus gesehen, die konvexen Sammellinsen **92** als reelle Bilder über dem Sicherheitselement **90** schwebende Lichtflecken **94** erzeugen, und die konkaven Zerstreuungslinsen **96** als virtuelle Bilder unterhalb des Sicherheitselements **90** schwebende Lichtflecken **98** erzeugen.

[0080] Die Linsen können insbesondere sphärisch, elliptisch oder zylindrisch sein. Zylinderlinsen ergeben strichartige Lichtflecke, bei elliptischen Linsen ändert sich die Schwebehöhe der Lichtflecken beim Drehen des Sicherheitselements, wie oben für elliptische Spiegel bereits beschrieben. Für die in Fig. 7 dargestellten plankonvexen bzw. plankonkaven Linsen **92**, **96** gilt für den Durchmesser d, den Krümmungsradius r, die Brennweite f und die Linsenhöhe h bei einem Brechungsindex des Linsenmaterials von n = 1,5 für an Luft grenzende Linsen:

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$f = 2 \cdot r$

und

$h \cdot (2r - h) = (d/2)^2$

[0081] Bei gegebenem Linsendurchmesser d und gegebener gewünschter Schwebehöhe f können damit der Krümmungsradius r und Strukturhöhe h der Linse bestimmt werden. Ist die Strukturhöhe einer Linse für eine gewünschte Anwendung zu groß, können die Linsen auch durch entsprechende Fresnellinsen ersetzt werden, wie im Zusammenhang mit Fig. 5 für Fresnel-Spiegel beschrieben. Auch hier ist darauf zu achten, dass die Zonenbreiten der Fresnel-Zonen groß gegen die Lichtwellenlänge sind, ansonsten aber beliebig gewählt werden können.

[0082] Bei den bisher beschriebenen Ausführungsbeispielen ist jedem Lichtfleck des Lichtfleckenbilds genau ein optisches Element zugeordnet, das bei Beleuchtung diesen Lichtfleck erzeugt, nämlich ein Hohlspiegel **24** (Fig. 2), ein Wölbspiegel **26** (Fig. 3), eine Sammellinse **92** oder eine Zerstreuungslinse **96** (Fig. 7). Die im Lichtfleckenbild erreichbare Auflösung, also der minimale Abstand zweier Lichtflecken im Lichtfleckenbild, ist bei einer solchen Gestaltung jedoch auf den Durchmesser d der gewölbten Spiegel oder Linsen beschränkt. Dieser Durchmesser ist wiederum über die oben genannte Bedingung für einen dreidimensionalen Bildeindruck $f/d < 5$ an die Schwebehöhe der Lichtflecken gekoppelt. Eine hohe Auflösung im Lichtfleckenbild ist somit nur für geringe Schwebehöhen und damit einer geringen dreidimensionalen Wirkung erreichbar.

[0083] Um dennoch eine höhere Auflösung im erzeugten Lichtfleckenbild bei unverändert großer Schwebehöhe zu erhalten, werden die in den bisherigen Ausführungsbeispielen verwendeten großen Spiegel oder Linsen jeweils durch eine Mehrzahl von kleineren Mikrospiegeln oder Mikroprismen ersetzt, die zusammen im Wesentlichen dieselbe optische Wirkung wie das ursprüngliche optische Element haben. Der einfacheren Benennung halber werden Mikrospiegel und Mikroprismen nachfolgend gemeinsam als Mikrooptikelemente bezeichnet.

[0084] Jedem Lichtfleck des Lichtfleckenbilds ist dann eine Mehrzahl von optischen Elementen in Form von Mikrooptikelementen zuordnet. Die höhere Auflösung im Lichtfleckenbild wird dabei dadurch erreicht, dass die Mikrooptikelemente nicht lückenlos nebeneinander, sondern im Abstand auf dem Flächenbereich verteilt werden. Die Zwischenräume der optischen Elemente eines Lichtflecks können dann mit optischen Elementen belegt werden, die anderen Lichtflecken zugeordnet sind. Auf diese Weise können mehrere Gruppen von Mikrooptikelementen, die jeweils verschiedenen Lichtflecken zugeordnet sind, im selben Flächenbereich ineinander verschachtelt angeordnet werden.

[0085] Der minimale Abstand zweier Lichtflecken im Lichtfleckenbild ist dann nicht mehr durch die Abmessung der ursprünglichen großen Spiegel oder Linsen gegeben, sondern durch die viel kleineren Abmessungen der Mikrooptikelemente, in die die ursprünglichen Spiegel oder Linsen zerlegt sind.

[0086] Zudem können bei der Zerlegung eines gewölbten Spiegels oder einer gekrümmten Linse in eine Mehrzahl von Mikrooptikelemente die im Prinzip zunächst ebenfalls gekrümmten Oberflächen der Mikrooptikelemente wegen ihrer geringen Größe in der Regel durch ebene Flächen ersetzt werden. Diese Ersetzung bleibt insbesondere wenn die Abmessungen der Mikrooptikelemente kleiner als das Auflösungsvermögen der Betrachtungssituation sind, ohne nachteilige Auswirkungen auf das erzeugte Lichtfleckbild. Als Vorteil ergibt sich, dass Mikrooptikelemente mit ebenen Oberflächen einfacher zu berechnen und herzustellen sind. Unter diesem Gesichtspunkt kann es sich sogar dann empfehlen, gewölbte Spiegel oder Linsen in kleine Mikrooptikelemente mit ebenen Oberflachen zu zerlegen, wenn keine Verschachtelung mehrerer Gruppen von Mikrooptikelementen gewünscht oder notwendig ist.

[0087] Zur Illustration zeigt Fig. 8 in (a) bis (d) vier Ausführungsbeispiele, bei denen ein gekrümmter Hohlspiegel in Mikrooptikelemente **100** mit quadratischer Grundfläche und ebener Spiegelfläche zerlegt ist. Bei dem Ausführungsbeispiel der **Fig.** 8(a) ist ein Hohlspiegel zur Erzeugung eines Lichtflecks durch eine Anordnung aus n × n Mikrospiegeln **100** ersetzt, die ohne Abstand in der Fläche des Sicherheitselements nebeneinander angeordnet sind. Die Mikrospiegeln **100** weisen beispielsweise eine Abmessung von 50 µm × 50 µm auf und können mit ebener Spiegelfläche ausgebildet werden, ohne die Abbildungsqualität zu beeinträchtigen. Die Anzahl n × n der Mikrospiegel beträgt beispielsweise 10 × 10, so dass die Mikrospiegel eine Gesamtfläche von 0, 5 mm × 0,5 mm einnehmen. Die Berechnung der Orientierung der ebenen Spiegelflächen ist weiter unten mit Bezug auf Fig. 10 erläutert. Wie für den Fachmann ersichtlich, ist die Berechnung und Herstellung der ebenen

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Mikrospiegel **100** wesentlich einfacher als die Berechnung und Herstellung eines gekrümmten Hohlspiegels gleicher optischer Wirkung.

[0088] Das Ausführungsbeispiel der **Fig.** 8(b) zeigt eine Gestaltung, bei der ein gekrümmter Hohlspiegel zunächst wie bei **Fig.** 8(a) durch eine Mehrzahl von Mikrospiegeln **102** mit ebener Spiegelfläche ersetzt ist. Die Mikrospiegel **102** sind allerdings schachbrettartig im Flächenbereich des Sicherheitselements angeordnet, so dass jede zweite Spiegelposition frei bleibt. Diese zunächst unbelegten und in der Figur weiß dargestellten Felder **104** können dann mit Mikrospiegeln belegt werden, die einem anderen Lichtfleck zugeordnet sind.

[0089] Die Auflösung des Lichtfleckenbilds kann durch eine solche Verschachtelung von Mikrospiegel-Gruppen deutlich erhöht werden: Sollen beispielsweise zwei Lichtflecken, die in 5 mm Höhe schweben, nur 0,2 mm nebeneinander liegen, so werden dazu gewölbte Spiegel oder Linsen mit einer Brennweite f = 5 mm benötigt. Wie oben beschrieben, müssen der Durchmesser und die Brennweite der optischen Elemente für eine dreidimensionale Wirkung der Bedingung f/d < 5 genügen, woraus sich bei den gemachten Vorgaben ein Optikdurchmesser d > 1 mm ergibt. Nebeneinander liegende gewölbte Spiegel oder Linsen müssten also mehr als 1 mm beabstandet sein, so dass sich die geforderte Auflösung von 0,2 mm auf diese Weise nicht erreichen lässt.

[0090] Wird dagegen eine Zerlegung wie in **Fig.** 8(b) verwendet, bei der nur jedes zweite Feld mit 50 µm × 50 µm großen Mikrospiegeln **102** zur Erzeugung des ersten Lichtflecks genutzt wird, können die dazwischen liegenden Felder **104** mit Mikrospiegeln belegt werden, die einen zweiten, 0,2 mm daneben liegenden Lichtfleck erzeugen. Die Bedingung f/d < 5 fordert einen Optikdurchmesser von mehr als 1 mm, was beispielsweise durch eine schachbrettartige Anordnung von 12 × 12 Mikrospiegeln **102** mit 12 × 12 freien Feldern **104** und damit d = 2·12·50 µm = 1,2 mm erreicht werden kann. Der minimale Abstand des von der Mikrospiegelgruppe **102** erzeugten Lichtflecks und des zweiten Lichtflecks, der von den in den Feldern **104** angeordneten Mikrospiegeln erzeugt wird, beträgt nunmehr 50 µm, so dass die geforderte Auflösung von 0,2 mm ohne weiteres erreicht werden kann.

[0091] Die Belegung einer schachbrettartigen Anordnung nach **Fig.** 8(b) mit Mikrospiegeln ist in Fig. 9 in einer Schnittdarstellung nochmals illustriert. Mit Bezug auf **Fig.** 9(a) wird jedes zweite Feld mit 50 µm × 50 µm großen Mikrospiegeln **102** zur Erzeugung des ersten Lichtflecks **110** belegt. Die Mikrospiegel **102** bilden eine Gruppe von Mikrospiegeln, die alle demselben Lichtfleck **110** zuordnet sind und diesen bei Beleuchtung gemeinsam erzeugen.

[0092] Die zwischen den Mikrospiegeln **102** liegenden Felder **104** stehen für die Belegung mit Mikrospiegeln, die anderen Lichtflecken zugeordnet sind, zur Verfügung. Im Extremfall können die Felder **104** mit Mikrospiegeln **106** belegt werden, die der Erzeugung eines Lichtflecks **112** dienen, der nur einen Mikrospiegeldurchmesser d_m, im Ausführungsbeispiel also 50 µm, von dem ersten Lichtfleck **110** entfernt ist, wie in **Fig.** 9(b) illustriert.

[0093] Wie aus Fig. 9 ersichtlich, ist der Optikdurchmesser d der Mikrospiegelgruppen **102**, **106** bei der alternierenden Spiegelanordnung durch $d = 2 \cdot n \cdot d_m$ gegeben, wobei n die Anzahl der Mikrospiegel einer Gruppe in einer Raumrichtung darstellt. Durch geeignete Wahl von n kann daher der Optikdurchmesser d trotz der hohen Auflösung d_m stets groß genug gemacht werden, um die Bedingung f/d < 5 zu erfüllen.

[0094] Zurückkommend auf die Darstellung der Fig. 8 versteht sich, dass die Belegung des Flächenbereichs des Sicherheitselements je nach der gewünschten Anzahl der zu verschachtelnden Gruppen von Mikrooptikelementen gewählt werden kann. Beispielsweise kann auch nur jedes vierte Feld mit Mikrospiegeln **102** belegt werden, die einem bestimmten Lichtfleck zugeordnet sind, wie in **Fig.** 8(c) illustriert. Die in der Figur weiß dargestellten, zunächst noch freien Felder **104** können dann mit Mikrospiegeln belegt werden, die bis zu drei anderen Lichtflecken zugeordnet sind. In einer weiteren Gestaltung ist jedes neunte Feld mit den einem bestimmten Lichtfleck zugeordneten Mikrospiegeln **102** belegt, wie in **Fig.** 8(d) gezeigt. Die in der Figur weiß dargestellten, zunächst noch freien Felder **104** können dann mit Mikrospiegeln belegt werden, die bis zu acht anderen Lichtflecken zugeordnet sind.

[0095] Die Berechnung der ebenen Spiegelflächen der Mikrospiegel ist in Fig. 10 veranschaulicht. Gezeigt sind im Querschnitt einige der Mikrospiegel **102** und der dazwischen liegenden, freien Felder **104** einer Gestaltung nach den **Fig.** 8(b) und **Fig.** 9(a).

[0096] Für die Berechnung bezeichnet (x_0, y_0, z_0) die Position des zu erzeugenden Lichtflecks **110** mit $z_0 > 0$, (x, y, 0) die Position des zu berechnenden Spiegelelements. $\vec{n}$ ist der Normalenvektor des Spiegels an

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der Position (x, y, 0), $\vec{k}$ der Richtungsvektor des einfallenden Lichtstrahls und $\vec{p}$ der Richtungsvektor des reflektierten Lichtstrahls.

[0097] Zu bestimmten ist jeweils die Lage des Spiegelflächen, also der Normalenvektor $\vec{n}$ so, dass das aus einer vorgegebenen Richtung $\vec{k}$ einfallende Licht für alle dem Lichtfleck **110** zugeordneten Mikrospiegel **102** auf den Brennpunkt (x_0, y_0, z_0) reflektiert wird. Dies gelingt erfindungsgemäß durch

$$\vec{n} = \frac{\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}}{\left|\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}\right|} \quad , \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 \end{pmatrix} \quad , \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + {z_0}^2}$$

[0098] Befindet sich die Lichtquelle **120** an der Position (x_L, y_L, z_L), so ist

$$\frac{\vec{k}}{|\vec{k}|} = \frac{\begin{pmatrix} x_L - x \\ y_L - y \\ z_L \end{pmatrix}}{\sqrt{(x_L - x)^2 + (y_L - y)^2 + {z_L}^2}}$$

[0099] Wird die Mikrospiegelgruppe **102** auf senkrechten Lichteinfall ausgelegt, so ist

$$\frac{\vec{k}}{|\vec{k}|} = \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix} \quad ,$$

so dass sich der Normalenvektor $\vec{n}$ zu

$$\vec{n} = \frac{\frac{\vec{p}_n}{|\vec{p}_n|} - \frac{\vec{k}}{|\vec{k}|}}{\left|\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}\right|} = \frac{\begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 + \sqrt{\ } \end{pmatrix}}{\sqrt{(x_0 - x)^2 + (y_0 - y)^2 + (z_0 + \sqrt{\ })^2}} \quad ,$$

ergibt, wobei die Abkürzung

$$\sqrt{\ } = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + {z_0}^2}$$

verwendet wurde.

[0100] In analoger Weise kann der Normalenvektor $\vec{n}$ für Mikrospiegel berechnet werden, deren Brennpunkt (x_0, y_0, z_0) mit $z_0 < 0$ unterhalb der Ebene des Sicherheitselements liegt. Dazu geht man erfindungsgemäß von der Beziehung

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$$\vec{n} = -\frac{\frac{\vec{p}}{|\vec{p}|} + \frac{\vec{k}}{|\vec{k}|}}{\left|\frac{\vec{p}}{|\vec{p}|} + \frac{\vec{k}}{|\vec{k}|}\right|}$$

aus, die weitere Berechnung erfolgt wie bei Hohlspiegeln.

[0101] Gekrümmte Linsen lassen sich bei der Zerlegung in Mikrooptikelemente durch kleine Mikroprismen nachstellen, die, wenn die Größe der Mikroprismen unterhalb des Auflösungsvermögens der Betrachtungssituation liegt, mit gleicher optischer Wirkung einsetzbar, aber einfacher zu berechnen und herzustellen sind.

[0102] In Fig. 11 sind zur Illustration bei einer schachbrettartigen Zerlegung wie in **Fig.** 8(b) einige Mikroprismen **122** im Querschnitt gezeigt. Analog zum Vorgehen bei den Mikrospiegeln **102** kann auch für die Mikroprismen **122** der Normalenvektor $\vec{n}$ so berechnet werden, dass das von der Lichtquelle **120** einfallende Licht jeweils zur gewünschten Position des Lichtflecks **110** gebrochen wird. Die in Fig. 11 freibleibenden Felder **124** können mit Mikroprismen belegt werden, die einem anderen Lichtfleck zugeordnet sind.

[0103] Bei allen beschriebenen Varianten könnten die refraktiven und/oder reflektiven optischen Elemente auch in ein Umgebungsmaterial einbettet bzw. mit einer Schutzschicht versehen sein. Durch eine solche Einbettung werden die optischen Elemente einerseits vor Verschmutzung und Abrieb geschützt und anderseits wird eine unbefugte Nachstellung durch Abprägen der Oberflächenstruktur wirksam verhindert.

[0104] Die Einbettung ist in Fig. 12 für ein Sicherheitselement **130** mit Mikrospiegeln **132** schematisch gezeigt. Durch die Einbettung der Mikrospiegel **132** in die transparente Schutzschicht **134** und den resultierenden Sprung des Brechungsindex an der Oberfläche **136** der Schutzschicht **134** ändert sich die Position der erzeugten Lichtflecke **140** gegenüber der Lichtfleckposition **142** bei einer nicht eingebetteten Mikrospiegelanordnung. Genauer gesagt, ändert sich bei einer Einbettung der Mikrospiegel **132** in eine Schutzschicht mit Brechungsindex n die Schwebehöhe eines von den Mikrospiegeln **132** erzeugten Lichtflecks **140** etwa um den Faktor 1/n. Übliche Schutzlackschichten **134** haben eine Brechzahl von etwa n = 1,5, so dass sich die Schwebehöhen der Lichtflecken gegenüber den für eine offene Anwendung berechneten Schwebehöhen um etwa 2/3 verringern. Diese Änderung wird selbstverständlich in der Regel bereits bei der Auslegung der Mikrospiegelanordnung berücksichtigt so dass nach der Einbettung die gewünschten Schwebehöhen erreicht werden.

[0105] Bei eingebetteten Prismen oder Linsen kann der Brechzahlunterschied zwischen Prismen- bzw. Linsenmaterial und Einbettungsmaterial bei der Berechnung der Lichtstrahlablenkung entsprechend berücksichtigt werden.

[0106] Um ein visuell ansprechendes dreidimensionales Lichtfleckenbild zu erzeugen, sollen die Lichtflecken unterschiedliche Helligkeiten aufweisen können. Derartige unterschiedliche Helligkeiten von Lichtflecken können im Rahmen der Erfindung auf verschiedene Arten erzeugt werden. Beispielsweise können dazu die optischen Elemente, die einem Lichtfleck zugeordnet sind, je nach dem gewünschten Bruchteil der Maximalhelligkeit abgedunkelt werden.

[0107] Gegenwärtig ist allerdings bevorzugt, die Helligkeit eines Lichtflecks nach Zerlegung in Mikrooptikelemente über den Flächenanteil, der mit Mikrooptikelementen belegt ist, oder über die Anzahl der Felder, die pro Raumwinkel für einen Lichtfleck zuständig sind, einzustellen. Dadurch ergeben sich Bildbereiche, die keine auf einen Lichtfleck gerichteten Spiegel oder Prismen enthalten und die dunkel gehalten werden müssen.

[0108] Derartige Bildbereiche können beispielsweise auf eine der folgenden Arten erzeugt werden. Bei einer ersten Variante werden die dunkleren Partien im spiegelnden Lichtfleckenbild mit Lichtfallen versehen, etwa mit Subwellenlängenstrukturen, wie etwa Mottenaugenstrukturen, oder mit trichterförmigen, reflektierenden Strukturen mit steilen Flanken, bei denen einfallendes Licht wenig oder gar nicht zurück reflektiert wird. Wegen der steilen Flanken sind derartige Lichtfallen allerdings nicht einfach herzustellen. Daher bietet es sich an, die dunklen Partien im spiegelnden Lichtfleckenbild mit Spiegeln auszustatten, die so orientiert sind, dass sich darin Raumbereiche spiegeln, die keine Lichtquellen enthalten. Die Spiegel können dazu beispielsweise auf den Körper des Betrachters gerichtet sein.

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[0109] Bei Durchsichtssicherheitselementen werden die dunklen Partien vorzugsweise mit Prismen ausgestattet, die Lichtstrahlen aus Richtungen zum Auge des Betrachters lenken, in denen sich keine Lichtquellen befinden, beispielsweise vom Fußboden.

[0110] Der Flächenbereich, in dem die optischen Elemente angeordnet sind, muss nicht eben, sondern kann in beliebiger Weise gekrümmt sein. Dies gelingt besonders einfach, wenn die optischen Elemente durch kleine Mikrooptikelemente gebildet sind. Da ohnehin für jedes Mikrooptikelement ein Normalenvektor berechnet wird (Fig. 10, Fig. 11), kann die lokale Position und Orientierung der Oberfläche des Sicherheitselements ohne großen Zusatzaufwand berücksichtigt werden, wie nachfolgend am Beispiel einer Mikrospiegelanordnung erläutert:
Bezeichnet wie oben (x_0, y_0, z_0) die Position des gewünschten Lichtflecks, (x, y, z) die Position eines Mikrospiegels im Raum, wobei diese Position die gekrümmte Oberfläche des Sicherheitselements beinhaltet, bezeichnet weiter $\vec{n}$ den Normalenvektor des Mikrospiegels an der Position (x, y, z), $\vec{k}$ den Richtungsvektor des einfallenden Lichtstrahls und $\vec{p}$ den Richtungsvektor vom Mikrospiegel zum Lichtfleck, so ist erfindungsgemäß

$$\vec{n} = \pm \frac{\frac{\vec{p}}{|\vec{p}|} \mp \frac{\vec{k}}{|\vec{k}|}}{\left| \frac{\vec{p}}{|\vec{p}|} \mp \frac{\vec{k}}{|\vec{k}|} \right|} \quad , \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 - z \end{pmatrix} \quad , \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + (z_0 - z)^2}$$

wobei das obere Vorzeichen für $z_0 > 0$, also ein über der Substratebene schwebendes, reelles Bild, und das untere Vorzeichen für $z_0 < 0$, also ein unterhalb der Substratebene schwebendes, virtuelles Bild gilt.

[0111] Bei einer Weiterbildung der Erfindung kann das Sicherheitselement bei Beleuchtung auch ein Lichtflecken-Wechselbild erzeugen, bei dem für den Betrachter aus unterschiedlichen Richtungen unterschiedliche Bilder sichtbar werden. Dazu kann beispielsweise für ein spiegelndes Sicherheitselement wie folgt vorgegangen werden, die Vorgehensweise für ein Durchsichtssicherheitselement ist analog:
Das Sicherheitselement soll bei seitlichem Kippen einen Bildwechsel von einem Lichtfleckenbild A zu einem Lichtfleckenbild B zeigen. Zunächst werden für beide Lichtfleckenbilder die benötigten optischen Elemente bestimmt, die die Lichtfleckenbilder bei Beleuchtung erzeugen. Dabei wird, wie im Zusammenhang mit den Fig. 8 bis Fig. 10 beschrieben, jedem Lichtfleck eine Mehrzahl von optischen Elementen, hier einer Mehrzahl von Mikrospiegeln zuordnet.

[0112] Bei der Anordnung der Mikrospiegel im Flächenbereich des Sicherheitselements werden dann für das Lichtfleckenbild A diejenigen Mikrospiegel weggelassen, bei denen die x-Komponente n_x des Normalenvektors größer als Null ist. Dadurch wird die Hälfte der Spiegelplätze frei und das Bild ist nur in einem eingeschränkten Winkelbereich sichtbar.

[0113] Für das Lichtfleckenbild B werden diejenigen Mikrospiegel weggelassen, bei denen die x-Komponente n_x des Normalenvektors kleiner als Null ist. Mit dieser reduzierten Spiegelanordnung werden die freigewordenen Spiegelplätze des Lichtfleckenbilds A belegt. Beim seitlichen Kippen der Anordnung wird dann abwechselnd das Lichtfleckenbild A und das Lichtfleckenbild B sichtbar.

[0114] Das Sicherheitselement kann auch auf vertikales Kippen ausgelegt werden, beispielsweise indem für das Lichtfleckenbild A diejenigen Mikrospiegel weggelassen werden, bei denen die y-Komponente des Normalenvektors n_y größer als Null ist, und für das Lichtfleckenbild B die Mikrospiegel, für die $n_y < 0$ ist. Die reduzierten Spiegelanordnungen mit ihrem eingeschränkten Sichtbarkeitsbereich werden dann auf dem Flächenbereich des Sicherheitselements gemischt.

[0115] Anstelle der genannten Bedingungen können selbstverständlich auch andere Kriterien zur Trennung der Lichtfleckenbilder eines Wechselbilds verwendet werden. Beispielsweise können durch die Bedingungen

$n_y > c_1$ für Bild A, $c_1 < n_y < c_2$ für Bild B, $n_y < c_2$ für Bild C

mit zwei Zahlenwerten $c_1 < c_2$ drei Lichtfleckenbilder A, B, C beim vertikalen Kippen wechseln. Durch die Wahl der Zahlenwerte c_1 und c_2 kann die Größer der Sichtbarkeitsbereiche nach Wunsch eingestellt werden.

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[0116] Neben dem Wechsel zwischen mehreren 3D-Lichtfleckenbildern kommt auch ein Wechsel zwischen einem oder mehreren 3D-Lichtfleckenbildern und einem oder mehreren auf andere Weise erzeugten Bildern in Frage.

[0117] Es kann sich auch empfehlen, in dem Lichtfleckenbild ein dreidimensionales Motiv mit einem zweidimensionalen Motiv zu kombinieren, bei dem alle Bildpunkte in derselben Höhe, vorzugsweise in Höhe der Ebene des Sicherheitselements oder nach der Ebene des Sicherheitselements liegen. Solche zweidimensionalen Lichtfleckenmotive lassen sich nämlich auch bei schlechteren Beleuchtungsbedingungen noch gut erkennen. Wird beispielsweise ein zweidimensionales Vordergrund-Motiv mit einem dreidimensionalen Hintergrund-Motiv kombiniert, so verschwindet das Lichtfleckenbild auch bei schlechten Lichtverhältnissen nicht vollständig, sondern wird lediglich auf das robustere zweidimensionale Vordergrundmotiv reduziert. Eine Echtheitsprüfung ist daher auch bei schlechten Lichtverhältnissen noch möglich.

[0118] Ein Lichtfleckenbild kann also neben schwebenden 3D-Lichtflecken, die aus bestimmten Blickwinkeln sichtbar sind, auch 2-dimensional erscheinende Bereiche enthalten, die aus den gleichen oder anderen Blickwinkeln sichtbar sind. Die 2D- und 3D-Partien können also nebeneinander liegen und/oder bei Änderung der Betrachtungsrichtung wechselweise am gleichen Ort erscheinen.

[0119] Bei 2D-3D-Bildern hat man neben 3-dimensional wirkenden Partien (die vor oder hinter der Ebene des Sicherheitselements zu sehen sind oder die Ebene des Sicherheitselements zu durchdringen scheinen) auch 2-dimensional wirkende Partien in Höhe der Ebene des Sicherheitselements oder nahe der Ebene des Sicherheitselements (in der Höhenstufe 0 oder nahe der Höhenstufe 0).

[0120] Für einen Bereich in der Höhe Null kann man ausgehen von der Spiegel- oder Prismenbelegung, die für Lichtpunkte in geringer Höhe (z. B. die Höhe 0,5 mm) mit dem gewünschten Blickwinkelbereich berechnet wird. Hier sind alle Normalenvektoren enthalten, die den avisierten Raumwinkel bedienen. Während für schwebende Lichtpunkte die Mikrospiegel oder Mikroprismen in der Ebene des Sicherheitselements so sortiert sind, dass bestimmte Punkte im Raum bedient werden, müssen die so berechneten Mikrospiegel einschließlich ihrer Neigung in dem für die Höhe 0 vorgesehenen Bereich statistisch verteilt werden. Dann werden keine bestimmten Punkte im Raum beleuchtet, sondern wie erwünscht ein Raumwinkel bedient. Für kleinere Intensität ist diese statistisch gemischt belegte Fläche entsprechend lückenhaft zu gestalten, indem z. B. nicht alle Pixel belegt werden oder die Pixel nicht voll belegt werden.

[0121] Nach einer anderen Weiterbildung weist das Lichtfleckenbild zusätzlich zu der offen sichtbaren Bildinformation noch eine versteckte Bildinformation (Hidden Image) auf. Dazu werden die optischen Elemente der offenen Bildinformation beabstandet angeordnet und die Lücken zumindest teilweise mit optischen Elementen der versteckten Bildinformation belegt.

[0122] Eine versteckte Bildinformation kann beispielsweise erzeugt werden, indem den zugehörigen Lichtflecken sehr kleine Öffnungswinkel zugeordnet werden, etwa ein Öffnungswinkel = 0 für Parallellicht.

[0123] Den Lichtflecken der versteckten Bildinformation können auch unterschiedliche Richtungen zugeordnet werden, die so weit auseinander liegen, dass beim Betrachten ohne Hilfsmittel kein zusammenhängendes Bild erfasst wird. Zur Echtheitsprüfung kann das Bild auf einer Mattscheibe aufgefangen werden. Die Richtungen der versteckten Bildinformation liegen vorzugsweise außerhalb der Richtungen, unter denen das offene 3D-Lichtfleckenbild betrachtet wird, so das Vorliegen einer versteckten Information nicht ohne weiteres erkennbar ist.

[0124] In einer vorteilhaften Ausgestaltung werden die optischen Elemente der versteckten Bildinformation teilweise oder vollständig in eng benachbarten Teilbereichen des Sicherheitselements untergebracht und gegebenenfalls mehrfach über die Fläche des Sicherheitselements wiederholt. Die versteckte Bildinformation kann dann durch Beleuchtung mit einem schmalen Laserstrahl sukzessive oder als Ganzes erfasst und auf einen geeignet platzierten Schirm projiziert werden.

[0125] Nachfolgend wird eine besonders bevorzugte Vorgehensweise beim Herstellen eines allgemeinen dreidimensionalen Lichtfleckenbilds genauer beschrieben.

[0126] Zunächst wird ein gewünschtes dreidimensionales Motiv mit Bildpunkten Pj und Höhenwerten Zj über der xy-Ebene definiert, wobei die Bildpunkte den bei Beleuchtung entstehenden Lichtflecken entsprechen. Für einen normalen Betrachtungsabstand von etwa 30 cm sollen die Bildpunktabstände dabei im Bereich von 0,1

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bis 0,5 mm liegen. Weiter wird den Bildpunkten P_j eine Helligkeit I_j zwischen 0% und 100% zugeordnet. Dann werden den Bildpunkten Öffnungskegel zugeordnet, die ein Öffnungsverhältnis > 0,2 aufweisen, beispielsweise ein Öffnungsverhältnis von 0,4. Für jeden Bildpunkt Pj definiert der Schnitt des von dem Bildpunkt ausgehenden Öffnungskegels mit der xy-Ebene dort einen Einzugsbereich Ej zu dem Bildpunkt Pj.

[0127] Die xy-Ebene selbst wird in erste, größere Felder, beispielsweise einer Abmessung von 0,1 mm × 0, 1 mm aufgeteilt. Jedes der größeren Felder wird weiter in zweite, kleinere Felder, beispielsweise einer Größe von 10 µm × 10 µm aufgeteilt. Die größeren Felder werden nachfolgend als Grobfelder, die kleiner Felder als Feinfelder bezeichnet.

[0128] Im Einzugsbereich E_j jedes Bildpunkts P_j werden nun soviele Feinfelder für diesen Bildpunkt reserviert, wie auf Grundlage des Höhenwerts Z_j und des Helligkeitswerts I_j bestimmt werden. Beispielsweise kann die Feinfelderanzahl proportional zum Helligkeitswert und umgekehrt proportional zu $(Zj)^{\alpha}$ mit einem Exponenten α 1 gewählt werden, der bei durch rinnenförmige Spiegel oder Zylinderlinsen gebildeten Lichtflecken $\alpha = 1$ und bei durch zweidimensional fokussierende Linsen oder Spiegel gebildeten Lichtflecken $\alpha = 2$ beträgt. Die für den Bildpunkt P_j reservierten Feinfelder werden dann im Wesentlichen gleichmäßig auf die Grobfelder im Einzugsbereich E_j des Bildpunkts P_j verteilt.

[0129] In die Anzahl der Feinfelder pro Grobfeld kann dabei auch ein Korrekturfaktor einfließen, der beispielsweise wie folgt bestimmt wird: Zunächst wird ohne Korrektfaktor innerhalb jedes Grobfelds die Anzahl der zu belegenden Feinfelder, die zu unterschiedlichen Bildpunkten P_j gehören, addiert. Dadurch ergibt sich ein Belegungsvorschlag für die Anzahl der insgesamt belegten Feinfelder in jedem Grobfeld.

[0130] Ist die Anzahl der belegten Feinfelder für alle Grobfelder geringer als die maximal mögliche Anzahl, so kann ein Korrekturfaktor größer 1 gewählt werden, und die Belegung mit diesem Korrekturfaktor multipliziert werden, so dass die maximale Belegung in einigen Grobfeldern erreicht wird. Übersteigt andererseits die Anzahl der belegten Feinfelder die Maximalbelegung, so wird entsprechend ein Korrekturfaktor kleiner 1 gewählt, der nach Multiplikation zu einer Belegung kleiner oder gleich der Maximalbelegung führt. Wenn die Maximalbelegung in nur wenigen Grobfeldern überschritten wird, können statt einer gleichmäßigen Reduktion auch nur die höchsten Intensitäten auf die Maximalbelegung gekappt werden oder die Feinfelder der überschreitenden Grobfelder werden in angrenzende Grobfelder verschoben.

[0131] Die so erhaltene Belegung kann nun im Flächenbereich des Sicherheitselements realisiert werden. In den belegten Feinfeldern werden Spiegel oder Prismen angeordnet, die das einfallende Licht auf den entsprechenden Lichtfleck spiegeln bzw. brechen. In dabei freibleibenden Flächenbereichen des Sicherheitselements können zusätzliche Sicherheitselemente eingebracht werden, beispielsweise kann dort ein Hidden Image der oben beschriebenen Art untergebracht werden.

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Patentansprüche

1. Darstellungselement mit einem Substrat mit einem Flächenbereich, in dem eine Mehrzahl optischer Elemente angeordnet ist, **dadurch gekennzeichnet**, dass das Darstellungselement ausgelegt und bestimmt ist, bei Beleuchtung ein Lichtfleckenbild aus einer Mehrzahl von Lichtflecken zu erzeugen, die für einen Betrachter oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind, wobei die optischen Elemente durch refraktive und/oder reflektive optische Elemente gebildet sind und jedem Lichtfleck des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element zugeordnet ist, welches bei Beleuchtung des Darstellungselements zur Erzeugung des ihm zugeordneten Lichtflecks beiträgt.

2. Darstellungselement nach Anspruch 1, dadurch gekennzeichnet, dass für die Lichtflecke und die zugeordneten optischen Elemente jeweils $f/d < 5$ gilt, wobei f die Schwebehöhe des Lichtflecks oberhalb oder unterhalb des Flächenbereichs bezeichnet und d den Durchmesser der zu diesem Lichtfleck beitragenden optischen Elemente.

3. Darstellungselement nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass die Lichtflecken des Lichtfleckenbilds in mehreren verschiedenen Schwebehöhen oberhalb oder unterhalb des Flächenbereichs schweben, um ein dreidimensionales Motiv zu bilden.

4. Darstellungselement nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass die Lichtflecken des Lichtfleckenbilds bereichsweise alle in derselben Schwebehöhe oberhalb oder unterhalb des Flächenbereichs schweben, um ein Kulissenmotiv zu bilden.

5. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass die optischen Elemente gewölbte Spiegel umfassen, insbesondere Hohlspiegel oder Wölbspiegel.

6. Darstellungselement nach Anspruch 5, dadurch gekennzeichnet, dass die gewölbten Spiegel sphärisch, elliptisch, rotationssymmetrisch asphärisch, nichtrotationssymmetrisch asphärisch oder rinnenförmig ausgebildet sind, wobei im letzteren Fall die Rinnen geradlinig oder krummlinig verlaufen.

7. Darstellungselement nach Anspruch 5 oder 6, dadurch gekennzeichnet, dass die gewölbten Spiegel zumindest teilweise durch Fresnelspiegel gebildet sind.

8. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, dass die optischen Elemente Linsen umfassen, insbesondere sphärische, elliptische, rotationssymmetrisch asphärische, nichtrotationssymmetrisch asphärische oder zylindrische Linsen.

9. Darstellungselement nach Anspruch 8, dadurch gekennzeichnet, dass die Linsen zumindest teilweise durch Fresnellinsen gebildet sind.

10. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, dass jedem Lichtfleck des Lichtfleckenbilds genau ein optisches Element zugeordnet ist.

11. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, dass jedem Lichtfleck des Lichtfleckenbilds eine Mehrzahl von optischen Elementen zuordnet ist, vorzugsweise, dass die optischen Elemente beabstandet auf dem Flächenbereich verteilt sind.

12. Darstellungselement nach Anspruch 11, dadurch gekennzeichnet, dass die Lichtflecke des Lichtfleckenbilds unterschiedliche Helligkeiten aufweisen und jedem Lichtfleck eine solche Anzahl von optischen Elementen zuordnet ist, die der Helligkeit des Lichtflecks innerhalb des von den Lichtflecken gebildeten Motivs entspricht, oder jedem Lichtfleck eine solche Gesamtfläche von optischen Elementen zuordnet ist, die der Helligkeit des Lichtflecks innerhalb des von den Lichtflecken gebildeten Motivs entspricht.

13. Darstellungselement nach Anspruch 11 oder 12, dadurch gekennzeichnet, dass optische Elemente, die verschiedenen Lichtflecken zugeordnet sind, in dem Flächenbereich ineinander verschachtelt angeordnet sind.

14. Darstellungselement nach wenigstens einem der Ansprüche 11 bis 13, dadurch gekennzeichnet, dass die optischen Elemente durch ebene Mikrospiegel oder durch kleine Mikroprismen gebildet sind.

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15. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 14, dadurch gekennzeichnet, dass das vorbestimmte Motiv ein Wechselbild ist, das aus unterschiedlichen Betrachtungsrichtungen unterschiedliche Bilder zeigt.

16. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 15, dadurch gekennzeichnet, dass der Flächenbereich, in dem die Mehrzahl optischer Elemente angeordnet ist, gekrümmt ist.

17. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 16, dadurch gekennzeichnet, dass eine Teilmenge der optischen Elemente eine versteckte Bildinformation erzeugt, die ohne Hilfsmittel nicht erkennbar ist.

18. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 17, dadurch gekennzeichnet, dass die optischen Elemente eine periodische Anordnung von Mikrospiegeln umfassen, die jeweils einen Abstand zum nächsten Nachbarn von 2 mm oder weniger aufweisen.

19. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 18, dadurch gekennzeichnet, dass die optischen Elemente in eine Umgebungsschicht oder einen Umgebungsschichtverbund, insbesondere in eine Schutzschicht eingebettet sind.

20. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 19, dadurch gekennzeichnet, dass die optischen Elemente als Prägestrukturen in einer Prägelackschicht ausgebildet sind.

21. Darstellungselement nach Anspruch 20, dadurch gekennzeichnet, dass die Prägestrukturen mit einer reflexionserhöhenden Beschichtung, insbesondere mit einer Metallisierung, einer hochbrechenden Beschichtung, einem Dünnschichtelement mit Farbkippeffekt oder einer cholesterischen Flüssigkristallschicht versehen sind.

22. Darstellungselement nach Anspruch 20 oder 21, dadurch gekennzeichnet, dass die Prägestrukturen Strukturhöhen von weniger als 100 µm, bevorzugt von weniger als 20 µm, besonders bevorzugt von weniger als 5 µm aufweisen.

23. Darstellungselement nach wenigstens einem der Ansprüche 1 bis 22, dadurch gekennzeichnet, dass das Darstellungselement ein Sicherheitselement für Sicherheitspapiere, Wertdokumente und andere abzusichernde Gegenstände ist, insbesondere ein Sicherheitsfaden, ein Sicherheitsband, ein Sicherheitsstreifen, ein Etikett oder ein Transferelement ist.

24. Verfahren zum Herstellen eines Darstellungselements nach einem der Ansprüche 1 bis 23, das ausgelegt und bestimmt ist, bei Beleuchtung ein Lichtfleckenbild aus einer Mehrzahl von Lichtflecken zu erzeugen, die für einen Betrachter oberhalb oder unterhalb des Flächenbereichs schwebend erscheinen und die in Form eines vorbestimmten Motivs angeordnet sind, wobei bei dem Verfahren ein Substrat bereitgestellt wird und in einem Flächenbereich des Substrats eine Mehrzahl refraktiver und/oder reflektiver optischer Elemente angeordnet wird, wobei jedem Lichtfleck des Lichtfleckenbilds zumindest ein refraktives und/oder reflektives optisches Element zugeordnet wird, welches bei Beleuchtung des Darstellungselements zur Erzeugung des ihm zugeordneten Lichtflecks beiträgt.

25. Verfahren nach Anspruch 24, dadurch gekennzeichnet, dass
– ein gewünschtes dreidimensionales Motiv mit Bildpunkten Pj und Höhenwerten Zj über einer xy-Ebene vorgegeben wird, wobei die Bildpunkte den bei Beleuchtung entstehenden Lichtflecken entsprechen,
– für jeden Bildpunkt P_j eine Helligkeit I_j zwischen 0% und 100% festgelegt wird,
– den Bildpunkten P_j Öffnungskegel zugeordnet werden, die ein Öffnungsverhältnis > 0,2 aufweisen,
– für jeden Bildpunkt Pj durch einen Schnitt des von dem Bildpunkt ausgehenden Öffnungskegels mit der xy-Ebene ein Einzugsbereich Ej bestimmt wird,
– die xy-Ebene in eine Anzahl von Grobfeldern und die Grobfelder jeweils in eine Anzahl von Feinfeldern aufgeteilt wird,
– für jeden Bildpunkt P_j auf Grundlage des festgelegten Höhenwerts Z_j und des festgelegten Helligkeitswerts I_j eine Anzahl an zu füllenden Feinfeldern bestimmt werden,
– die für den Bildpunkt P_j bestimmten zu füllenden Feinfelder im Wesentlichen gleichmäßig auf die Grobfelder im Einzugsbereich E_j des Bildpunkts P_j verteilt werden, und

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– die zu füllenden Feinfelder mit refraktiven und/oder reflektiven optischen Elementen belegt werden, die bei Beleuchtung des Darstellungselements zur Erzeugung des dem Bildpunkt P_j entsprechenden Lichtflecks beitragen.

26. Datenträger mit einem Darstellungselement nach wenigstens einem der Ansprüche 1 bis 23.

27. Datenträger nach Anspruch 26, dadurch gekennzeichnet, dass das Darstellungselement ein zumindest teilweise durchsichtiges Sicherheitselement ist, das in oder über einem transparenten Fensterbereich oder einer durchgehenden Öffnung des Datenträgers angeordnet ist.

28. Datenträger nach Anspruch 26, dadurch gekennzeichnet, dass das Darstellungselement ein reflektierendes Sicherheitselement ist, das in einem opaken Bereich des Datenträgers angeordnet ist.

29. Datenträger nach wenigstens einem der Ansprüche 26 bis 28, dadurch gekennzeichnet, dass der Datenträger ein Wertdokument, wie eine Banknote, insbesondere eine Papierbanknote, eine Polymerbanknote, eine Folienverbundbanknote oder eine Urkunde, ein Pass oder eine Ausweiskarte ist.

30. Anzeigeeinrichtung mit einer Steuereinrichtung und einem Darstellungselement nach einem der Ansprüche 1 bis 23, wobei die räumliche Ausrichtung der optischen Elemente des Darstellungselements durch die Steuereinrichtung einstellbar ist.

Es folgen 6 Blatt Zeichnungen

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Anhängende Zeichnungen

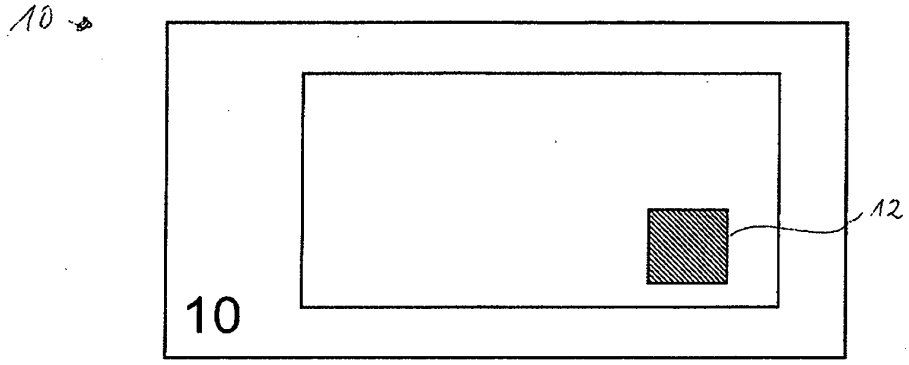


Fig. 1

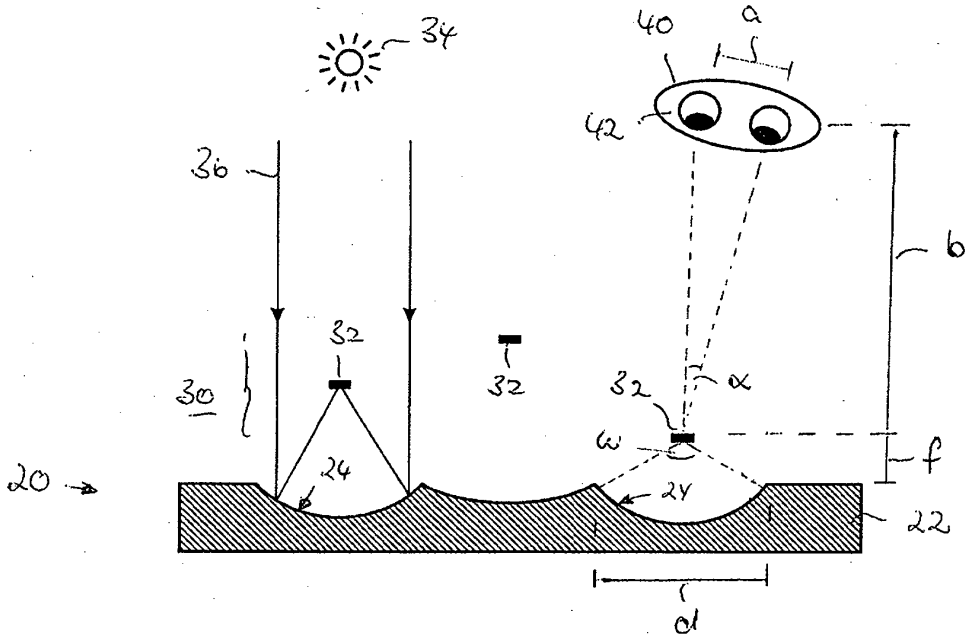


Fig. 2

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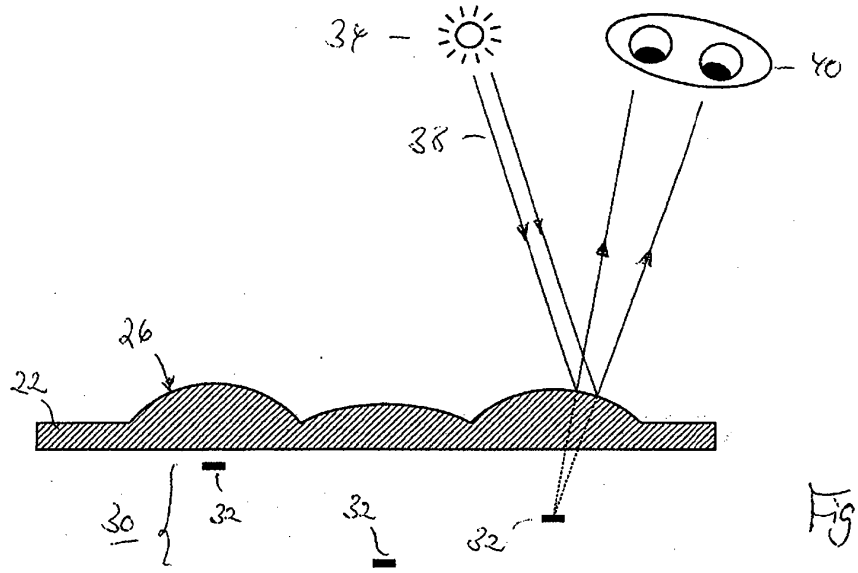


Fig 3

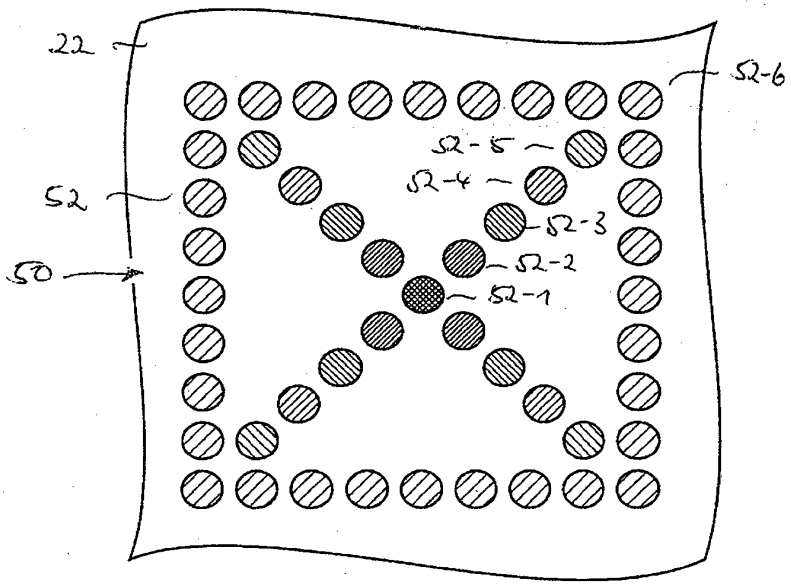


Fig 4

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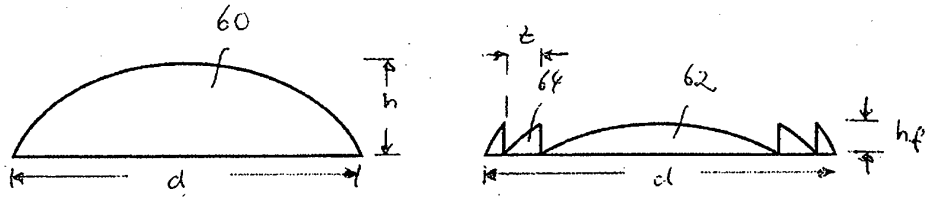


Fig. 5

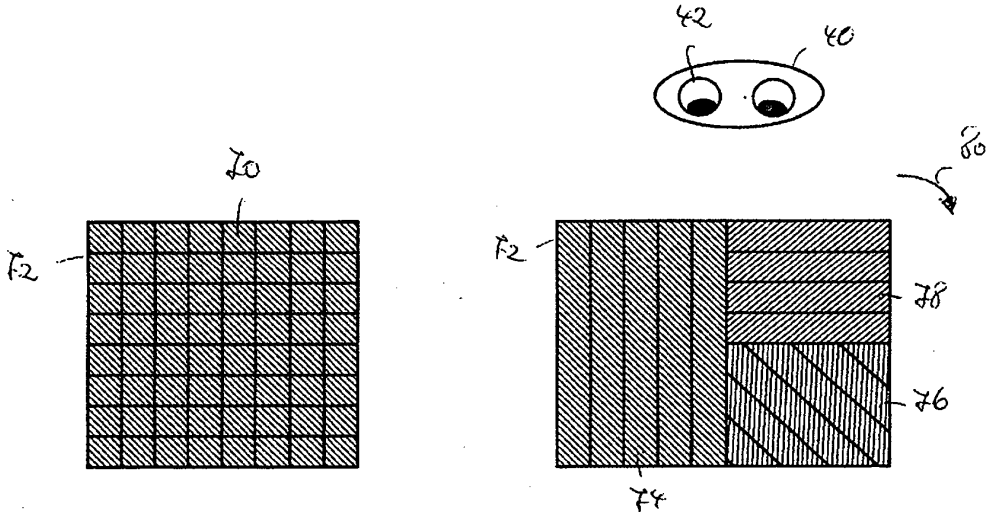


Fig 6

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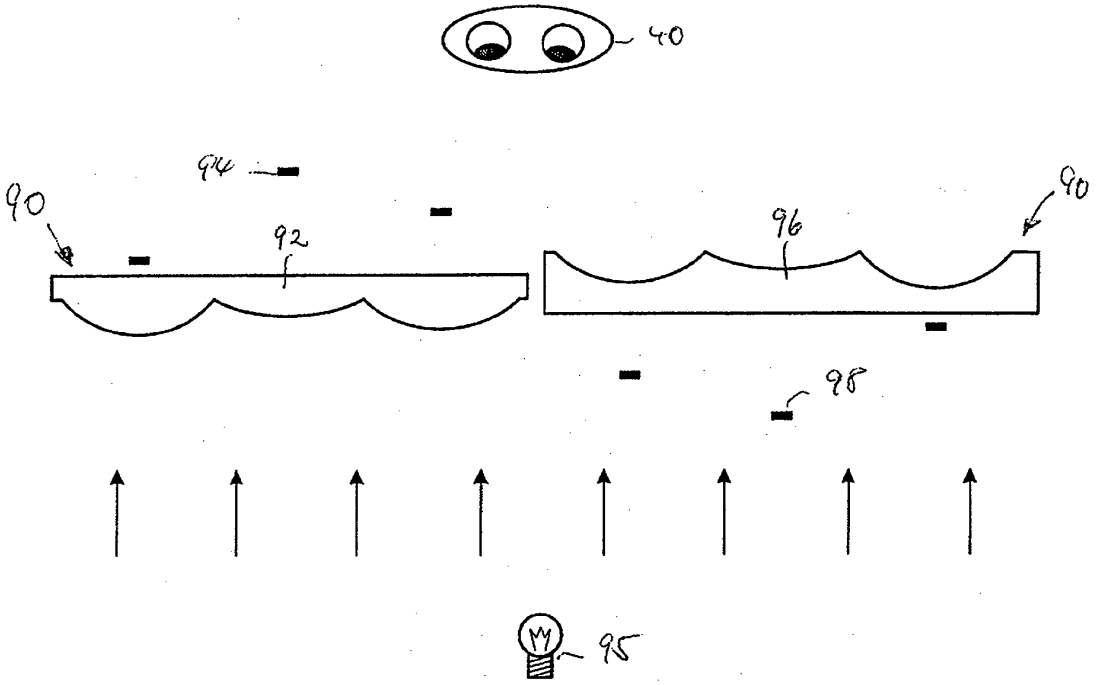


Fig. 7



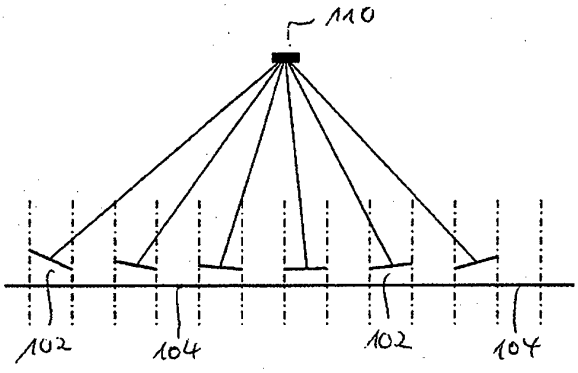
Fig. 8

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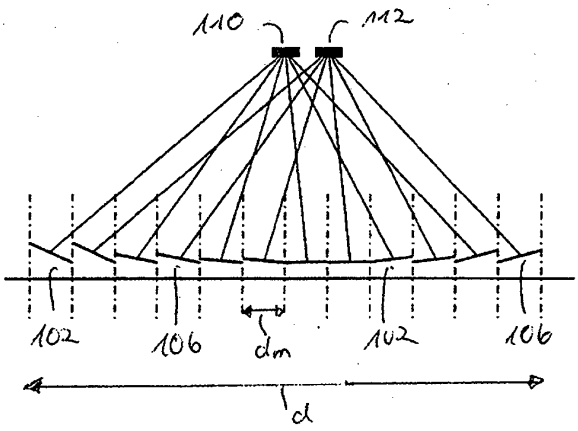


(c) (d)

Fig. 8



(a)



(b)

Fig. 9

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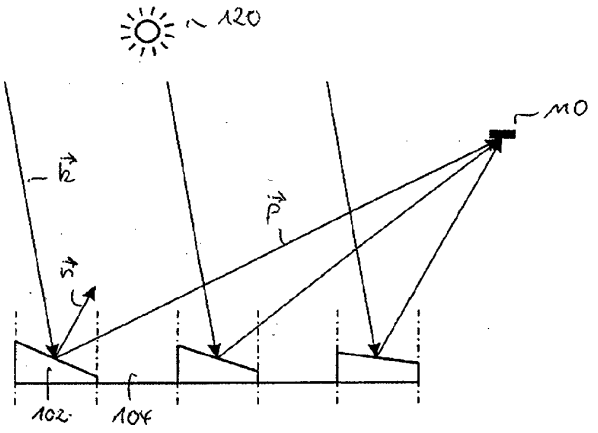


Fig. 10

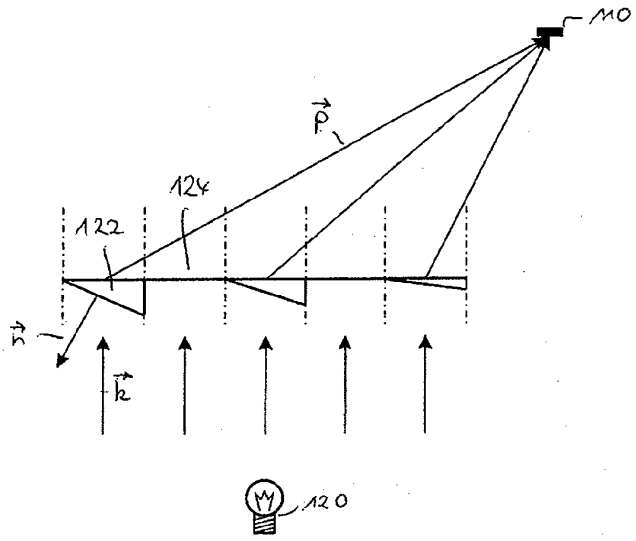


Fig 11

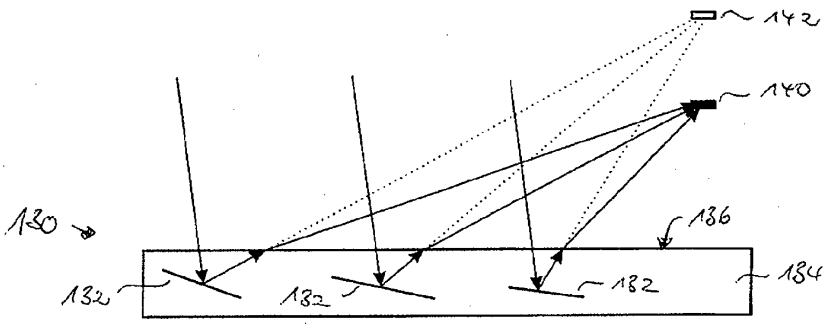


Fig 12

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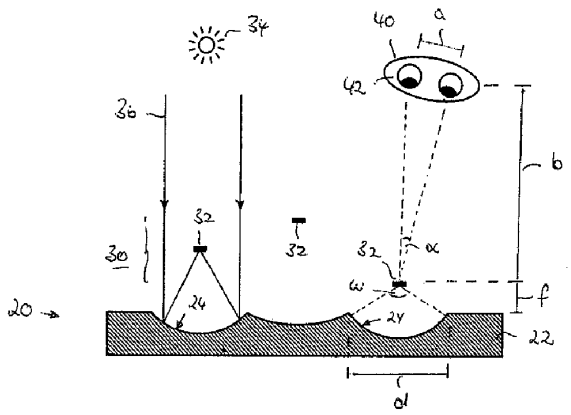
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ABSTRACT DE102010048262

The invention relates to a display element (20) having a substrate (22) with a surface area in which a plurality of optical elements (24) is arranged. According to the invention, the display element (20) is designed and determined to generate a light spot image (30) of a plurality of light spots (32) which appear to be floating above or below the area area for an observer (40) and which are in shape a predetermined motif are arranged, wherein the optical elements are formed by refractive and / or reflective optical elements (24) and each light spot (32) of the light spot image is associated with at least one refractive and / or reflective optical element (24) which when illuminated (34) of the display element (20) for generating its associated light spot (32) contributes.

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DESCRIPTION DE102010048262

[0001]
The invention relates to a display element having a substrate with a surface region in which a plurality of optical elements is arranged. The invention further relates to a method for producing such a presentation element and a data carrier with such a presentation element.

[0002]
Data carriers, such as valuables or identity documents, but also other valuables, such as branded articles, are often provided with security elements for the purpose of security, which permit verification of the authenticity of the data carrier and at the same time serve as protection against unauthorized reproduction.

[0003]
Particular attention is currently being given to security elements with three-dimensional images, since these are easily recognizable and testable on the one hand, even for the layman, and on the other hand, they can not be faithfully reproduced with conventional copying methods.

[0004]

Several techniques are known with which a three-dimensional image impression can be produced when viewing flat images in a two-eyed manner.

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In anaglyph images, about two stereoscopic fields are superimposed on each other.

When viewed with an aid such as red-green glasses or polarized glasses, the two fields are separated for the two eyes.

[0005]

Another technique uses lens or mirror raster images consisting of a multi-layer structure with motif layer and spaced from the motif layer lens or Mirror layer exist. An example of this technique are the 3D Moiré Magnifier, as described in WO 2009/000530 A2.

[0006]
Another approach, as described for example in the publication WO 90/08338 A1, is to form the motif as a flat relief, wherein the surface of the motif imitated and / or fragmented found in the surface of the image.

[0007]

Finally, for security elements holograms, holographic stereograms and hologram-like lattice images have long been used to produce a three-dimensional image impression.

In this technique, light diffraction and interference at the holographic structures and diffraction gratings play a crucial role.

[0008]

On this basis, the invention has the object to provide a display element of the type mentioned, which has an attractive visual appearance. For security applications, the display element should also have a high security against counterfeiting and, moreover, it should also be easy for non-professionals to check for authenticity.

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[0009]

This object is achieved by the presentation element having the features of the main claim. A method for producing such a presentation element, a data carrier equipped with such a presentation element and a display device equipped with such a presentation element are specified in the independent claims. Further developments of the invention are the subject of the dependent claims.

[0010]

According to the invention, a generic imaging element includes a substrate having a surface area in which a plurality of optical elements are arranged. The display element is designed and determined to generate a light spot image from a plurality of light spots when illuminated, which appear to be floating above or below the surface area for an observer and which are arranged in the form of a predetermined motif. For this purpose, the said optical elements are formed by refractive and / or reflective optical elements, wherein each light spot of the light spot image is associated with at least one refractive and / or reflective optical element, which contributes to the generation of its associated light spot when lighting the display element.

[0011]

The invention is thus based on the idea of specifying a three-dimensional motif consisting of light patches floating above or below the display element. In order to produce the spots of light when illuminated, the display element comprises adjacent or interleaved portions of mirrors, lenses or prisms adapted to produce in a picture space, with appropriate illumination, floating light reflections which together represent the predetermined three-dimensional motif. The floating light reflections are in the physical sense real images or virtual images of the illuminating light sources, as explained in more detail below. The visual impression is particularly good when the display element is illuminated with parallel light, for example, a far-away light source.

[0012]

The three-dimensional light spot image resulting from the illumination offers the viewer an unusual

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and visually appealing three-dimensional image impression, which gives the presentation element a high attention and recognition value. The presence or absence of the effect is easy for any user to determine, so the presentation element is easily verifiable. Nevertheless, the mirror or Due to the required know-how and the technology required for a potential counterfeiter, it is difficult to readjust the lens arrangement.

[0013]

Hereinafter, the refractive and / or reflective optical elements of the shorter designation are usually referred to only as "optical elements". However, it is understood that within the scope of the invention, refractive and / or reflective optical elements are always meant. The optical elements may be either purely refractive, such as a lens or microprism, purely reflective, such as a mirror or micromirror, or both refractive and reflective, such as a semi-transparent coated lens or a semi-transparent coating provided micro prism. In any case, diffraction and interference effects play no role in the refractive and / or reflective optical elements according to the invention and can always be neglected.

[0014]

In a preferred embodiment, the optical elements and the flying heights of the light spots are designed such that the conditions f / d <5 apply to the light spots and the associated optical elements, where f denotes the flying height of a light spot above or below the surface area and d Indicates the diameter of the contributing to this light spot optical elements. This ensures that the light spots are at normal viewing distance of about 30 cm for both eyes of the viewer within the opening of the associated optical element.

[0015]

According to an advantageous variant of the invention, the light spots of the light spot image float in a plurality of different flying heights above or below the surface area in order to form a three-dimensional motif. According to an alternative, likewise advantageous variant of the invention, the light spots of the light spot image float in regions, all in the same flying height above or below the surface area, in order to form a backdrop motif. Advantageously, in the light spot image, a three-dimensional motif can be combined with a two-dimensional motif, since then even in poor lighting conditions a light spot image can still be recognized and thus an authenticity check is possible.

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[0016]

The optical elements suitably include domed mirrors, in particular concave mirrors (concave domed mirrors) or dome mirrors (convex domed mirrors). The domed mirrors may be spherical, elliptical, rotationally symmetric aspherical, non-rotationally asymmetric aspherical or channel-shaped, in the latter case the grooves may be straight or curved. Elliptical mirrors have different mirror curvatures in the x and y directions, and in the case of aspherical mirrors, the mirror surface deviates from a spherical form. Aspherical mirrors may be rotationally symmetric or, in the most general case, non-rotationally symmetric. Straight line shaped mirrors may be considered as a special case of elliptical mirrors in which the radius of curvature is infinitely large in one spatial direction. In order to realize a low structural height, the curved mirrors may also be formed at least partially by Fresnel mirrors.

[0017]

Alternatively or additionally, the optical elements may also comprise lenses, in particular spherical, elliptical, rotationally symmetrical aspherical, non-rotationally symmetrical aspherical or cylindrical lenses. Elliptical lenses have different curvatures in the x and y directions, and in aspherical lenses, the refractive lens surface deviates from a spherical shape. Aspherical lenses may be rotationally symmetric or, in the most general case, non-rotationally symmetric. Cylindrical lenses can be considered as a special case of elliptical lenses in which the radius of curvature is infinitely large in one spatial direction. The lenses may also be formed at least partially by Fresnel lenses in order to arrive at a lower structural height.

[0018]
In an advantageous variant of the invention, each light spot of the light spot image is assigned exactly one optical element.

[0019]

According to an alternative, likewise advantageous variant of the invention, each light spot of the light spot image is assigned not only an optical element but a plurality of optical elements.

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Assignment means that the optical element contributes to the generation of this light spot when illuminated by reflection (reflection) and / or refraction of light. The optical elements are preferably distributed on the surface area at a distance. Due to the resulting spaces between the individual optical elements, a plurality of groups of optical elements, which are each assigned to different light spots, can then be arranged in one another in the same surface area. In this way, a particularly high spatial resolution in the light spot image can be achieved, as explained in more detail below.

[0020]
As a further advantage of assigning a plurality of optical elements to a light spot has been found that due to the then possible smaller dimensions of the individual optical elements elements with flat boundary surfaces can be used, which are easier to calculate and manufacture than a single curved, optical element same optical effect.

[0021]

In order to produce a light spot image in which the light spots have different brightnesses, advantageously each light spot of the light spot image is assigned a number of optical elements which corresponds to the brightness of the light spot within the motif formed by the light spots.

If the optical elements have different sizes, each light spot can also be assigned such a total area of optical elements that corresponds to the brightness of the light spot within the motif formed by the light spots.

[0022]
Particularly preferably, the optical elements are formed by planar micromirrors or by small microprisms.

[0023]

The predetermined motif may also be a change picture showing different pictures from different viewing directions.

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A concrete example of the generation of such a change image is described below. It is understood that the term "alternating pictures" also includes those pictures in which only picture parts are subject to change.

[0024]

In the case of change pictures, pictures or picture parts change when the viewing direction changes, in particular when the picture is tilted; which is why such pictures are also called tilt pictures. The change can be made when tilting horizontally or vertically, or when tilting in a direction that is between horizontal and vertical.

[0025]

If the change in the image content is abrupt, one speaks of flip pictures. If the change over intermediate stages one speaks of Morphing pictures.

[0026]

Furthermore, 2D-3D images can also be formed as a light spot image. In addition to 3-dimensional acting games (which can be seen in front of or behind the plane of the presentation element or seem to penetrate the plane of the presentation element), one also has 2-dimensional acting games in or near the plane of the presentation element (in altitude level 0 or near the height level 0)

[0027]

In a 2D 3D image, 2D and 3D games can be side by side and / or alternately appear in the same location as the viewing direction changes. In such a 2D-3D change picture z. B. a two-dimensional image content (z. As a font or logo) depending on the direction in a 3D image and hidden.

[0028]

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According to one embodiment of the invention, the area in which the plurality of optical elements is arranged may also be curved, for example cylindrically or spherically curved.

[0029]

In a further variant of the invention, a subset of the optical elements generates hidden image information which can not be recognized without auxiliary means.

The hidden image information is in contrast to the open image information formed by the above-described light spot image, which is visible to the naked eye under normal illumination without further aids. The hidden image information, however, is not readily visible to the naked eye in normal lighting, but is for example visible only in directional lighting with laser light or requires a special catching screen.

[0030]

In an advantageous variant of the invention, the optical elements comprise a periodic arrangement of micromirrors, each having a distance to the nearest neighbor of 2 mm or less, in particular of 1 mm or less. A viewer then no longer recognizes the mirror images of the mirrors, but sees only one light spot per mirror, the shape of which depends on the illumination of the surroundings. If the observer tilts the display element, then the points of light of the mirrors move slightly to the side, depending on the design of the mirror as a hollow or curvature mirror, as if the light points would lie before or preferably behind the plane of the display element. As a result of the periodic arrangement of the micromirrors, the observer thus sees a regular grid of light points which, when the display element is tilted, preferably appear to move as if they were located in a further backward plane. The light point grating can therefore form the background for a further motif, for example for the arching effect described in the co-pending German Patent Application DE 10 2009 056 934.0, or for a sawtooth representation with a kinematic effect, such as the hologram structures of the document EP 0 868 313 B1 (local paragraph [0034] or

Fig. 8 with reflective sawtooth structures).

[0031]

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In order to protect the optical elements on the one hand against contamination and abrasion and on the other hand to effectively prevent unauthorized readjustment by stamping the surface structure, the optical elements are advantageously embedded in an ambient layer or an ambient layer composite, in particular in a protective layer. Such an embedding usually changes the flying height of the light spots, since a refractive index difference between embedding material and air or Embedding material and lens material changed the optical path. However, such a change in the optical beam path can be taken into account in the design of the optical elements without further ado, so that after embedding the desired flying heights are realized.

[0032]

In an advantageous embodiment, the optical elements are formed as stamping structures in an embossing lacquer layer. If the display element is designed to be at least partially reflecting, then the embossed structures are preferably provided with a reflection-enhancing coating. As a reflection-enhancing coating is in particular a full-area or screened metallization, a high refractive index coating, a thin-film element with color shift effect or a cholesteric liquid crystal layer into consideration.

[0033]
The structural heights of the embossed structures are preferably below 100 .mu.m, preferably below 20 .mu.m, more preferably below 5 .mu.m.

[0034]

The presentation elements according to the invention can be combined with other security features, for example with diffractive structures, with hologram structures in all variants, metallized or non-metallized, with sub-wavelength structures, metallized or non-metallized, with subwavelength gratings, with layer systems which show a color change on tilting, semitransparent or opaque , with diffractive optical elements, with refractive optical elements, such as prism beam shapers, with special hole shapes, with safety features with specifically set electrical conductivity, with incorporated materials with magnetic coding, with substances with phosphorescent, fluorescent or luminescent effect, with safety features based on liquid crystals , with matt structures, with additional micromirror elements, with elements with louvre effect or with sawtooth structures.

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Further security features with which the presentation elements according to the invention can be combined are given in the document WO 2005/052650 A2 on pages 71 to 73; These are included in the present description.

[0035]

The invention also includes a method for producing a refractive display element of the type described, which is designed and intended to produce a spot of light from a plurality of spots of light that appear to float above or below the area of view and which are in the form of a predetermined one Motif are arranged. In the method, a substrate is provided and a plurality of refractive and / or reflective optical elements are arranged in a surface area of the substrate, wherein each light spot of the light spot image is assigned at least one refractive and / or reflective optical element which, when the display element is illuminated, generates the light source contributes to its associated light spot.

[0036]

According to an advantageous variant of the method, a desired three-dimensional motif with pixels Pj and height values Zj is predefined over an xy plane, the pixels corresponding to the light spots produced during illumination, a brightness I between 0% and 100% is defined for each pixel P, If, for each pixel Pj, a catchment area Ej is determined for each pixel Pj by a section of the aperture cone emanating from the pixel with the xy plane, the xy plane becomes a The number of coarse fields and the coarse fields are each subdivided into a number of fine fields. For each pixel P, a number of fine fields to be filled are determined on the basis of the specified height value Z and the set brightness value I. The values for the pixel P to be filled are determined Fine fields substantially evenly on the coarse fields distributed in the catchment area E of the pixel P, and - are filled to be filled fine fields with refractive and / or reflective optical elements that contribute to the generation of the light spot corresponding to the pixel P when lighting the display element.

[0037]

Finally, the invention also includes a data carrier with a display element of the type described, wherein the display element can be arranged in particular as a reflective security element in an opaque region of the data carrier, or as at least partially transparent security element in or over a transparent window area or a through opening of the data carrier ,

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The data carrier may in particular be a value document, such as a banknote, in particular a paper banknote, a polymer banknote or a film composite banknote, but also an identity card, such as a credit card, bank card, cash card, authorization card, identity card or a Trade personalization page.

[0038]

The invention further includes a display device with a control device and a display element of the type described above, wherein the spatial orientation of the optical elements of the display element is adjustable by the control device. In this way, the display element can show different light spot images depending on the drive. The change in the spatial orientation of the optical elements can be done very quickly, so that the viewer the impression of a continuous image sequence arises. The display device can thus be used as a 3D display for a wide variety of applications.

[0039]
Further embodiments and advantages of the invention will be explained below with reference to the figures, in the representation of a scale and proportion to faithful reproduction has been omitted in order to increase the clarity.

[0040]
Show it:

[0041]
1 is a schematic representation of a banknote with a security element according to the invention,

[0042]
2 shows schematically a first exemplary embodiment of the invention with concave mirrors as reflective optical elements,

[0043]
3 shows another embodiment of the invention with arching mirrors as reflective optical elements,

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[0044]
4 shows a given light spot motif in the form of a three-dimensional light pyramid,

[0045]
5 shows in (a) a bulging mirror and in (b) the bulging mirror of (a) replaced by a Fresnel mirror,

[0046]
6 is a plan view of a plurality of domed mirrors, in (a) with mirrors with a square base and in (b) with channel-shaped mirrors of different orientation,

[0047]
7 shows a further embodiment of the invention, in which the refractive optical elements are formed by lenses,

[0048]
8 in (a) to (d) four exemplary embodiments in which a curved concave mirror is divided into micro-optical elements with a square base surface and a flat mirror surface,

[0049]
9 shows the layout of a checkerboard-like arrangement with micromirrors according to FIG. 8 (b), wherein (a) shows an intermediate step with only one micromirror group and (b) the complete coverage with two micromirror groups for two closely adjacent light spots, FIG.

[0050]
FIG. 10 illustrates the calculation of the plane mirror surfaces of the micromirrors of FIGS. 8 and 9;

[0051]
Fig. 11 illustrates the calculation of microprisms arising in the decomposition of a condenser lens, and

[0052]

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Fig. 12 shows schematically a security element with embedded micromirrors.

[0053]

The invention will now be explained using the example of security elements for banknotes.

Fig. 1 shows a schematic representation of a banknote 10, which is provided with a security element 12 according to the invention.

The security element 12 may be formed as a reflective security element, which is present in an opaque area of the banknote 10, or may be formed as a see-through security element, which is arranged, for example, over a transparent window area of the banknotes 10.

[0054]

When illuminated, for example, by sunlight or a ceiling lamp, the security element 12 generates for a viewer a three-dimensional spot image of a plurality of light spots, which seem to float for a viewer above or below the plane of the security element 12.

Different light spots have different flying heights, so that the light spots together form a three-dimensional motif, for example a light pyramid protruding from the banknote.

[0055]
These spots of light resulting from the illumination and projecting from the banknote offer the viewer an unusual, visually appealing three-dimensional image impression that is easy to check and memorize, even for laymen.

[0056]

To explain the principle of the invention, FIG. 2 shows a first exemplary embodiment of a security element 20, in which the three-dimensional motif 30 is illustrated in simplified form by three pixels

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32.

The security element 20 includes a substrate 22 which includes a plurality of small concave mirrors 24 in a surface area.

Since only three pixels 32 of the motif are shown in simplified form in the figure, only three concave mirrors 24 are correspondingly shown.

However, it will be appreciated that in practice a security element 20 will typically have a large number, for example, tens, hundreds or even thousands of refractive and / or reflective optical elements 24.

Concrete examples of security elements with a large number of optical elements are described below.

[0057]

Returning to the illustration of FIG. 2, the focal length f of the concave mirrors 24 arranged in the plane of the substrate 22 is in each case selected so that the concave mirrors 24 produce the given pixels as light spots 32 when illuminated by a light source 34 that is far away.

More precisely, the light spots 32 represent real images of the light source, as indicated in the left image part of FIG. 2 by the geometric beam path 36.

[0058]

A three-dimensional image impression, ie the perception of the viewer 40, that the light spots 32 float at a certain height above the surface of the substrate 22, only arises through binocular vision.

For this purpose, it must be ensured by the design of the concave mirror arrangement that the real

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images 32 of the light source 34 are in each case for both eyes 42 within the opening of the relevant optical system, in this case a recessed mirror 24.

[0059]

As illustrated in the right-hand part of FIG. 2, a light spot 32 lies within the opening of the concave mirror 24 for both eyes 42, when the opening angle ω of the concave mirror 24 is greater than the viewing angle α of the observer 40, viewed from the light spot 32.

The opening angle ω is given by the ratio of mirror diameter d and focal length f, ω = d / f and the viewing angle α by the ratio of eye distance a and viewing distance b, ie α = a / b.

For a typical eye distance a ≈ 6.5 cm and a typical viewing distance b ≈ 30 cm, one obtains the condition f / d <b / a ≈ 5, ie the condition that the ratio of the flying height f of a light spot 32 to the diameter of the Light spot generating concave mirror 24 must be less than about 5.

If the diameter of the concave mirrors 24 is, for example, d = 0.5 mm, as in the exemplary embodiment of FIG. 2, flying heights of up to 2.5 mm can be achieved with a three-dimensional image impression.

[0060]

The refractive and / or reflective optical elements may have dimensions of a few 100 .mu.m or even a few millimeters, but may also be made significantly smaller.

For example, a concave mirror can be divided into a plurality of micromirrors and distributed over a specific area of the substrate 22, as explained in more detail below.

In any case, the dimension of an optical element used according to the invention, however, is significantly above the wavelength of light, so that diffraction and interference effects can be neglected.

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In particular, the dimension of the optical elements is therefore advantageously above 2 µm, preferably even above 5 µm.

[0061]

The light spots 32 of the given subject 30 can float for the viewer 40 not only above, but also below the surface 22 of the substrate. With reference to FIG. 3, a plurality of small bulging mirrors 26 are arranged for this purpose in a surface area of the substrate 22 whose focal lengths are selected so that the bulging mirrors 26 generate the predetermined pixels as light spots 32 when illuminated by a light source 34 that is far away. More specifically, in this case, the light spots 32 represent virtual images of the light source 34, which seem to float to the observer below the surface of the substrate, as indicated by the geometrical optical path 38 in the right-hand image portion of FIG.

[0062]

Hollow and camber mirrors can also both be provided in the same security element, if parts of the motif project, other parts are to recede behind the substrate surface. By way of illustration, FIG. 4 shows a predetermined motif in the form of a three-dimensional pyramid of light 50 made up of a plurality of light spots 52 which float in different flying heights above or below the surface of the substrate 22.

[0063]

In the embodiment of Fig. 4, all domed mirrors are designed with a diameter of 0.5 mm. The focal length f is given positive for concave mirrors (flying height above the substrate surface), negative for arching mirrors (flying height below the substrate surface). With this convention, the light spot 52-1 of the pyramid tip has a fly height of f = +2 mm, while the light spots 52-2 and 52-3 of the pyramid edges have a height f = +1.2 mm and f = +0, respectively, 4 mm floating. The light spots 52-1 to 52-3 with their positive flying heights are generated by concave mirrors, as already explained in principle in FIG.

[0064]

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In the pyramid 50 further outward, the light spots 52-4 and 52-5 have a flying height of f = -0.4 mm or f = -1.2 mm, ie for the viewer float below the substrate surface 22. Finally, the pyramid base is formed of spots of light 52-6 which have a flying height of f = -2 mm and are thus 4 mm below the pyramid tip 52-1.

[0065]
For all light spots 52, the condition | f | / d <5 is satisfied, so that the pyramid 50 appears to be real three-dimensional to the viewer at normal viewing distance and seems to pierce the substrate plane from bottom to top.

[0066]

The flying height of the light spots is determined by the radius of curvature of the domed mirrors, as shown in Fig. 5 (a) by way of example for a dome mirror 60.

With a diameter d and a radius of curvature r, the dome mirror 60 has a focal length of f = r / 2. For example, with a mirror diameter d = 0.5 mm for a focal length or Flying height of f = 2 mm, a radius of curvature of r = 4 mm required. The structural height of the arching mirror in this case is given by the relationship h · (2r - h) = (d / 2) <2> to h = 7.8 µm.

[0067]

Depending on the desired flying height, it is possible to produce mirror structures whose height h is too great for a desired application, for example because a maximum permissible embossing height or embossing depth in an embossed layer is exceeded. In this case, the bulging mirror 60 of Fig. 5 (a) may be replaced by a corresponding Fresnel mirror 62 having a substantially lower feature height hf, as shown in Fig. 5 (b). The zone widths z of the Fresnel zones 64 can be selected arbitrarily, as long as they are large against the wavelength of light, in particular as long as z is> 2 µm. Otherwise, the width z of the Fresnel zones 64 for the optical efficiency of the Fresnel mirror 62 is irrelevant.

[0068]

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If the curved mirrors of a security element have several different focal lengths, the light spots of the light spot image thus have a number of different flying heights above and / or below the substrate surface, thus creating a truly three-dimensional motif. In some designs, however, it may also be appropriate to form all curved mirrors with the same focal length, so that all the light spots of the light spot image have the same flying height. In this way, a backdrop motif is created which floats above or below the substrate surface at a certain height.

[0069]

The arched mirrors do not have to be spherically curved. As optical elements according to the invention, it is also possible, for example, to use elliptical hollow or curved mirrors which have a different mirror curvature in the x and y directions. Since the focal length f of an arched mirror is proportional to the radius of curvature r according to the above, the fly height f of the associated light spot changes for the observer when an elliptically curved mirror is rotated.

[0070]

Contains a given motif at least partially elliptical hollow or camber, so the light spots in the focal planes of the respective games rise when rotating the arrangement against the background or lower into the background. This effect is particularly conspicuous if the light spots rising or falling during rotation are combined with turning spots that do not change when turning, which represent a resting reference point for the eye.

[0071]
With reference to the plan view of Fig. 6 (a), the plurality of domed mirrors 70 may be arranged, for example, with a rectangular or square base in a surface area 72 of the security element.

[0072]

For a three-dimensional image impression for a viewer already sufficient lateral parallax, so a parallax along the line connecting the two eyes 42 of the viewer 40th

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The curved mirrors 74, 76, 78 can therefore also be channel-shaped, as shown in the plan view of FIG. 6 (b). Channel-shaped curved mirrors have only in one direction, namely perpendicular to the channel, a non-zero curvature, while the curvature disappears in channel direction.

[0073]

With an image constructed from channel-shaped arched mirrors 74, 76, 78, attractive visual effects can also be realized. The light spots appear at a suitable viewing angle above or below the substrate surface floating in the form of hanging in the air bright strokes.

[0074]

Because of the adjacent eyes resulting in a 3D trough image perpendicular to the line connecting the eyes 42 extending grooves 74, the strongest spatial effect. However, inclined grooves 76 also have a vertical component and thus also produce a light spot image with a three-dimensional effect.

[0075]

If one rotates (80) an image with grooves 76 lying diagonally in the image plane in such a way that the grooves are vertical, the three-dimensional effect increases. On the other hand, if the observer turns the channels 76 horizontally, the three-dimensional impression is reduced. In a security element, which, as shown in Fig. 6 (b), contains portions with different orientation of the grooves 74, 76, 78, the light spots of the respective portions rise when rotating (80) of the arrangement against the background or lower in the background.

[0076]

Under trough-shaped domed mirrors are to be understood both channel-shaped concave mirror and trough-shaped arching mirror. Channel-shaped concave mirrors generate spots of light that float above the substrate surface, while channel-shaped concave mirrors produce spots of light that float below the substrate surface.

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[0077]

Further, the trough-shaped domed mirrors need not be straight, as shown in Fig. 6 (b), but they may be curvilinear as well. Even with such a design, attractive visual effects can be realized.

[0078]

In a further variant of the invention illustrated in FIG. 7, the optical elements are formed by refractive lenses instead of reflecting mirrors. The refractive security element 90 in this case represents a see-through security element, which is checked by the viewer 40 in view of an ideally far away light source 95 for authenticity.

[0079]
As lenses, both converging lenses 92 and dispersing lenses 96 are contemplated, and as viewed from the viewer 40, the convex converging lenses 92 generate floating spots 94 as real images over the security element 90, and the concave diverging lenses 96 float as virtual images below the security element 90 Create light spots 98.

[0080]

The lenses may in particular be spherical, elliptical or cylindrical.

Cylindrical lenses result in line-like light spots, with elliptical lenses the flying height of the light spots changes when the security element is rotated, as already described above for elliptical mirrors. For the plano-convex or plano-concave lenses 92, 96 shown in FIG. 7, for the diameter d, the radius of curvature r, the focal length f and the lens height h with a refractive index of the lens material of n = 1.5 for lenses bordering on air: $f = 2 \cdot r$ and $h \cdot (2r - h) = (d / 2)$ <2>

[0081]

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Given the lens diameter d and given desired fly height f, the radius of curvature r and the height of the structure h of the lens can thus be determined. If the structural height of a lens is too large for a desired application, the lenses can also be replaced by corresponding Fresnel lenses, as described in connection with FIG. 5 for Fresnel mirrors. Again, it is important to ensure that the zone widths of the Fresnel zones are large against the wavelength of light, but otherwise can be chosen arbitrarily.

[0082]

In the exemplary embodiments described so far, each light spot of the light spot image is assigned exactly one optical element which generates this light spot when illuminated, namely a concave mirror 24 (FIG. 2), a curvature mirror 26 (FIG. 3), a converging lens 92 or a diverging lens 96 (FIG. FIG. 7). The achievable in the light spot image resolution, so the minimum distance between two light spots in the light spot image is limited in such a design, however, to the diameter d of the domed mirror or lens. This diameter is in turn coupled to the flying height of the light spots via the abovementioned condition for a three-dimensional image impression f / d <5. A high resolution in the light spot image is thus only achievable for low flying heights and thus a low three-dimensional effect.

[0083]

In order nevertheless to obtain a higher resolution in the generated light spot image with a constant flying height, the large mirrors or lenses used in the previous embodiments are each replaced by a plurality of smaller micromirrors or microprisms, which together have substantially the same optical effect as the original optical element , For ease of designation, micromirrors and microprisms are collectively referred to as micro-optic elements hereinafter.

[0084]

Each light spot of the light spot image is then assigned a plurality of optical elements in the form of micro-optical elements. The higher resolution in the light spot image is achieved by the fact that the micro-optical elements are not distributed seamlessly next to each other, but at a distance on the surface area. The interstices of the optical elements of a light spot can then be occupied by optical elements associated with other light spots. In this way, a plurality of groups of micro-optical elements, each associated with different light spots, can be nested within the same area.

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[0085]
The minimum distance between two light spots in the spot spot image is then no longer dictated by the size of the original large mirrors or lenses, but by the much smaller dimensions of the micro-optic elements into which the original mirrors or lenses are dissected.

[0086]

In addition, in the decomposition of a curved mirror or a curved lens into a plurality of micro-optical elements, the initially curved surfaces of the micro-optical elements are generally replaced by flat surfaces because of their small size.

This replacement, in particular when the dimensions of the micro-optic elements are smaller than the resolution of the viewing situation, does not adversely affect the generated spot image. An advantage is that micro-optical elements with flat surfaces are easier to calculate and produce. From this point of view, it may even be advisable to dissect arched mirrors or lenses into small micro-optic elements with even surfaces, if no nesting of several groups of micro-optic elements is desired or necessary.

[0087]

For illustration, Fig. 8 shows in (a) to (d) four embodiments in which a curved concave mirror is decomposed into micro-optical elements 100 with a square base surface and a flat mirror surface. In the embodiment of Fig. 8 (a), a concave mirror for generating a light spot is replaced by an array of n × n micromirrors 100 juxtaposed without spacing in the surface of the security element. The micromirrors 100 have, for example, a dimension of 50 µm × 50 µm and can be formed with a flat mirror surface without impairing the imaging quality. The number n × n of the micromirrors is, for example, 10 × 10, so that the micromirrors occupy a total area of 0.5 mm × 0.5 mm. The calculation of the orientation of the plane mirror surfaces is explained below with reference to FIG. As one skilled in the art will appreciate, the calculation and fabrication of the planar micromirrors 100 is substantially simpler than the calculation and fabrication of a curved concave mirror of the same optical effect.

[0088]

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The embodiment of Fig. 8 (b) shows a configuration in which a curved concave mirror is first replaced, as in Fig. 8 (a), by a plurality of micromirrors 102 having a plane mirror surface. However, the micromirrors 102 are arranged like a checkerboard in the area of the security element, so that every second mirror position remains free. These fields, which are initially unoccupied and white in the figure, can then be occupied by micromirrors which are assigned to another light spot.

[0089]

The resolution of the light spot image can be significantly increased by such an interleaving of micromirror groups: If, for example, two light spots which hover in a height of 5 mm are only 0.2 mm apart, curved mirrors or lenses with a focal length f = 5 are used mm needed. As described above, the diameter and the focal length of the optical elements for a three-dimensional effect must satisfy the condition f / d <5, resulting in an optical diameter d> 1 mm in the given specifications. Adjacent domed mirrors or lenses would therefore have to be more than 1 mm apart so that the required resolution of 0.2 mm can not be achieved in this way.

[0090]

If, on the other hand, a decomposition as in FIG. 8 (b) is used in which only every other field with 50 µm × 50 µm micromirrors 102 is used to produce the first light spot, the intermediate fields 104 can be covered with micromirrors, which form a second, 0.2 mm adjacent light spot produce. The condition f / d <5 requires an optical diameter of more than 1 mm, for example, by a checkered arrangement of 12 × 12 micromirrors 102 with 12 × 12 free fields 104 and thus d = 2 × 12 × 50 µm = 1.2 mm can be achieved. The minimum distance of the light spot produced by the micromirror group 102 and the second light spot generated by the micromirrors arranged in the fields 104 is now 50 µm, so that the required resolution of 0.2 mm can be easily achieved.

[0091]

The occupancy of a checkered arrangement according to FIG. 8 (b) with micromirrors is again illustrated in FIG. 9 in a sectional view. Referring to FIG. 9 (a), every other field is occupied with 50 µm × 50 µm micromirrors 102 for generating the first light spot 110. The micromirrors 102 form a

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group of micromirrors which are all assigned to the same light spot 110 and generate it together when illuminated.

[0092]

The fields 104 lying between the micromirrors 102 are available for occupancy with micromirrors associated with other light spots. In the extreme case, the fields 104 can be covered with micromirrors 106, which serve to generate a light spot 112, which is only a micromirror diameter dm, in the exemplary embodiment 50 µm, away from the first light spot 110, as illustrated in FIG. 9 (b).

[0093]

As can be seen from FIG. 9, the optical diameter d of the micromirror groups 102, 106 in the alternating mirror arrangement is given by $d = 2 \times n \times dm$, where n represents the number of micromirrors of a group in one spatial direction. By a suitable choice of n, therefore, the optical diameter d can always be made large enough, in spite of the high resolution dm, to satisfy the condition $f / d < 5$.

[0094]

Returning to the illustration of FIG. 8, it will be understood that the occupancy of the surface area of the security element can be selected according to the desired number of groups of microoptical elements to be nested. For example, only every fourth field may be populated with micromirrors 102 associated with a particular light spot, as illustrated in FIG. 8 (c). The initially empty fields 104 shown in white in the figure can then be covered with micromirrors, which are associated with up to three other light spots. In a further embodiment, every ninth field is occupied by the micromirrors 102 associated with a particular light spot, as shown in FIG. 8 (d). The initially still free fields 104 shown in white in the figure can then be covered with micromirrors, which are assigned to up to eight other light spots.

[0095]

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The calculation of the plane mirror surfaces of the micromirrors is illustrated in FIG. Shown are in cross-section some of the micromirrors 102 and the intervening free fields 104 of a design as shown in Figs. 8 (b) and 9 (a).

[0096]
For the calculation, (x0, y0, z0) denotes the position of the light spot 110 to be generated with z0> 0, (x, y, 0) the position of the mirror element to be calculated. n → is the normal vector of the mirror at the position (x, y, 0), k → the directional vector of the incident light beam and p → the directional vector of the reflected light beam.

[0097]

The position of the mirror surfaces, ie the normal vector n.sub.o, is in each case determined in such a way that the light incident from a given direction k.sub.f is reflected onto the focal point (x.sub.0, y.sub.0, z.sub.0) for all micromirrors 102 assigned to the light spot 110.

This succeeds according to the invention by

[0098]
If the light source 120 is at the position (xL, yL, zL), then

[0099]
If the micromirror group 102 is designed for vertical incidence of light, then so that the normal vector n → to <img class = "EMIRef" id = "349019841-00290002" / > using the abbreviation .

[0100]

In an analogous manner, the normal vector n → can be calculated for micromirrors whose focal point (x0, y0, z0) with z0 <0 lies below the plane of the security element.

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According to the invention, this is based on the relationship , the further calculation is carried out as for concave mirrors.

[0101]
Curved lenses can be readjusted by microprisms, which, when the size of the microprisms is below the resolving power of the viewing situation, can be used with the same optical effect, but are easier to calculate and produce when decomposing into microoptical elements.

[0102]

In Fig. 11, for illustration in a checkered decomposition as shown in Fig. 8 (b), a few microprisms 122 are shown in cross section.

Analogous to the procedure for the micromirrors 102, the normal vector n.sub.o can also be calculated for the microprisms 122 in such a way that the light incident from the light source 120 is refracted in each case to the desired position of the light spot 110.

The fields 124 which are not shown in FIG. 11 may be occupied by microprisms associated with another light spot.

[0103]

In all the variants described, the refractive and / or reflective optical elements could also be embedded in a surrounding material or provided with a protective layer. Such an embedding protects the optical elements on the one hand from contamination and abrasion, and on the other hand effectively prevents unauthorized readjustment by embossing the surface structure.

[0104]

The embedding is shown schematically in FIG. 12 for a security element 130 with micromirrors

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132. By embedding the micromirrors 132 in the transparent protective layer 134 and the resulting crack of the refractive index on the surface 136 of the protective layer 134, the position of the generated light spots 140 with respect to the light spot position 142 changes with a non-embedded micromirror arrangement. Specifically, when the micromirrors 132 are embedded in a protective layer of refractive index n, the flying height of a light spot 140 generated by the micromirrors 132 changes approximately by a factor of 1 / n. Conventional protective lacquer layers 134 have a refractive index of about n = 1.5, so that the flying heights of the light spots decrease by about 2/3 compared to the flying heights calculated for an open application. Of course, this change is of course taken into account in the design of the micromirror arrangement, so that after embedding the desired flying heights are achieved.

[0105]

For embedded prisms or lenses, the refractive index difference between prism or Lens material and embedding material are taken into account when calculating the light beam deflection accordingly.

[0106]

In order to produce a visually appealing three-dimensional light spot image, the light spots should be able to have different brightnesses. Such different brightnesses of light spots can be generated in various ways within the scope of the invention. For example, for this purpose, the optical elements associated with a light spot can be darkened depending on the desired fraction of the maximum brightness.

[0107]

At present, however, it is preferable to set the brightness of a light spot after decomposition into micro-optical elements via the area fraction occupied by micro-optical elements or via the number of fields which are responsible for a light spot per solid angle. This results in image areas that contain no directed to a light spot mirror or prisms and must be kept dark.

[0108]

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Such image areas may be generated, for example, in one of the following ways. In a first variant, the darker parts in the specular spot image are provided with light traps, such as sub-wavelength structures, such as moth-eye structures, or funnel-shaped, steep-edged reflective structures, where incident light is reflected little or no back. However, because of the steep flanks such light traps are not easy to produce. Therefore, it is advisable to provide the dark areas in the specular spot image with mirrors that are oriented in such a way that they reflect areas of space that do not contain light sources. For example, the mirrors may be aimed at the viewer's body.

[0109]
For see-through security elements, the dark areas are preferably provided with prisms directing light rays from directions to the observer's eye, in which there are no light sources, for example from the floor.

[0110]

The surface area in which the optical elements are arranged does not have to be flat, but can be curved in any desired manner.

This is particularly simple if the optical elements are formed by small micro-optical elements. Since anyway for each micro-optical element, a normal vector is calculated (Fig. 10, 11), the local position and orientation of the surface of the security element can be taken into account without much additional effort, as explained below using the example of a micromirror arrangement: as above (x0, y0, z0) designates the position of the desired light spot, (x, y, z) the position of a micromirror in space, this position including the curved surface of the security element, further denotes n → the normal vector of the micromirror at the position (x, y, z), k → the directional vector of the incident light beam and p → the direction vector from the micromirror to the light spot, according to the invention where the upper sign for z0> 0, ie a real image floating above the substrate level, and the lower sign for z0 < 0, that is, a floating below the substrate level, virtual image applies.

[0111]

In a development of the invention, the security element can also generate a light spot change image when illuminated, in which different images become visible to the viewer from different

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directions. For this purpose, for example, for a reflective security element proceed as follows, the procedure for a see-through security element is analogous: The security element should show a picture change from a light spot image A to a light spot image B in case of lateral tilting. First of all, the required optical elements which generate the light spot images when illuminated are determined for both light spot images. In this case, as described in connection with FIGS. 8 to 10, each light spot is assigned a plurality of optical elements, in this case a plurality of micromirrors.

[0112]

In the arrangement of the micromirrors in the surface area of the security element, those micromirrors are then omitted for the light spot image A, in which the x-component nx of the normal vector is greater than zero. As a result, half of the mirror spaces become free and the image is only visible in a restricted angular range.

[0113]

For the spot image B, those micromirrors are omitted in which the x-component nx of the normal vector is less than zero. With this reduced mirror arrangement, the vacant mirror locations of the light spot image A are occupied. During lateral tilting of the arrangement, the light spot image A and the light spot image B are then alternately visible.

[0114]

The security element can also be designed for vertical tilting, for example by omitting for the light spot image A those micromirrors in which the y-component of the normal vector ny is greater than zero and for the light spot image B the micromirrors for which ny <0. The reduced mirror arrays with their limited visibility range are then mixed on the area of the security element.

[0115]

Of course, other criteria for separating the light spot images of a change image can be used instead of the conditions mentioned. For example, by the conditions ny> c1 for image A, c1 <ny <c2 for image B, ny <c2 for image C with two numerical values c1 <c2, three light spot images A,

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B, C can change on vertical tilting. By selecting the numerical values c1 and c2, the size of the visibility ranges can be set as desired.

[0116]
In addition to the change between several 3D light spot images, a change between one or more 3D light spot images and one or more differently generated images is also possible.

[0117]

It may also be advisable to combine in the light spot image a three-dimensional motif with a two-dimensional motif in which all the pixels lie at the same height, preferably at the level of the security element or the security element level.

Such two-dimensional light spot motifs can still be recognized well even under poorer lighting conditions. If, for example, a two-dimensional foreground motif is combined with a three-dimensional background motif, the light spot image does not disappear completely even in poor lighting conditions, but is only reduced to the more robust two-dimensional foreground motif. An authenticity check is therefore still possible in low light conditions.

[0118]

Thus, in addition to floating 3D light spots, which are visible from certain angles, a light spot image can also contain 2-dimensional areas that are visible from the same or other angles of view. The 2D and 3D games can therefore be next to each other and / or alternately appear in the same place when changing the viewing direction.

[0119]
In 2D 3D images, in addition to 3-dimensional games (which appear in front of or behind the plane of the security element or seem to penetrate the plane of the security element), there are also 2-dimensional games at or near the level of the security element Level of the security element (at altitude 0 or near altitude 0).

[0120]

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For a zero height range, one can assume the mirror or prism occupancy used for low-light spots (e.g.

B. the height 0.5 mm) is calculated with the desired viewing angle range. Here all normal vectors are contained, which serve the advised solid angle. While the micromirrors or microprisms in the plane of the security element are sorted for floating points of light in such a way that certain points in the space are operated, the micromirrors thus calculated, including their inclination, must be statistically distributed in the area provided for height 0. Then no specific points in the room are illuminated, but as desired, a solid angle operated. For smaller intensity, this statistically mixed occupied area is correspondingly sketchy to make by z. B. not all pixels are occupied or the pixels are not fully occupied.

[0121]

According to another development, the light spot image in addition to the publicly visible image information on a hidden image information (hidden image) on. For this purpose, the optical elements of the open image information are arranged at a distance and the gaps are at least partially occupied by optical elements of the hidden image information.

[0122]
Hidden image information can be generated, for example, by assigning very small aperture angles to the associated light spots, such as an opening angle = 0 for parallel light.

[0123]

The light spots of the hidden image information can also be assigned to different directions which are so far apart that no coherent image is detected when viewed without aids.

For authenticity, the image can be captured on a screen. The directions of the hidden image information are preferably outside the directions under which the open 3D spot image is viewed, so that the presence of hidden information is not readily apparent.

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[0124]

In an advantageous embodiment, the optical elements of the hidden image information are partially or completely housed in closely adjacent subregions of the security element and optionally repeated several times over the surface of the security element. The hidden image information can then be successively or wholly detected by illumination with a narrow laser beam and projected onto a suitably placed screen.

[0125]
Hereinafter, a particularly preferable manner of producing a general three-dimensional spot image will be described in more detail.

[0126]

First, a desired three-dimensional motif is defined with pixels Pj and height values Zj above the xy-plane, the pixels corresponding to the light spots resulting from illumination.

For a normal viewing distance of about 30 cm, the pixel spacing should be in the range of 0.1 to 0.5 mm. Furthermore, the pixels Pj are assigned a brightness Ij between 0% and 100%. Then, the pixels are associated with opening cone having an opening ratio> 0.2, for example, an aperture ratio of 0.4. For each pixel Pj, the intersection of the aperture cone emanating from the pixel with the xy plane defines a catchment area Ej to the pixel Pj there.

[0127]

The xy plane itself is divided into first, larger fields, for example a dimension of 0.1 mm × 0.1 mm. Each of the larger fields is further divided into second, smaller fields, for example a size of 10 µm × 10 µm. The larger fields are referred to below as coarse fields, the small fields as fine fields.

[0128]

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In the catchment area Ej of each pixel Pj, as many fine fields are now reserved for this pixel, as determined on the basis of the height value Zj and the brightness value Ij. For example, the fine field number may be selected to be proportional to the brightness value and inversely proportional to (Zj) <α> with an exponent α 1, α = 1 for light spots formed by channel-shaped mirrors or cylindrical lenses, and α = 2 for light spots formed by two-dimensionally focusing lenses or mirrors is. The fine fields reserved for the pixel Pj are then distributed substantially uniformly over the coarse fields in the catchment area Ej of the pixel Pj.

[0129]

The number of fine fields per coarse field can also include a correction factor which is determined, for example, as follows: First, without correction factor within each coarse field, the number of fine fields to be occupied, which belong to different pixels Pj, is added. This results in an allocation proposal for the number of total occupied fine fields in each coarse field.

[0130]

If the number of occupied fine fields for all coarse fields is less than the maximum possible number, then a correction factor greater than 1 can be selected and the coverage multiplied by this correction factor, so that the maximum coverage in some coarse fields is achieved. If, on the other hand, the number of occupied fine fields exceeds the maximum occupancy, then a correction factor smaller than 1 is selected, which after multiplication leads to an occupancy smaller than or equal to the maximum occupancy. If the maximum occupancy is exceeded in only a few coarse fields, instead of a uniform reduction, only the highest intensities can be clipped to the maximum occupancy or the fine fields of the crossing coarse fields are shifted to adjacent coarse fields.

[0131]

The occupancy thus obtained can now be realized in the surface area of the security element. In the occupied fine fields, mirrors or prisms are arranged which reflect or break the incident light onto the corresponding light spot. Additional security elements can be introduced into the area of the security element that remains free, for example, a hidden image of the type described above can be accommodated there.

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QUOTES INCLUED IN THE DESCRIPTION

[0132]

This list of the documents listed by the applicant has been generated automatically and is included solely for the better information of the reader. The list is not part of the German patent or Utility model application. The DPMA accepts no liability for any errors or omissions.

Cited patent literature

[0133]
WO 2009/000530 A2 WO 90/08338 A1 DE 102009056934 EP 0868313 B1 WO 2005/052650 A2

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CLAIMS DE102010048262

1.
A display element having a substrate with a surface area in which a plurality of optical elements is arranged, characterized in that the display element is designed and intended to generate a spot of light from a plurality of light spots which, when illuminated, float above or below the surface area appear and which are arranged in the form of a predetermined motif, wherein the optical elements are formed by refractive and / or reflective optical elements and each light spot of the light spot image is associated with at least one refractive and / or reflective optical element which upon illumination of the display element for generating the contributes to its associated light spot.

2.
Representation element according to claim 1, characterized in that for the light spots and the associated optical elements in each case f / d <5, where f denotes the flying height of the light spot above or below the surface area and d the diameter of the contributing to this light spot optical elements.

3.
Display element according to claim 1 or 2, characterized in that the light spots of the light spot image float in several different flying heights above or below the surface area to form a three-dimensional motif.

4.
Representation element according to claim 1 or 2, characterized in that the light spots of the light

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spot image in some areas all hover in the same flying height above or below the surface area to form a backdrop motif.

5.
Presentation element according to at least one of claims 1 to 4, characterized in that the optical elements comprise curved mirrors, in particular concave mirrors or bulging mirrors.

6.
Representation element according to claim 5, characterized in that the curved mirrors are spherical, elliptical, rotationally symmetric aspherical, non-rotationally symmetrical aspherical or channel-shaped, in the latter case, the grooves are rectilinear or curvilinear.

7.
Representation element according to claim 5 or 6, characterized in that the curved mirrors are at least partially formed by Fresnel mirror.

8.
Display element according to at least one of claims 1 to 7, characterized in that the optical elements comprise lenses, in particular spherical, elliptical, rotationally symmetrical aspherical, non-rotationally symmetric aspherical or cylindrical lenses.

9.
Display element according to claim 8, characterized in that the lenses are at least partially formed by Fresnel lenses.

10.
Display element according to at least one of claims 1 to 9, characterized in that each light spot of the light spot image is associated with exactly one optical element.

11.
Representation element according to at least one of claims 1 to 9, characterized in that each light spot of the light spot image is assigned a plurality of optical elements, preferably that the optical elements are spaced apart on the surface area.

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12.
A display element according to claim 11, characterized in that the light spots of the light spot image have different brightnesses and each light spot is assigned such a number of optical elements corresponding to the brightness of the light spot within the motif formed by the light spots, or each light spot such a total area of optical Assigns to elements that corresponds to the brightness of the light spot within the motif formed by the light spots.

13.
Display element according to claim 11 or 12, characterized in that optical elements which are assigned to different light spots are arranged in the surface area nested one inside the other.

14.
Display element according to at least one of claims 11 to 13, characterized in that the optical elements are formed by plane micromirrors or by small microprisms.

15.
Presentation element according to at least one of claims 1 to 14, characterized in that the predetermined motif is a change picture showing different images from different viewing directions.

16.
Display element according to at least one of claims 1 to 15, characterized in that the surface area in which the plurality of optical elements is arranged, is curved.

17.
Representation element according to at least one of claims 1 to 16, characterized in that a subset of the optical elements generates a hidden image information that is not recognizable without tools.

18.
A display element according to at least one of claims 1 to 17, characterized in that the optical elements comprise a periodic arrangement of micromirrors, each having a distance to the nearest neighbor of 2 mm or less.

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19.
Display element according to at least one of Claims 1 to 18, characterized in that the optical elements are embedded in an ambient layer or an ambient layer composite, in particular in a protective layer.

20.
Representation element according to at least one of claims 1 to 19, characterized in that the optical elements are formed as embossed structures in an embossing lacquer layer.

21.
Representation element according to claim 20, characterized in that the embossed structures are provided with a reflection-enhancing coating, in particular with a metallization, a high refractive index coating, a thin-film element with a color-shift effect or a cholesteric liquid crystal layer.

22.
Representation element according to claim 20 or 21, characterized in that the embossed structures have structure heights of less than 100 microns, preferably less than 20 microns, more preferably less than 5 microns.

23.
Display element according to at least one of claims 1 to 22, characterized in that the display element is a security element for security papers, documents of value and other items to be protected, in particular a security thread, a security tape, a security strip, a label or a transfer element.

24.
A method of making a display element according to any one of claims 1 to 23, which is designed and intended to produce a light spot image of a plurality of light spots which appear to be floating above or below the surface area when illuminated and which are arranged in the form of a predetermined subject In the method, a substrate is provided and a plurality of refractive and / or reflective optical elements are arranged in a surface area of the substrate, wherein each light spot of the light spot image is assigned at least one refractive and / or reflective optical element, which is illuminated when the display element is illuminated contributes to the generation of its associated light spot.

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25.

A method according to claim 24, characterized in that - a desired three-dimensional motif with pixels Pj and height values Zj is given over an xy-plane, the pixels corresponding to the light spots resulting from illumination, - for each pixel Pj a brightness Ij between 0% and 100% is set, - are assigned to the pixels Pj opening cone, which have an aperture ratio> 0.2, - for each pixel Pj is determined by a section of the emanating from the pixel opening cone with the xy plane a catchment area Ej, - the xy - divided into a number of coarse fields and the coarse fields each in a number of fine fields, - for each pixel Pj on the basis of the specified height value Zj and the fixed brightness value Ij a number of fine fields to be filled are determined, - for the pixel Pj certain fine fields to be filled substantially evenly on the G rob fields are distributed in the catchment area Ej of the pixel Pj, and - the fine fields to be filled are occupied by refractive and / or reflective optical elements which, when the display element is illuminated, contribute to the generation of the light spot corresponding to the pixel Pj.

26.

Data carrier with a display element according to at least one of claims 1 to 23.

27.

A data carrier according to claim 26, characterized in that the display element is an at least partially transparent security element, which is arranged in or above a transparent window area or a through opening of the data carrier.

28.

A data carrier according to claim 26, characterized in that the display element is a reflective security element which is arranged in an opaque region of the data carrier.

29.

A data carrier according to at least one of claims 26 to 28, characterized in that the data carrier is a value document, such as a banknote, in particular a paper banknote, a polymer banknote, a film composite banknote or a document, a passport or an identity card.

30.

Display device with a control device and a display element according to one of claims 1 to 23, wherein the spatial orientation of the optical elements of the display element is adjustable by the control device.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/152,623	01/19/2021	MARK A. RAYMOND	79897.01436

CONFIRMATION NO. 9833

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Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004

PUBLICATION NOTICE

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Title:METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

Publication No.US-2021-0173187-A1
Publication Date:06/10/2021

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

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The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/152,623	01/19/2021	MARK A. RAYMOND	79897.01436	9833

166539 7590 07/06/2022

Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004

EXAMINER	
CHWASZ, JADE R	

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NOTIFICATION DATE	DELIVERY MODE
07/06/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

IPDOCKET@swlaw.com
jjohnson@swlaw.com
ksandoval@swlaw.com

PTOL-90A (Rev. 04/07)

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Office Action Summary	**Application No.** 17/152,623	**Applicant(s)** RAYMOND et al.	
	Examiner JADE R CHWASZ	**Art Unit** 2872	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 19 January 2021.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 1/19/21 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date 4/15/21.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Drawings

2. The drawings were received on 1/19/21. These drawings are acknowledged.

Claim Rejections - 35 USC § 112

3. The following is a quotation of 35 U.S.C. 112(b):

> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claims 1-20 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor (or for applications subject to pre-AIA 35 U.S.C. 112, the applicant), regards as the invention.

5. Claims 1, 7, 12 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being incomplete for omitting essential steps, such omission amounting to a gap between the steps. See MPEP § 2172.01. The omitted steps are: the claims fail to recite further limitations or steps for fabricating said security element. A design output file is generated, however, the claims lack limitations or steps as to how the design output file is used to fabricate the security element. For purposes of examination, it is suggested to add the limitation "and forming the array of micro mirrors according to the design output file." Appropriate correction is required.

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6. Claims 2-6, 8-11, 13-20 are dependent on claims 1, 7 and 12 and inherit at least the same deficiencies as claims 1, 7 and 12.

Allowable Subject Matter

7. Claims 1, 7, 12, would be allowable if rewritten or amended to overcome the rejection(s) under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), 2nd paragraph, set forth in this Office action.

8. Claims 2-6, 8-11, 13-20 would be allowable if rewritten to overcome the rejection(s) under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), 2nd paragraph, set forth in this Office action and to include all of the limitations of the base claim and any intervening claims.

Conclusion

9. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

10. Cho et al. (US 8,622,557) discloses a micromirror array lens with self-tilted micromirrors. Each self-tilted mirror comprises a substrate and a tilting point. The designed optical surface profile determines the required motion of the micromirror plate and a surface profile shape memory is built into the micro mechanical elements of the self-tilted micromirrors so that each micromirror plate has the required motion.

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JADE R CHWASZ whose telephone number is (571)272-8199. The examiner can normally be reached 5:30 am to 3:00 pm, M-F.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an

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interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephone Allen can be reached on 571-272-2434. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

JRC
/JADE R CHWASZ/
Primary Examiner, Art Unit 2872

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Notice of References Cited	Application/Control No. 17/152,623	Applicant(s)/Patent Under Reexamination RAYMOND et al.	
	Examiner JADE R CHWASZ	Art Unit 2872	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8622557-B2	01-2014	Cho; Gyoung Il	G02B26/0833	359/223.1
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/152,623	RAYMOND et al.
	Examiner	**Art Unit**
	JADE R CHWASZ	2872

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/27/2022								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
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	15	✓								
	16	✓								
	17	✓								
	18	✓								
	19	✓								
	20	✓								

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/152,623	RAYMOND et al.
	Examiner	Art Unit
	JADE R CHWASZ	2872

CPC - Searched*		
Symbol	**Date**	**Examiner**
B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012	06/23/2022	JRC
B42D25/29, B42D25/21, B42D25/351, B42D25/23, B42D25/24, B42D25/41, B42D25/435, B42D25/00, B42D25/20, B42D25/40, B42D25/45, B42D2033/20, B42D2035/20, B42D2035/24, G02B27/0012, G02B17/00	06/23/2022	JRC

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**
359	851,852,853,855	06/22/2022	JRC

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/152,623	RAYMOND et al.
	Examiner	Art Unit
	JADE R CHWASZ	2872

Search Notes		
Search Notes	**Date**	**Examiner**
Inventor name/assignee search	06/22/2022	JRC
Information disclosure statement review	06/22/2022	JRC
Reviewed related applications 15/162113, 16/203128 for relevant search and prior art	06/22/2022	JRC
Global Dossier and IP.com NPL review	06/22/2022	JRC
B42D25/29, B42D25/21, B42D25/351, B42D25/23, B42D25/24, B42D25/41, B42D25/435, B42D25/00, B42D25/20, B42D25/40, B42D25/45, B42D2033/20, B42D2035/20, B42D2035/24, G02B27/0012, G02B17/00, B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012 with text in SEARCH	06/22/2022	JRC
359/851,852,853,855 with text in SEARCH	06/22/2022	JRC
Text search in SEARCH	06/22/2022	JRC

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	Interference search (see attached history)	06/23/2022	JRC

Search History

Report Run Date: 2022-06-27 UTC
Searches: 2
Markers: 0

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Search #	Timestamp	Results	Page
1	2022-06-27 16:15 UTC	3,419,260	3
2	2022-06-27 16:15 UTC	24,872,015	4

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Content: Non-Patent Literature (23)

IEEE Xplore Publications: IEEE Periodicals | IEEE Xplore Publications: IEEE Conferences | IEEE Xplore Publications: IEEE Standards | IEEE Xplore Publications: IEEE Early Access | IEEE Xplore Publications: SMPTE Periodicals | IEEE Xplore Publications: SMPTE Conferences | IEEE Xplore Publications: SMPTE Standards | IEEE Xplore Publications: MIT Press eBooks | IEEE Xplore Publications: Wiley-IEEE eBooks | IEEE Xplore Publications: IBM Periodicals | IEEE Xplore Publications: URSI Periodicals | IEEE Xplore Publications: VDE Conferences | IEEE Xplore Publications: Periodicals from China | IP.com Prior Art Database: The IP.com Journal | IP.com Prior Art Database: Internet Society RFC | IP.com Prior Art Database: IBM TDB Archive | IP.com Prior Art Database: Legacy Journals | IP.com Prior Art Database: Software Patent Institute | OnePetro.org: Periodicals at OnePetro.org | OnePetro.org: Conferences at OnePetro.org | Other Literature: IBM Redbooks | Other Literature: PubMed Central | Other Literature: arXiv.org

1 **2022-06-27 16:15 UTC | 3,419,260 results from**

De-Dup: None | **Cut-off:** None | **Sort:** Relevance

Main Concept: Text
method of fabricating a security element, comprising: assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane; with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane; for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; and generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors.

Concept Modifiers: None

Filters: None

Content: Patents + NPL (190)

US Patents | US Designs | US Applications | EPO Patents | EPO Applications | China Patents | China Applications | Japan Patents | Japan Applications | Korea Patents | Korea Applications | WIPO Applications | Argentina Patents | Argentina Applications | Brazil Patents | Brazil Applications | Canada Patents | Canada Applications | Chile Patents | Chile Applications | Colombia Applications | Costa Rica Applications | Cuba Patents | Cuba Applications | Dominican Republic Applications | Ecuador Patents | Ecuador Applications | El Salvador Applications | Guatemala Applications | Honduras Applications | Mexico Patents | Mexico Applications | Nicaragua Patents | Panama Applications | Peru Applications | Trinidad & Tobago Patents | Uruguay Applications | Austria Patents | Austria Applications | Belarus Patents | Belgium Patents | Belgium Applications | Bosnia & Herzegovina Patents | Bosnia & Herzegovina Applications | Bulgaria Patents | Bulgaria Applications | Croatia Patents | Croatia Applications | Czech Republic Patents | Czech Republic Applications | Czechoslovakia Patents | Czechoslovakia Applications | Denmark Patents | Denmark Applications | Estonia Patents | Estonia Applications | EUIPO Patents | Finland Patents | Finland Applications | France Patents | France Applications | Germany Patents | Germany Applications | Great Britain Patents | Great Britain Applications | Greece Patents | Greece Applications | Hungary Patents | Hungary Applications | Iceland Patents | Iceland Applications | Ireland Patents | Ireland Applications | Italy Patents | Italy Applications | Latvia Patents | Latvia Applications | Lithuania Patents | Lithuania Applications | Luxembourg Patents | Malta Patents | Monaco Patents | Montenegro Patents | Montenegro Applications | Netherlands Patents | Netherlands Applications | Norway Patents | Norway Applications | Poland Patents | Poland Applications | Portugal Patents | Portugal Applications | Republic of Moldova Patents | Republic of Moldova

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Applications | Romania Patents | Romania Applications | San Marino Patents | San Marino Applications | Serbia Patents | Serbia Applications | Slovakia Patents | Slovakia Applications | Slovenia Patents | Spain Patents | Spain Applications | Sweden Patents | Sweden Applications | Switzerland Patents | Switzerland Applications | Ukraine Patents | Yugoslavia/Serbia and Montenegro Patents | Yugoslavia/Serbia and Montenegro Applications | Armenia Patents | Australia Patents | Australia Applications | Cyprus Patents | Gulf Cooperation Council Patents | Hong Kong Patents | India Patents | India Applications | Indonesia Patents | Indonesia Applications | Israel Applications | Jordan Patents | Jordan Applications | Kyrgyzstan Patents | Macao Applications | Malaysia Patents | Mongolia Patents | New Zealand Patents | Philippines Patents | Philippines Applications | Saudi Arabia Patents | Saudi Arabia Applications | Singapore Patents | Singapore Applications | Taiwan Patents | Taiwan Applications | Tajikistan Patents | Tajikistan Applications | Thailand Patents | Thailand Applications | Uzbekistan Patents | Vietnam Patents | Algeria Patents | ARIPO Patents | ARIPO Applications | Egypt Patents | Kenya Patents | Malawi Patents | Morocco Patents | Morocco Applications | OAPI Patents | South Africa Patents | Tunisia Applications | Zambia Patents | Zimbabwe Patents | EAPO Patents | EAPO Applications | Georgia Patents | Georgia Applications | Kazakhstan Patents | Kazakhstan Applications | Russia Patents | Russia Applications | Turkey Patents | Turkey Applications | IEEE Xplore Publications: IEEE Periodicals | IEEE Xplore Publications: IEEE Conferences | IEEE Xplore Publications: IEEE Standards | IEEE Xplore Publications: IEEE Early Access | IEEE Xplore Publications: SMPTE Periodicals | IEEE Xplore Publications: SMPTE Conferences | IEEE Xplore Publications: SMPTE Standards | IEEE Xplore Publications: MIT Press eBooks | IEEE Xplore Publications: Wiley-IEEE eBooks | IEEE Xplore Publications: IBM Periodicals | IEEE Xplore Publications: URSI Periodicals | IEEE Xplore Publications: VDE Conferences | IEEE Xplore Publications: Periodicals from China | IP.com Prior Art Database: The IP.com Journal | IP.com Prior Art Database: Internet Society RFC | IP.com Prior Art Database: IBM TDB Archive | IP.com Prior Art Database: Legacy Journals | IP.com Prior Art Database: Software Patent Institute | OnePetro.org: Periodicals at OnePetro.org | OnePetro.org: Conferences at OnePetro.org | Other Literature: IBM Redbooks | Other Literature: PubMed Central | Other Literature: arXiv.org

2 **2022-06-27 16:15 UTC | 24,872,015 results from**

De-Dup: None | **Cut-off:** None | **Sort:** Relevance

Main Concept: Text

method of fabricating a security element, comprising: assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane; with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane; for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; and generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors.

Concept Modifiers: None

Filters: None

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17152623
Filing Date	2021-01-19
First Named Inventor	Mark A. Raymond
Art Unit	
Examiner Name	
Attorney Docket Number	79897.01436

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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/J.R.C/	5	6695455	B1	2004-02-24	INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/J.R.C/	1	20020114078	A1	2002-08-22	HALLE, MICHAEL ET AL	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	Mark A. Raymond
	Art Unit	
	Examiner Name	
	Attorney Docket Number	79897.01436

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/J.R.C/	11	20080258457	A1	2008-10-23	COMMANDER, LAWRENCE GEORGE	

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	Art Unit	
	Examiner Name	
	Attorney Docket Number	79897.01436

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
/J.R.C/	1	2012048847	WO	A1	2012-04-19	GIESECKE & DEVRIENT GMBH		
/J.R.C/	2	2011012460	WO	A2	2011-02-03	GIESECKE & DEVRIENT GMBH		
/J.R.C/	3	2013056825	WO	A1	2013-04-25	GIESECKE & DEVRIENT GMBH		
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/J.R.C/	7	2760677	EP	B1	2016-01-13	MAYER, ET AL		
/J.R.C/	8	2013045054	WO	A1	2013-04-04	MAYER, ET AL		

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

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	First Named Inventor	Mark A. Raymond
	Art Unit	
	Examiner Name	
	Attorney Docket Number	79897.01436

/J.R.C/	1	International Search Report for International Application No. PCT/US2016/061845 dated March 16, 2017	
/J.R.C/	2	International Search Report for International Application No. PCT/US2018/028241, dated August 16, 2018	
/J.R.C/	3	European Search Report for EP Application No. 16871264.4-1020/3362827 PCT/US2016061845 dated October 17, 2018	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/JADE R CHWASZ/	Date Considered	06/27/2022

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17152623
	Filing Date	2021-01-19
	First Named Inventor	Mark A. Raymond
	Art Unit	
	Examiner Name	
	Attorney Docket Number	79897.01436

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Kent A. Lembke/	Date (YYYY-MM-DD)	2021-04-15
Name/Print	Kent A. Lembke	Registration Number	44866

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.R.C/

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	2	15/162113	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2017/10/24 12:23 PM
L2	31	lumenco-$.as.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2017/10/24 12:26 PM
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L29	2147	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2017/10/24 03:08 PM
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L39	2156	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2017/11/15 09:41 AM
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L42	39385	L39 L40 L41	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2017/11/15 09:41 AM
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		near2 mirror$3) or (mirror near2 array$4)))	IBM_TDB)				
L44	262	(securit$4 same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2017/11/15 10:01 AM
L45	171	L44 not L43	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2017/11/15 10:01 AM
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L56	24954	(b42d25/373 or	(US-PGPUB; USPAT;	OR	OFF	OFF	2018/02/12

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		b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)				02:36 PM
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L64	40130	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/10/09 10:13 AM

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L69	1	("20140268327").PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2018/10/15 09:55 AM
L70	2	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/10/29 01:33 PM
L71	0	((voxel$3) and ambient$4 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/10/29 01:33 PM
L72	14	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/10/29 01:34 PM
L73	18	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/10/29 01:38 PM

		(mirror near2 array$4))).clm.					
L74	104	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/10/29 01:41 PM
L77	34417	(B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/11/06 02:03 PM
L78	104	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/11/06 02:03 PM
L79	1	L78 and L77	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/11/06 02:03 PM
L80	26848	((plane near4 (apart or spaced or spacing or distanc$3 or separat$4)) same (mirror$3 or reflect$4))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/11/06 02:04 PM
L81	124	L80 and L77	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2018/11/06 02:04 PM
L82	1	(15/588831).APP.	(USPAT; USOCR)	OR	OFF	OFF	2020/07/20 12:34 PM
L83	13	("20020114078" | "20080258456" | "20100231860" | "20120098249" | "20140268327" | "20150183258" | "5105306" | "5924870" | "6288842" | "6695455" | "7261417" | "9176266").PN. OR ("10317691").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2020/07/20 12:35 PM
L84	40	lumenco-$.as.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM

L85	199	raymond-mark-a$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L86	33	porras-soto-hector-andres.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L87	89	lange-howard-g$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L88	17	L87 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L89	61	L85 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L90	2300	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L91	31853	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L92	46393	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L93	49936	L90 L91 L92	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L94	141	L93 and (securit$4 same (plane near4 (apart or spaced or spacing or distanc$3 or separat$4)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:18 PM
L95	40538	(B42D25/373,	(US-PGPUB; USPAT;	OR	OFF	OFF	2020/07/20

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		B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012).cpc.	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)				01:19 PM
L96	29409	((plane near4 (apart or spaced or spacing or distanc$3 or separat$4)) same (mirror$3 or reflect$4))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:19 PM
L97	158	L96 and L95	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:19 PM
L98	121	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:19 PM
L99	2300	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:19 PM
L100	31853	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:19 PM
L101	46393	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:19 PM
L102	49936	L99 L100 L101	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 01:19 PM
L103	203	L102 and (micro-mirror$3 or	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	OFF	OFF	2020/07/20 01:19 PM

		micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)	JPO; DERWENT; IBM_TDB)				
L104	49	L102 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and metallization	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/20 02:10 PM
L105	20	(US-20150183258-$ or US-20120098249-$ or US-20080112056-$ or US-20020114078-$ or US-20050180020-$ or US-20100208036-$ or US-20050057812-$ or US-20170242263-$ or US-20150377711-$ or US-20100202040-$ or US-20130038942-$ or US-20100195174-$ or US-20100099100-$ or US-20060239336-$).did. or (US-6695455-$ or US-7359120-$ or US-5933228-$ or US-7261417-$ or US-8149511-$).did. or (WO-2011138616-$).did.	(US-PGPUB; USPAT; DERWENT)	OR	OFF	OFF	2020/07/21 07:21 AM
L106	11	L105 and (nickel or tool$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/21 07:21 AM
L107	5	L106 and metallizat$4	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/21 07:21 AM
L108	1	16/203128	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/07/21 07:37 AM
L109	89	lange-howard-g$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L110	17	L109 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L111	200	raymond-mark-a$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	OFF	OFF	2020/09/11 09:11 AM

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			IBM_TDB)				
L112	62	L111 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L113	122	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L114	2301	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L115	32470	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L116	47178	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L117	50775	L114 L115 L116	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L118	206	L117 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L119	20	(US-20150183258-$ or US-20120098249-$ or US-20080112056-$ or US-20020114078-$ or US-20050180020-$ or US-20100208036-$ or US-20050057812-$ or	(US-PGPUB; USPAT; DERWENT)	OR	OFF	OFF	2020/09/11 09:11 AM

		US-20170242263-$ or US-20150377711-$ or US-20100202040-$ or US-20130038942-$ or US-20100195174-$ or US-20100099100-$ or US-20060239336-$).did. or (US-6695455-$ or US-7359120-$ or US-5933228-$ or US-7261417-$ or US-8149511-$).did. or (WO-2011138616-$).did.					
L120	11	L119 and (nickel or tool$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L121	5	L120 and metallizat$4	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:11 AM
L122	41314	(B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:12 AM
L123	29608	((plane near4 (apart or spaced or spacing or distanc$3 or separat$4)) same (mirror$3 or reflect$4))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:12 AM
L124	161	L123 and L122	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:12 AM
L125	53	L117 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and metallization	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/09/11 09:12 AM
L126	20	(US-20150183258-$ or US-20120098249-$ or US-20080112056-$ or US-20020114078-$ or US-20050180020-$ or US-20100208036-$ or US-20050057812-$ or US-20170242263-$ or US-20150377711-$ or US-20100202040-$ or	(US-PGPUB; USPAT; DERWENT)	OR	OFF	OFF	2020/10/27 01:42 PM

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		US-20130038942-$ or US-20100195174-$ or US-20100099100-$ or US-20060239336-$).did. or (US-6695455-$ or US-7359120-$ or US-5933228-$ or US-7261417-$ or US-8149511-$).did. or (WO-2011138616-$).did.					
L127	14	L126 and (polymer or nickel)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/10/27 01:43 PM
L128	4	L126 and varnish	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/10/27 02:53 PM
L129	2	wo-2015120977-$.did.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/10/28 09:37 AM
L130	4	ep-1897700-$.did.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/05 02:30 PM
L131	40	lumenco-$.as.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:33 AM
L132	34	porras-soto-hector-andres.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:33 AM
L133	89	lange-howard-g$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:33 AM
L134	17	L133 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:33 AM
L135	200	raymond-mark-a$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:33 AM
L136	62	L135 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:33 AM
L137	2304	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	OFF	OFF	2020/11/16 06:34 AM

			IBM_TDB)				
L138	32733	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:34 AM
L139	47527	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:34 AM
L140	51178	L137 L138 L139	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:34 AM
L141	211	L140 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:34 AM
L142	122	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:34 AM
L143	4	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:34 AM
L144	27	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2020/11/16 06:34 AM
L145	7	15/162113	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	OFF	OFF	2022/06/22 01:42 PM

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			JPO; DERWENT; IBM_TDB)				
L146	45	lumenco-$.as.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L147	211	raymond-mark-a$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L148	44	porras-soto-hector-andres.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L149	92	lange-howard-g$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L150	20	L5 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L151	67	L3 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L152	3	(("20120098249") or ("20150183258") or ("6695455")).PN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 01:42 PM
L153	0	(13/322431).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L154	67	("20020021832" | "20020135177" | "20030103351" | "20040043203" | "20050135798" | "20060052152" | "20060082877" | "4164748" | "4480893" | "5012274" | "5616912" | "5695346" | "5731883" | "5835194" | "5924870" | "5933228" | "5959718" | "6091479" | "6177953" | "6224214" | "6481849" | "6781761" | "6859240" | "6943953" | "6984425" | "6995913" | "7002748" | "7016116" | "7038854" | "7057823" | "7083340" | "7149035" | "7151541" | "7153047" | "7164537").PN. OR ("7359120").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L155	7	(("5105306") or	(US-PGPUB; USPAT;	OR	ON	ON	2022/06/22

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		("6288842") or ("7261417") or ("9176266") or ("20020114078") or ("20100231860") or ("20120048847")).PN.	USOCR)				01:42 PM
L156	1	("20080258456").PN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 01:42 PM
L157	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L158	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L159	53935	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L160	5682414	L13 "114" L15	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L161	58638	L13 L14 L15	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L162	168	L17 and (securit$4 same (plane near4 (apart or spaced or spacing or distanc$3 or separat$4)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L163	1	("20130106092").PN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 01:42 PM
L164	1	(13/696680).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L165	13	("3912395" | "4033696" | "5321493" | "5554432").PN. OR ("5933228").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM

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L166	139	("0992151" | "1824353" | "1849036" | "1942841" | "20020012447" | "20020018299" | "20030002160" | "20040001604" | "20040076310" | "20040081799" | "20060227427" | "2268351" | "2355902" | "2432896" | "2888855" | "2992103" | "3122853" | "3264164" | "3312006" | "3357772" | "3463581" | "3643361" | "3811213" | "4185191" | "4417784" | "4498736" | "4756922" | "4765656" | "4892336" | "4892385" | "4920039" | "5232764" | "5254390" | "5623368" | "5695346" | "5712731" | "5723200" | "5812313" | "5886798" | "5995638" | "6060143" | "6195150" | "6256149" | "6288842" | "6301363" | "6329040" | "6381071" | "6424467" | "6712399" | "6726858" | "6751024" | "6761377" | "6819775" | "6856462" | "6870681" | "6900944" | "6935756").PN. OR ("7333268").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L167	85	("1475430" | "20060003295" | "20070165182" | "20070177131" | "20070211238" | "20070216518" | "20070229263" | "20070229928" | "20070241553" | "20070246933" | "20070274559" | "20080014378" | "20080037131" | "20080054621" | "20080079257" | "20080088859" | "20080160226" | "20080163994" | "20080182084" | "20080198468" | "20080216976" | "20080250954" | "20080258456" | "20080259416" |	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM

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		"20090001709" | "20090008923" | "20090008926" | "20090102605" | "20090115185" | "20090218397" | "20090236061" | "20090290221" | "20090297805" | "20090322071" | "20100175843" | "20100177094" | "20100182221" | "20100194091" | "20100194532" | "20100196587" | "20100207376" | "20100208036" | "20100307705" | "20100308570" | "20100320742" | "20110007374" | "20110012337" | "20110027538" | "20110045248" | "20110069360" | "20110079997" | "20110091665" | "20110095518" | "20110101670" | "20110109078" | "20110114733" | "20110157183" | "20120126525" | "20120168515" | "20120170124" | "4765656" | "5712731" | "5723200" | "5772250" | "6288842" | "6329040" | "6450540" | "7667894" | "7728931" | "7808605" | "7852557" | "7974006" | "7986459" | "8083894" | "8149511").PN. OR ("8400495").URPN.					
L168	0	(13/322431).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L169	42	("20100208036"|"7762591"|"20080036196"|"20100182221"|"20100194532"|"7738175"|"20080259456"|"20090122412"|"5177637"|"20080037131"|"20080160226"|"20090297805"|"20100165425"|"20080259456"|"20100109317"|"200900	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM

		08923"|"20090122412"|"20090008923"|"20090122412"|"20110045248").PN.					
L170	0	(11/922166).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L171	55	(securit$4 same (plane near4 (apart or spaced or spacing or distanc$3 or separat$4)) same (mirror$3 or reflect$4))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L172	28870	((plane near4 (apart or spaced or spacing or distanc$3 or separat$4)) same (mirror$3 or reflect$4))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L173	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L174	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L175	53935	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L176	58638	L29 L30 L31	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L177	267	L32 and L28	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L178	13	("3912395" | "4033696" | "5321493" | "5554432").PN. OR ("5933228").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L179	0	(10/021743).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM

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L180	20	("20050057812" | "5986811" | "6304263" | "6329963").PN. OR ("7261417").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L181	1	(10/728278).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L182	61	("3653742" | "3897997" | "3989357" | "5360973" | "5986811" | "6014259" | "6100862" | "6262841" | "6288842" | "6304263" | "6317108" | "6329963" | "6437920" | "6445509" | "6466185" | "6683725" | "RE27356").PN. OR ("7046447").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L183	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L184	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L185	53935	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L186	58638	L39 L40 L41	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L187	220	L42 and (securit$4 same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L188	466	(securit$4 same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM

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L189	246	L44 not L43	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L190	246	L45 and securit$4	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L191	15	("20030164814" | "20050248827" | "4710732" | "5468540" | "5818023" | "6233088" | "6421013" | "6504941" | "6545385" | "6775048" | "6807012" | "7006276" | "7116462" | "7136215" | "7283112").PN. OR ("8023175").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L192	1	(14/750403).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L193	1	("8149342").PN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 01:42 PM
L194	2	(("8149342") or ("20140049706")).PN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 01:42 PM
L195	3	(("8149342") or ("20140049706") or ("20110169919")).PN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 01:42 PM
L196	2	(("20040263970") or ("6501641")).PN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 01:42 PM
L197	112	(securit$4 same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L198	16205	((micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L199	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L200	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L201	53935	((B42D25/29 OR B42D25/21 OR B42D25/351 OR	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	OFF	OFF	2022/06/22 01:42 PM

		B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	IBM_TDB)				
L202	58638	L55 L56 L57	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L203	247	L58 and L54	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L204	1	(12/665834).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L205	85	("1475430" | "20060003295" | "20070165182" | "20070177131" | "20070211238" | "20070216518" | "20070229263" | "20070229928" | "20070241553" | "20070246933" | "20070274559" | "20080014378" | "20080037131" | "20080054621" | "20080079257" | "20080088859" | "20080160226" | "20080163994" | "20080182084" | "20080198468" | "20080216976" | "20080250954" | "20080258456" | "20080259416" | "20090001709" | "20090008923" | "20090008926" | "20090102605" | "20090115185" | "20090218397" | "20090236061" | "20090290221" | "20090297805" |	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM

		"20090322071" | "20100175843" | "20100177094" | "20100182221" | "20100194091" | "20100194532" | "20100196587" | "20100207376" | "20100208036" | "20100307705" | "20100308570" | "20100320742" | "20110007374" | "20110012337" | "20110027538" | "20110045248" | "20110069360" | "20110079997" | "20110091665" | "20110095518" | "20110101670" | "20110109078" | "20110114733" | "20110157183" | "20120126525" | "20120168515" | "20120170124" | "4765656" | "5712731" | "5723200" | "5772250" | "6288842" | "6329040" | "6450540" | "7667894" | "7728931" | "7808605" | "7852557" | "7974006" | "7986459" | "8083894" | "8149511").PN. OR ("8400495").URPN.					
L206	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L207	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L208	53935	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM

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		B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)					
L209	58638	L62 L63 L64	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L210	247	L65 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L211	2	(("8008613") or ("4793669")).PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L212	5	(("8008613") or ("4793669") or ("6928095") or ("20120170124") or ("20130265668")).PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L213	1	("20140268327").PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L214	6	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L215	4	((voxel$3) and ambient$4 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L216	27	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L217	33	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L218	127	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM

		same (imag$4 or display$4)					
L219	48195	(B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L220	127	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L221	5	L78 and L77	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L222	28870	((plane near4 (apart or spaced or spacing or distanc$3 or separat$4)) same (mirror$3 or reflect$4))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L223	179	L80 and L77	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L224	1	(15/588831).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L225	13	("20020114078" | "20080258456" | "20100231860" | "20120098249" | "20140268327" | "20150183258" | "5105306" | "5924870" | "6288842" | "6695455" | "7261417" | "9176266").PN. OR ("10317691").URPN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 01:42 PM
L226	45	lumenco-$.as.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L227	211	raymond-mark-a$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L228	44	porras-soto-hector-andres.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	OFF	OFF	2022/06/22 01:42 PM

			IBM_TDB)				
L229	92	lange-howard-g$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L230	20	L87 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L231	67	L85 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L232	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L233	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L234	53935	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L235	58638	L90 L91 L92	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L236	168	L93 and (securit$4 same (plane near4 (apart or spaced or spacing or distanc$3 or separat$4)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L237	48195	(B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378,	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM

		G02B27/0012).cpc.					
L238	28870	((plane near4 (apart or spaced or spacing or distanc$3 or separat$4)) same (mirror$3 or reflect$4))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L239	179	L96 and L95	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L240	127	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L241	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L242	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L243	53935	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L244	58638	L99 L100 L101	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L245	247	L102 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L246	75	L102 and (micro-mirror$3 or	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	OFF	OFF	2022/06/22 01:42 PM

		micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and metallization	JPO; DERWENT; IBM_TDB)				
L247	39	(US-20150183258-$ or US-20120098249-$ or US-20080112056-$ or US-20020114078-$ or US-20050180020-$ or US-20100208036-$ or US-20050057812-$ or US-20170242263-$ or US-20150377711-$ or US-20100202040-$ or US-20130038942-$ or US-20100195174-$ or US-20100099100-$ or US-20060239336-$).did. or (US-6695455-$ or US-7359120-$ or US-5933228-$ or US-7261417-$ or US-8149511-$).did. or (WO-2011138616-$).did.	(US-PGPUB; USPAT; DERWENT)	OR	OFF	OFF	2022/06/22 01:42 PM
L248	12	L105 and (nickel or tool$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L249	6	L106 and metallizat$4	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L250	3	16/203128	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L251	92	lange-howard-g$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L252	20	L109 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L253	211	raymond-mark-a$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L254	67	L111 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L255	127	((voxel$3) same (micro-mirror$3 or	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	OFF	OFF	2022/06/22 01:42 PM

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		micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	JPO; DERWENT; IBM_TDB)				
L256	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L257	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L258	53935	((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L259	58638	L114 L115 L116	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L260	247	L117 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L261	39	(US-20150183258-$ or US-20120098249-$ or US-20080112056-$ or US-20020114078-$ or US-20050180020-$ or US-20100208036-$ or US-20050057812-$ or US-20170242263-$ or US-20150377711-$ or US-20100202040-$ or US-20130038942-$ or US-20100195174-$ or US-20100099100-$ or US-20060239336-$).did. or (US-6695455-	(US-PGPUB; USPAT; DERWENT)	OR	OFF	OFF	2022/06/22 01:42 PM

		$ or US-7359120-$ or US-5933228-$ or US-7261417-$ or US-8149511-$).did. or (WO-2011138616-$).did.					
L262	12	L119 and (nickel or tool$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L263	6	L120 and metallizat$4	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L264	48195	(B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L265	28870	((plane near4 (apart or spaced or spacing or distanc$3 or separat$4)) same (mirror$3 or reflect$4))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L266	179	L123 and L122	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L267	75	L117 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and metallization	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L268	39	(US-20150183258-$ or US-20120098249-$ or US-20080112056-$ or US-20020114078-$ or US-20050180020-$ or US-20100208036-$ or US-20050057812-$ or US-20170242263-$ or US-20150377711-$ or US-20100202040-$ or US-20130038942-$ or US-20100195174-$ or US-20100099100-$ or US-20060239336-$).did. or (US-6695455-$ or US-7359120-$ or US-5933228-$ or US-7261417-$ or US-	(US-PGPUB; USPAT; DERWENT)	OR	OFF	OFF	2022/06/22 01:42 PM

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		8149511-$).did. or (WO-2011138616-$).did.					
L269	19	L126 and (polymer or nickel)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L270	4	L126 and varnish	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L271	2	wo-2015120977-$.did.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L272	4	ep-1897700-$.did.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L273	45	lumenco-$.as.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L274	44	porras-soto-hector-andres.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L275	92	lange-howard-g$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L276	20	L133 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L277	211	raymond-mark-a$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L278	67	L135 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L279	2744	359/851,852,853,855.ccls.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L280	37905	(b42d25/373 or b42d25/29 or b42d25/378 or g02b17/002 or g02b27/0012).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L281	53935	((B42D25/29 OR B42D25/21 OR	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	OFF	OFF	2022/06/22 01:42 PM

		B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)	JPO; DERWENT; IBM_TDB)				
L282	58638	L137 L138 L139	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L283	247	L140 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L284	127	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L285	6	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L286	33	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/06/22 01:42 PM
L287	1	(14/750403).APP.	(USPAT; USOCR)	OR	OFF	OFF	2022/06/22 02:01 PM
L288	33	(Artificial Intelligence) More Like: US-9851256-B2 Text: (US-6080988-A OR WO-2019126148-A1 OR US-20190186999-A1 OR US-10876899-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO,	OR	OFF	OFF	2022/06/22 02:01 PM

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		B2 OR US-10422698-B2 OR US-20180100768-A1 OR US-10900842-B2 OR JP-2001516441-A OR ES-2745225-T3 OR EP-3161438-A1 OR WO-2015200796-A1 OR US-10801896-B2 OR US-20200225092-A1 OR EP-3161438-B1 OR US-20150377711-A1 OR EP-3161438-A4 OR US-6339219-B1 OR DE-102011052336-A1 OR US-20210033470-A1 OR US-5929440-A).did.	MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L289	35	("3896309" | "5929440" | "6031619" | "6208413" | "6339219" | "6444972" | "6835932" | "7064883" | "7646494" | "7705307" | "7705309" | "7825381" | "8242446" | "8283256" | "8440972" | "8624187" | "20020036265" | "20060075803" | "20060131500" | "20070196944" | "20070296838" | "20080230698" | "20090001271" | "20090238236" | "20100148283" | "20110127073" | "20110159638" | "20110279681" | "20110291225" | "20120032082" | "20150061020").pn. OR ("9851256").urpn. AND (PGPB | USPT | USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2022/06/22 02:08 PM
L290	41	(Artificial Intelligence) More Like: US-20170242263-A1 Text: (CN-108027521-A OR US-10189294-B2 OR CN-107107646-A OR RU-2436158-C2 OR CN-103260893-B OR WO-2017095616-A1 OR EP-3362827-A1 OR US-20170157973-A1 OR CN-103260893-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA,	OR	OFF	OFF	2022/06/22 02:11 PM

		OR CN-102438838-B OR CN-102438838-A OR RU-2013120905-A OR RU-2599361-C2 OR WO-2012048847-A1 OR EP-2627520-A1 OR CN-110636946-B OR EP-3613600-A1 OR EP-3362827-A4 OR US-20190092084-A1 OR US-10317691-B2).did.	VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L291	1	17/152623	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/06/22 02:32 PM
L292	1	(10/728278).APP.	(USPAT; USOCR)	OR	ON	ON	2022/06/22 02:48 PM
L293	61	("3653742" | "RE27356" | "3897997" | "3989357" | "5360973" | "5986811" | "6014259" | "6100862" | "6262841" | "6288842" | "6304263" | "6317108" | "6329963" | "6437920" | "6445509" | "6466185" | "6683725").pn. OR ("7046447").urpn. AND (PGPB | USPT | USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 02:48 PM
L294	88	("2002376" | "4407567" | "4566939" | "4834512" | "5004319" | "5083857" | "5212555" | "5369433" | "5402407" | "5467121" | "5612736" | "5696619" | "5881034" | "5897195" | "5986811" | "6025951" | "6028689" | "6064423" | "6084843" | "6104425" | "6111900" | "6123985" | "6232936" | "6282213" | "6315423" | "6329737" | "6498673" | "6507366" | "6549730" | "6625342"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/06/22 02:59 PM

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		| "6649852" | "6650461" | "6658208" | "6711319" | "6741384" | "6784771" | "6833938" | "6885819" | "6900901" | "6900922" | "6906848" | "6906849" | "6914712" | "6919982" | "6934072" | "6934073" | "6943950" | "6958777" | "6970284" | "6995909" | "6999226" | "7023466" | "7031046" | "7046447" | "7068416" | "7077523" | "7161729" | "20020018407" | "20020102102" | "20020135673" | "20030007720" | "20030058520" | "20030071125" | "20030174234" | "20030184843" | "20040009683" | "20040012460" | "20040021802" | "20040052180" | "20040246362" | "20040252958" | "20050024736" | "20050057812" | "20050136663" | "20050174625" | "20050180019" | "20050212856" | "20050224695" | "20050225884" | "20050231792" | "20050264870" | "20060012766" | "20060012852" | "20060028709" | "20060187524" | "20060209439").pn. OR ("7474454").urpn. AND (PGPB | USPT | USOC).dbnm.					
L295	755	((359/851,852,853,855.ccls.) ((b42d25/373 OR b42d25/29 OR b42d25/378 OR g02b17/002 OR g02b27/0012).cpc.) ((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH,	OR	OFF	OFF	2022/06/23 06:51 AM

		B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)) AND (micro-mirror$3 OR micromirror$3 OR (micro near2 mirror$3) OR (mirror near2 array$4)) AND (imag$4 near3 plane$2)	TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L296	19	L295 AND (execut$4 near3 cod$4)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/06/23 07:08 AM
L297	1	("20120098249").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2022/06/23 08:35 AM
L298	0	wo-2013056825-did$	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/06/23 09:09 AM
L299	3	wo-2013056825-$.did.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2022/06/23 09:09 AM

			IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L300	39	(Artificial Intelligence) More Like: WO-2013056825-A1 Text: (CN-107107649-A OR DE-202015009514-U1 OR CN-110774796-A OR TW-200409190-A OR TW-594848-B OR RU-2017124615-A OR EP-2566703-B1 OR WO-2011138039-A1 OR EP-2566703-A1 OR CN-107107649-B OR EP-3230080-B1 OR WO-2006087138-A1 OR EP-1853763-A1 OR EP-1853763-B1 OR EP-2768660-A1 OR DE-102011116408-A1 OR DE-102014018512-A1 OR DE-202015009513-U1 OR EP-2321673-A1 OR WO-2010015383-A1).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/06/23 09:17 AM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N75	5	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4)).clm.	(USPAT)	OR	OFF	OFF	2018/10/29 01:37 PM
N76	6	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))).clm.	(USPAT)	OR	OFF	OFF	2018/10/29 01:38 PM
N145	12	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or	(USPAT)	OR	OFF	OFF	2020/11/16 06:33 AM

		(mirror near2 array$4))).clm.					
N146	10	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4)).clm.	(USPAT)	OR	OFF	OFF	2020/11/16 06:33 AM
N147	10	(((359/851,852,853,855.ccls.) ((b42d25/373 OR b42d25/29 OR b42d25/378 OR g02b17/002 OR g02b27/0012).cpc.) ((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)) AND (micro-mirror$3 OR micromirror$3 OR (micro near2 mirror$3) OR (mirror near2 array$4)) AND (imag$4 near3 plane$2)) AND (execut$4 near3 cod$4)	(US-PGPUB; USPAT)	OR	ON	ON	2022/06/23 11:28 AM
N148	92	(((359/851,852,853,855.ccls.) ((b42d25/373 OR b42d25/29 OR b42d25/378 OR g02b17/002 OR g02b27/0012).cpc.) ((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR	(US-PGPUB; USPAT)	OR	ON	ON	2022/06/23 11:31 AM

		G02B27/0012 OR G02B17/002).CPC.)) AND (micro-mirror$3 OR micromirror$3 OR (micro near2 mirror$3) OR (mirror near2 array$4)) AND (imag$4 near3 plane$2)) AND (securit$4)					
N149	47	(((micro-mirror$3 OR micromirror$3 OR (micro near2 mirror$3) OR (mirror near2 array$4)) AND (imag$4 near3 plane$2)) AND (securit$4)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/06/23 11:43 AM

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Application

US 17152623
US 15162113
EP 21184802
EP 16871264
PCT/US16/61845
US 15588831
PCT/US18/28241
US 16203128

Publication

Giesecke+Devrient GmbH,
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BIB DATA SHEET

CONFIRMATION NO. 9833

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
17/152,623	01/19/2021	359	2872	79897.01436

APPLICANTS

LUMENCO, LLC, Englewood, CO;

INVENTORS

MARK A. RAYMOND, LITTLETON, CO;
HECTOR ANDRES PORRAS SOTO, LITTLETON, CO;
HOWARD G. LANGE, SAN DIEGO, CA;

**** CONTINUING DATA ************************

This application is a CON of 16/203,128 11/28/2018 PAT 10901191
which is a DIV of 15/162,113 05/23/2016 PAT 10189294 *
which claims benefit of 62/262,767 12/03/2015
(*)Data provided by applicant is not consistent with PTO records.

**** FOREIGN APPLICATIONS ************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
02/22/2021

Foreign Priority claimed ❑ Yes ☑ No 35 USC 119(a-d) conditions met ❑ Yes ☑ No Verified and Acknowledged /JADE R CHWASZ/ Examiner's Signature	❑ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CO	20	20	3

ADDRESS

Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004
UNITED STATES

TITLE

METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

FILING FEE RECEIVED		
830	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	❑ All Fees ❑ 1.16 Fees (Filing) ❑ 1.17 Fees (Processing Ext. of time) ❑ 1.18 Fees (Issue) ❑ Other _____ ❑ Credit

BIB (Rev. 05/07).

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/152,623	Filing Date 01/19/2021	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	07/18/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $240 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/ANGELA S WHITE/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	
	)	
Mark A. Raymond	)	Group Art Unit: 2872
	)	
Application No.: 17/152,623	)	Examiner: Jade R. Chwasz
	)	
Filed: January 19, 2021	)	
	)	
Confirmation No.: 9833	)	**AMENDMENT IN RESPONSE TO NON-FINAL OFFICE ACTION**
	)	
Atty. File No.: 79897.01436	)	
	)	
For: "METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES"	)	

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Examiner:

In response to the non-final Office Action of June 30, 2022 ("the Office Action"), please amend the above-identified application as follows:

Amendments to the Claims are reflected in the listing of claims that begins on page 2 of this paper.

Remarks/Arguments begin on page 6 of this paper.

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AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all previous versions, and listings, of claims in the application:

Listing of Claims:

1. (CURRENTLY AMENDED) A method of fabricating a security element, comprising:

assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane;

with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane;

for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; [[and]]

generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors [[.]] ; and

forming the array of the micro mirrors according to the design output file.

2. (ORIGINAL) The method of claim 1, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.

3. (ORIGINAL) The method of claim 1 wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.

4. (ORIGINAL) The method of claim 3, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.

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5. (ORIGINAL) The method of claim 1, wherein the angular orientations are calculated based on heights of the first and second image display.

6. (ORIGINAL) The method of claim 1, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.

7. (CURRENTLY AMENDED) A method of fabricating a security element, comprising:

with a processor of a computing device, executing code to provide an array design module configured to select a set of micro mirrors in an array of the micro mirrors to display pixels of a first object in a first image display plane and to display pixels of a second object in a second image display plane spaced apart from the first image display plane;

for each of the pixels, determining, with the array design module, an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; [[and]]

generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors, wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of the micro mirrors [[.]] ; and

forming the array of the micro mirrors according to the design output file.

8. (ORIGINAL) The method of claim 7, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.

9. (ORIGINAL) The method of claim 7, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.

10. (ORIGINAL) The method of claim 7, wherein the angular orientations are calculated based on heights of the first and second image display.

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11. (ORIGINAL) The method of claim 7, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.

12. (CURRENTLY AMENDED) A method of fabricating a security element useful on paper and coin currency and on product labels, comprising:

with a processor of a computing device, executing code to provide an array design module configured to define an array of micro mirrors to be formed on a surface of a substrate; [[and]]

generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors[[,]] ; and

forming the array of micro mirrors according to the design output file,

wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate,

wherein the image comprises a plurality of pixels, and

wherein the array of micro mirrors includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels.

13. (ORIGINAL) The method of claim 12, wherein a voxel is created at each of the point on the plane via intersection of two or more beams of the reflected ambient light, and wherein each of the created voxels produces an effect of a point source of light floating above the surface of the substrate in the plane.

14. (ORIGINAL) The method of claim 12, wherein each of the different sets concurrently reflect the ambient light to concurrently generate the plurality of pixels.

15. (CURRENTLY AMENDED) The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by casting the micro mirrors with a mirror tool in contact with the surface of the substrate[[,]] .

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16. (ORIGINAL) The method of claim 15, wherein the substrate provided in the providing step comprises a clear, energy-cured polymer.

17. (ORIGINAL) The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by metallization of surfaces of the micro mirrors, wherein the metallization applies a layer of aluminum, gold, or silver to form reflective surfaces.

18. (ORIGINAL) The method of claim 17, wherein the forming the array of micro mirrors includes, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors and wherein the surface of the substrate includes an embossable coating or layer.

19. (ORIGINAL) The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by filling in recessed surfaces associated with the micro mirrors with a filler comprising at least one of an ultraviolet (UV) varnish, an e-beam solvent, and a water-based varnish.

20. (ORIGINAL) The method of claim 19, wherein the filler has a refractive index of at least 1.55, whereby at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image.

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REMARKS

Prior to this Amendment, claims 1-20 were pending in the application.

Claims 1, 7, and 12 are amended to address the indefiniteness rejection presented in the Office Action by adding a step as urged by the Office.

Claim 15 is amended to correct punctuation at the end of the claim.

After the Amendment is entered, claims 1-20 remain for consideration by the Examiner.

Allowable Subject Matter

Applicant thanks Examiner Chwasz for identifying claims 1-20 as reciting allowable subject matter. Particularly, in the Office Action independent claims 1, 7, and 12 were found to be allowable if rewritten or amended to overcome the indefiniteness rejections stated in the Office Action. For the sake of furthering prosecution of these claims to allowance, the claims are amended as suggested by the Examiner such that claims 1, 7, and 12 and claims 2-6, 8-11, and 13-20, which depend from these claims, should be in condition for allowance.

Applicant reserves the right to pursue canceled or forfeited claim scope and equivalents thereof in continuing applications.

Claim Rejections under 35 U.S.C. §112

In the Office Action, claims 1-20 were rejected under 35 U.S.C. §112(b) as being indefinite for failing to point out and distinctly claim the subject matter which the inventors regards as the invention.

Specifically, in the Office Action, independent claims 1, 7, and 12 were rejected under 35 U.S.C. §112(b) as being incomplete for omitting essential steps, such omission amounting to a gap between the steps. Applicant has amended the claims as suggested by the Examiner to include the step of "forming the array of micro mirrors according to the design output file" (or similar language) in each of these independent claims. With this change, Applicant believes claims 1-20 fully comply with 35 U.S.C. §112(b).

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Conclusions

Based upon the foregoing, Applicant believes that all pending claims are in condition for examination by the Office.

No fee is believed due with this Amendment. However, please credit any overpayment or charge any underpayment to Deposit Account No. 19-2814.

Respectfully submitted,

SNELL & WILMER L.L.P.

Date: July 18, 2022

By: /Kent A. Lembke/
Kent A. Lembke
Reg. No. 44,866
303-634-2149 Tel

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Electronic Acknowledgement Receipt	
EFS ID:	46211264
Application Number:	17152623
International Application Number:	
Confirmation Number:	9833
Title of Invention:	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES
First Named Inventor/Applicant Name:	MARK A. RAYMOND
Customer Number:	166539
Filer:	Kent Alan Lembke./Kayleigh Sandoval
Filer Authorized By:	Kent Alan Lembke.
Attorney Docket Number:	79897.01436
Receipt Date:	18-JUL-2022
Filing Date:	19-JAN-2021
Time Stamp:	13:47:20
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		79897-01436_Amendment_NFOA_7-6-22.pdf	142557 c386a884a87f275f1c4f808d367c9881e019b532	yes	7

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	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Request for Reconsideration-After Non-Final Rejection	1	1
	Claims	2	5
	Applicant Arguments/Remarks Made in an Amendment	6	7
Warnings:			
Information:			
	Total Files Size (in bytes):	142557	

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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166539 7590 08/01/2022

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One Arizona Center
Phoenix, AZ 85004

EXAMINER	
CHWASZ, JADE R	
ART UNIT	PAPER NUMBER
2872	

DATE MAILED: 08/01/2022

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/152,623	01/19/2021	MARK A. RAYMOND	79897.01436	9833

TITLE OF INVENTION: METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$600	$0.00	$0.00	$600	11/01/2022

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PTOL-85 (Rev. 02/11)

Giesecke+Devrient GmbH,
Giesecke+Devrient Currency Technology GmbH,
and Papierfabrik Louisenthal GmbH. - Ex. 1002

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

166539 7590 08/01/2022

Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/152,623	01/19/2021	MARK A. RAYMOND	79897.01436	9833

TITLE OF INVENTION: METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$600	$0.00	$0.00	$600	11/01/2022

EXAMINER	ART UNIT	CLASS-SUBCLASS
CHWASZ, JADE R	2872	359-851000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

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and Papierfabrik Louisenthal GmbH. - Ex. 1002

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

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OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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Notice of Allowability	Application No. 17/152,623	Applicant(s) RAYMOND et al.	
	Examiner JADE R CHWASZ	Art Unit 2872	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 7/18/22.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-20 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/JADE R CHWASZ/
Primary Examiner, Art Unit 2872

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Response to Amendment

2. The amendments to the claims, in the submission dated 7/18/22, are acknowledged and accepted.

Allowable Subject Matter

3. Claims 1-20 are allowed.

4. The following is an examiner's statement of reasons for allowance:

5. Claim 1 is allowable over the prior art of record for at least the reason that even though the prior art discloses a method of fabricating a security element, comprising: assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane; with a processor of a computing device, ***the prior art fails to teach or reasonably suggest,*** executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane; for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the

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micro mirrors and forming the array of the micro mirrors according to the design output file, in combination with the other limitations of claim 1.

6. Claims 2-6 are dependent on claim 1 and are allowable over the prior art of record for at least the same reasons as claim 1.

7. Claim 7 is allowable over the prior art for at least the reason that even though the prior art discloses a method of fabricating a security element, comprising: with a processor of a computing device, ***the prior art fails to teach or reasonably suggest,*** executing code to provide an array design module configured to select a set of micro mirrors in an array of the micro mirrors to display pixels of a first object in a first image display plane and to display pixels of a second object in a second image display plane spaced apart from the first image display plane; for each of the pixels, determining, with the array design module, an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors, wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of the micro mirrors; and forming the array of the micro mirrors according to the design output file, in combination with the other limitations of claim 7.

8. Claims 8-11 are dependent on claim 7 and are allowable over the prior art of record for at least the same reasons as claim 7.

9. Claim 12 is allowable over the prior art of record for at least the reason that even though the prior art discloses a method of fabricating a security element useful on paper

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and coin currency and on product labels, comprising: with a processor of a computing device, ***the prior art fails to teach or reasonably suggest,*** executing code to provide an array design module configured to define an array of micro mirrors to be formed on a surface of a substrate; generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors, and forming the array of micro mirrors according to the design output file, wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate, wherein the image comprises a plurality of pixels, and wherein the array of micro mirrors includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels, in combination with the other limitations of claim 12.

10. Claims 13-20 are dependent on claim 12 and are allowable over the prior art of record for at least the same reasons as claim 12.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

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Conclusion

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JADE R CHWASZ whose telephone number is (571)272-8199. The examiner can normally be reached 5:30 am to 3:00 pm, M-F.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephone Allen can be reached on 571-272-2434. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

JRC
/JADE R CHWASZ/
Primary Examiner, Art Unit 2872

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and Papierfabrik Louisenthal GmbH. - Ex. 1002**

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/152,623	RAYMOND et al.
	Examiner	**Art Unit**
	JADE R CHWASZ	2872

CPC							
Symbol						**Type**	**Version**
G02B	/	17	/	002		F	2013-01-01
B42D	/	25	/	425		I	2014-10-01
B42D	/	25	/	324		I	2014-10-01
B42D	/	25	/	351		I	2014-10-01
B42D	/	25	/	328		I	2014-10-01
B42D	/	25	/	29		I	2014-10-01
B42D	/	25	/	373		I	2014-10-01
B42D	/	25	/	378		I	2013-01-01
G02B	/	27	/	0012		I	2013-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	20	
/JADE R CHWASZ/ Primary Examiner, Art Unit 2872	22 July 2022	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20220722

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	17/152,623	RAYMOND et al.
	Examiner	**Art Unit**
	JADE R CHWASZ	2872

INTERNATIONAL CLASSIFICATION				
CLAIMED				
G02B17/00	/	17	/	00
B42D25/29	/	25	/	29
G02B27/00	/	27	/	00

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
359	851

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/JADE R CHWASZ/ Primary Examiner, Art Unit 2872	22 July 2022	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20220722

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	17/152,623	RAYMOND et al.
	Examiner	**Art Unit**
	JADE R CHWASZ	2872

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		10		19										
	2		11		20										
	3		12												
	4		13												
	5		14												
	6		15												
	7		16												
	8		17												
	9		18												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	20	
/JADE R CHWASZ/ Primary Examiner, Art Unit 2872	22 July 2022	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20220722

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
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✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/27/2022	07/22/2022							
	1	✓	=							
	2	✓	=							
	3	✓	=							
	4	✓	=							
	5	✓	=							
	6	✓	=							
	7	✓	=							
	8	✓	=							
	9	✓	=							
	10	✓	=							
	11	✓	=							
	12	✓	=							
	13	✓	=							
	14	✓	=							
	15	✓	=							
	16	✓	=							
	17	✓	=							
	18	✓	=							
	19	✓	=							
	20	✓	=							

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Giesecke+Devrient Currency Technology GmbH,
and Papierfabrik Louisenthal GmbH. - Ex. 1002

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/152,623	RAYMOND et al.
	Examiner	Art Unit
	JADE R CHWASZ	2872

CPC - Searched*		
Symbol	**Date**	**Examiner**
B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012	06/23/2022	JRC
B42D25/29, B42D25/21, B42D25/351, B42D25/23, B42D25/24, B42D25/41, B42D25/435, B42D25/00, B42D25/20, B42D25/40, B42D25/45, B42D2033/20, B42D2035/20, B42D2035/24, G02B27/0012, G02B17/00	06/23/2022	JRC

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**
359	851,852,853,855	06/22/2022	JRC

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/152,623	RAYMOND et al.
	Examiner	Art Unit
	JADE R CHWASZ	2872

Search Notes		
Search Notes	**Date**	**Examiner**
Inventor name/assignee search	06/22/2022	JRC
Information disclosure statement review	06/22/2022	JRC
Reviewed related applications 15/162113, 16/203128 for relevant search and prior art	06/22/2022	JRC
Global Dossier and IP.com NPL review	06/22/2022	JRC
B42D25/29, B42D25/21, B42D25/351, B42D25/23, B42D25/24, B42D25/41, B42D25/435, B42D25/00, B42D25/20, B42D25/40, B42D25/45, B42D2033/20, B42D2035/20, B42D2035/24, G02B27/0012, G02B17/00, B42D25/373, B42D25/328, B42D25/351, B42D25/324, B42D25/425, B42D25/29, G02B17/002, B42D25/378, G02B27/0012 with text in SEARCH	06/22/2022	JRC
359/851,852,853,855 with text in SEARCH	06/22/2022	JRC
Text search in SEARCH	06/22/2022	JRC
Updated search queries in SEARCH	07/20/2022	JRC

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	Interference search (see attached history)	06/23/2022	JRC
	Interference search (see attached history)	07/20/2022	JRC

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www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 9833

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
17/152,623	01/19/2021	359	2872	79897.01436

APPLICANTS

LUMENCO, LLC, Englewood, CO;

INVENTORS

MARK A. RAYMOND, LITTLETON, CO;
HECTOR ANDRES PORRAS SOTO, LITTLETON, CO;
HOWARD G. LANGE, SAN DIEGO, CA;

**** CONTINUING DATA ************************

This application is a CON of 16/203,128 11/28/2018 PAT 10901191
which is a DIV of 15/162,113 05/23/2016 PAT 10189294 *
which claims benefit of 62/262,767 12/03/2015
(*)Data provided by applicant is not consistent with PTO records.

**** FOREIGN APPLICATIONS ************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
02/22/2021

Foreign Priority claimed ❑ Yes ☑ No 35 USC 119(a-d) conditions met ❑ Yes ☑ No Verified and Acknowledged /JADE R CHWASZ/ Examiner's Signature	❑ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CO	20 ✓	20 ✓	3 ✓

ADDRESS

Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004
UNITED STATES

TITLE

METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

FILING FEE RECEIVED		
830	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	❑ All Fees ❑ 1.16 Fees (Filing) ❑ 1.17 Fees (Processing Ext. of time) ❑ 1.18 Fees (Issue) ❑ Other _____ ❑ Credit

BIB (Rev. 05/07).

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L301	250	L140 and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L302	127	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L303	6	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)) and (imag$4 near3 plane$2)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L304	33	((voxel$3) and (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L305	19	L295 AND (execut$4 near3 cod$4)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/07/20 10:10 AM
L306	70	L135 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L307	22	L133 and security	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM

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L308	215	raymond-mark-a$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L309	12	L105 and (nickel or tool$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L310	6	L106 and metallizat$4	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L311	94	lange-howard-g$.in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L312	226	L42 and (securit$4 same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L313	250	L44 not L43	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:10 AM
L314	127	((voxel$3) same (micro-mirror$3 or micromirror$3 or (micro near2 mirror$3) or (mirror near2 array$4))) same (imag$4 or display$4)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:11 AM
L315	182	L96 and L95	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	OFF	OFF	2022/07/20 10:11 AM
L316	79	(fabricat$4 AND (micromirror$3 OR micro-mirror$3 OR (micro near2 mirror$3)) AND design$3 AND (angular$3 OR angle$3)).clm.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/07/20 10:25 AM
L317	42	(fabricat$4 AND (micromirror$3 OR micro-mirror$3 OR	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2022/07/20 10:28 AM

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		(micro near2 mirror$3)) AND (design$3 SAME file$3) AND (angular$3 OR angle$3)) AND L282	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N150	47	(((micro-mirror$3 OR micromirror$3 OR (micro near2 mirror$3) OR (mirror near2 array$4)) AND (imag$4 near3 plane$2)) AND (securit$4)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/07/20 10:11 AM
N151	92	(((359/851,852,853,855.ccls.) ((b42d25/373 OR b42d25/29 OR b42d25/378 OR g02b17/002 OR g02b27/0012).cpc.) ((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)) AND (micro-mirror$3 OR micromirror$3 OR (micro near2 mirror$3) OR (mirror near2 array$4)) AND (imag$4 near3 plane$2)) AND (securit$4)	(US-PGPUB; USPAT)	OR	ON	ON	2022/07/20 10:11 AM
N152	10	(((359/851,852,853,855.ccls.) ((b42d25/373 OR b42d25/29 OR	(US-PGPUB; USPAT)	OR	ON	ON	2022/07/20 10:11 AM

		b42d25/378 OR g02b17/002 OR g02b27/0012).cpc.) ((B42D25/29 OR B42D25/21 OR B42D25/351 OR B42D25/23 OR B42D25/24 OR B42D25/41 OR B42D25/435 OR B42D25/00 OR B42D25/20 OR B42D25/40 OR B42D25/45 OR B42D2033/20 OR B42D2035/20 OR B42D2035/24 OR G02B27/0012 OR G02B17/002).CPC.)) AND (micro-mirror$3 OR micromirror$3 OR (micro near2 mirror$3) OR (mirror near2 array$4)) AND (imag$4 near3 plane$2)) AND (execut$4 near3 cod$4)					
N153	61	(fabricat$4 AND (micromirror$3 OR micro-mirror$3 OR (micro near2 mirror$3)) AND design$3 AND (angular$3 OR angle$3)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/07/20 10:26 AM
N154	4	(fabricat$4 AND (micromirror$3 OR micro-mirror$3 OR (micro near2 mirror$3)) AND (design$3 SAME file$3) AND (angular$3 OR angle$3)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/07/20 10:26 AM
N155	16	(fabricat$4 AND (micromirror$3 OR micro-mirror$3 OR (micro near2 mirror$3)) AND (design$3 SAME file$3) AND (angular$3 OR angle$3)) AND L282	(US-PGPUB; USPAT)	OR	ON	ON	2022/07/20 10:28 AM

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PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

166539 7590 08/01/2022
Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004

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I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/152,623	01/19/2021	MARK A. RAYMOND	79897.01436	9833

TITLE OF INVENTION: METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$600	$0.00	$0.00	$600	11/01/2022

EXAMINER	ART UNIT	CLASS-SUBCLASS
CHWASZ, JADE R	2872	359-851000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Snell & Wilmer L.L.P.
2 Kent A. Lembke
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: LUMENCO, LLC

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Englewood, CO

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ☒ Corporation or other private group entity ❑ Government

4a. Fees submitted: ☒ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

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☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Kent A. Lembke/ Date August 16, 2022

Typed or printed name Kent A. Lembke Registration No. 44866

Giesecke+Devrient GmbH,
Giesecke+Devrient Currency Technology GmbH,
and Papierfabrik Louisenthal GmbH. - Ex. 1002

Electronic Patent Application Fee Transmittal

Application Number:	17152623
Filing Date:	19-Jan-2021
Title of Invention:	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES
First Named Inventor/Applicant Name:	MARK A. RAYMOND
Filer:	Kent Alan Lembke./Kayleigh Sandoval
Attorney Docket Number:	79897.01436

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	600	600

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Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**600**

Electronic Acknowledgement Receipt	
EFS ID:	46419698
Application Number:	17152623
International Application Number:	
Confirmation Number:	9833
Title of Invention:	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES
First Named Inventor/Applicant Name:	MARK A. RAYMOND
Customer Number:	166539
Filer:	Kent Alan Lembke./Kayleigh Sandoval
Filer Authorized By:	Kent Alan Lembke.
Attorney Docket Number:	79897.01436
Receipt Date:	16-AUG-2022
Filing Date:	19-JAN-2021
Time Stamp:	12:31:49
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$600
RAM confirmation Number	E20228FC32563321
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

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and Papierfabrik Louisenthal GmbH. - Ex. 1002

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	79897-01436_IF_Transmittal.pdf	1267623 1acfa618c7093e7020f5c02bbb03b65b81440c42	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	38252 8b7857195304c1af730153b918674915ff2d937a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1305875		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17152623
	Filing Date	2021-01-19
	First Named Inventor	Mark A. Raymond
	Art Unit	
	Examiner Name	
	Attorney Docket Number	79897.01436

/J.R.C/ Change(s) applied to document, /A.C./ /J.R.C/ 8/8/2022	2	20100231860	A1	2010-09-16	SATOSHI, MAEKAWA	
	3	20120098249	A1	2012-04-26	~~GIESECKE & DEVRIENT GMBH~~ Rahm et al.	
/J.R.C/	4	20150183258	A1	2015-07-02	~~LUMENCO, LLC~~ Raymond et al.	
/J.R.C/	5	20140268327	A1	2014-09-18	DUNN, ET AL	
/J.R.C/	6	20100208036	A1	2010-08-19	KAULE, WITTICH	
/J.R.C/	7	20130038942	A1	2013-02-14	HOLMES, BRIAN WILLIAM	
/J.R.C/	8	20050057812	A1	2005-03-17	RABER, PETER E.	
/J.R.C/	9	20080112056	A1	2008-05-15	RAYMOND ET AL	
/J.R.C/	10	20080258456	A1	2008-10-23	RAHM, ET AL	
/J.R.C/	11	20080258457	A1	2008-10-23	COMMANDER, LAWRENCE GEORGE	

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.R.C/

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17152623
Filing Date	2021-01-19
First Named Inventor	Mark A. Raymond
Art Unit	
Examiner Name	
Attorney Docket Number	79897.01436

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/J.R.C/	1	5105306	A	1992-04-14	OHALA, JOHN J.	
/J.R.C/	2	6288842	B1	2001-09-11	FLORCZAK, JEFFREY M.	
/J.R.C/	3	7261417	B2	2007-08-28	GYOUNG, CHO ET AL	
Change(s) applied to document, /A.C./ 8/8/2022 /J.R.C/	4	9176266	B2	2015-11-03	~~GIESECKE & DEVRIENT GMBH~~ Fuhse et al.	
/J.R.C/	5	6695455	B1	2004-02-24	INDUSTRIAL TECHNOLOGY ~~RESEARCH~~ INSTITUTE Su	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/J.R.C/	1	20020114078	A1	2002-08-22	HALLE, MICHAEL ET AL	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.R.C/

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United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/152,623	09/20/2022	11448863	79897.01436	9833

166539 7590 08/31/2022

Snell & Wilmer (Denver)
400 East Van Buren Street
One Arizona Center
Phoenix, AZ 85004

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 109 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PAIR WEB site http://pair.uspto.gov for additional inventors):

MARK A. RAYMOND, LITTLETON, CO;
HECTOR ANDRES PORRAS SOTO, LITTLETON, CO;
HOWARD G. LANGE, SAN DIEGO, CA;

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

LUMENCO, LLC, Englewood, CO;

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IR103 (Rev. 10/09)

DocuSign Envelope ID: E1B80B47-F9E5-4359-8E91-C85D0FCB794F

Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	17/152,623
Filing Date	01/19/2021
First Named Inventor	Mark A. Raymond
Title	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES
Art Unit	2872
Examiner Name	JADE R CHWASZ
Attorney Docket Number	1530-007USC1

SIGNATURE of Applicant or Patent Practitioner

Signature	/KEEGAN CALDWELL/	Date (Optional)	
Name	Keegan Caldwell	Registration Number	73731
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ *Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Document Description: Power of Attorney

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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date
17/152,623	01/19/2021

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 145340

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Lumenco, LLC

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	DocuSigned by: Mark A. Raymond E4F84E6A2078467...	Date (Optional)	
Name	Mark A. Raymond		
Title	Chief Executive Officer		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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POWER OF ATTORNEY BY APPLICANT

No more than ten (10) patent practitioners total may be appointed as set forth below by name and registration number. This page need not be submitted if appointing the Patent Practitioner(s) associated with a Customer Number (see form PTO/AIA/82B):

Name	Registration Number

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The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
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8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt	
EFS ID:	48352051
Application Number:	17152623
International Application Number:	
Confirmation Number:	9833
Title of Invention:	METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES
First Named Inventor/Applicant Name:	MARK A. RAYMOND
Customer Number:	166539
Filer:	Keegan M. Caldwell/Rachel Riley
Filer Authorized By:	Keegan M. Caldwell
Attorney Docket Number:	79897.01436
Receipt Date:	26-JUL-2023
Filing Date:	19-JAN-2021
Time Stamp:	13:37:59
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	1530-007USC1_POA.pdf	201779 c41f88a7ec3a85dfb401f0d023536aa1ebb97517	no	4

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Information:	
Total Files Size (in bytes):	201779

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/152,623	01/19/2021	MARK A. RAYMOND	79897.01436

CONFIRMATION NO. 9833

145340
Caldwell Intellectual Property Law
200 Clarendon Street
59th Floor
Boston, MA 02116

POA ACCEPTANCE LETTER

OC000000060076844

Date Mailed: 08/02/2023

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 07/26/2023.

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/sltorres/

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APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/152,623	**03/18/2024 02:44:13 PM Z ET**	**1530-007USC1**

Title of Invention

METHOD OF FABRICATING ARRAYS OF INDIVIDUALLY ORIENTED MICRO MIRRORS FOR USE IN IMAGING SECURITY DEVICES

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	11448863
CONFIRMATION #	9833	FILED BY	JANELLA STONE
PATENT CENTER #	64727369	FILING DATE	01/19/2021
CUSTOMER #	145340	FIRST NAMED INVENTOR	MARK A. RAYMOND
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Bryan Fuller

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
012942-00007_POA.pdf	1	Power of Attorney	1154 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
012942-00007_POA.pdf	6448B8E7BE2DD3DC0430984BB2E4B9EC99E9AD5A4366CB56A902603580DB95802623159F8CEA72B5A552E72F89CC47E3384F16BFFE65B45EC992FDF3E916F849

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If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
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Application Number	Filing Date
17152623	01/19/2021

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☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 72766

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

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OR

☐ The address associated with Customer Number: 72766

OR

☐	Firm or Individual Name				
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

LUMENCO, LLC

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	/Mark Raymond/	Date (Optional)	
Name	MARK RAYMOND		
Title	CEO		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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United States Patent and Trademark Office
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/152,623	01/19/2021	MARK A. RAYMOND	1530-007USC1

CONFIRMATION NO. 9833

145340
Caldwell Intellectual Property Law
200 Clarendon Street
59th Floor
Boston, MA 02116

POWER OF ATTORNEY NOTICE

OC000000070331689

Date Mailed: 03/28/2024

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/18/2024.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/snguyen/

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/152,623	01/19/2021	MARK A. RAYMOND	1530-007USC1

CONFIRMATION NO. 9833

72766
Hall Estill Hardwick Gable Golden & Nelson, P.C.
100 North Broadway
Suite 2900
Oklahoma City, OK 73102

POA ACCEPTANCE LETTER

OC000000070331775

Date Mailed: 03/28/2024

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/18/2024.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

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/snguyen/