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I, Harald Gigas, pursuant to 28 U.S.C. § 1746, hereby declare as follows:

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2. I submit this declaration to certify the accuracy of the English translation of DE 10 2007 044 597.2.

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4. I certify that the attached document translated from German to the English language is a true, correct, and complete translation of the corresponding source text from DE 10 2007 044 597.2.

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I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. Executed on August 21, 2024, at Ansonia, CT.


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Description

Optoelectronic device

[0001] The present invention relates to an optoelectronic device that can emit electromagnetic radiation during operation and has a desired color impression in the switched-off state.

[0002] At least one object of certain embodiments of the present invention is therefore to specify an optoelectronic device with a wavelength conversion layer that can reduce or avoid an undesired color impression in a switched-off state.

[0003] This object is achieved by the scope having the features of the independent claim.

Advantageous embodiments and further embodiments of the scope are characterized in the dependent claims and are illustrated in the following description and the drawings.

[0004] An optoelectronic device according to an embodiment of the invention comprises in particular an organic layer sequence, which in operation emits electromagnetic radiation having a first spectrum, as well as a structured layer disposed downstream of the organic layer sequence in the beam path of the electromagnetic radiation emitted by the organic layer sequence and comprises first and second regions. The first regions each have a wavelength conversion layer configured to at least partially convert electromagnetic radiation with the first wavelength spectrum into electromagnetic radiation with a second wavelength spectrum. Furthermore, the second regions each comprise a filter layer that is at least partially opaque to electromagnetic radiation with a third wavelength spectrum that corresponds to at least a part of the second wavelength spectrum.

[0005] In particular, an observer can in this case detect the electromagnetic radiation emitted when the optoelectronic device is in operation. This can substantially correspond to a superimposition of the electromagnetic radiation with the first wavelength spectrum emitted by the second regions, and to the electromagnetic radiation with the second wavelength spectrum emitted by the wavelength conversion layer of the first regions.

[0006] When the optoelectronic device is in operation, the electromagnetic radiation with the first wavelength spectrum is emitted by the organic layer sequence and impinges on the first and second regions of the structured layer. In the first regions, the electromagnetic radiation with the first wavelength spectrum is at least partially converted, but is in different embodiments completely converted into electromagnetic radiation with the second wavelength spectrum. Although the respective filter layers in the second regions are opaque to electromagnetic radiation with the third wavelength spectrum that corresponds to at least a part of the second wavelength spectrum, they are preferably transmissive to electromagnetic radiation with the first wavelength spectrum. In the overall impression of the electromagnetic radiation emitted by the optoelectronic device, the first and second wavelength spectrums are therefore superimposed.

[0007] In at least one embodiment, the structured layer is physically and/or chemically bonded to the organic layer sequence. This means in particular that the structured layer is applied to the organic layer sequence, for example with an adhesive, preferably with a transparent adhesive, or a gel that is adjusted with respect to its refractive index, or has chemical, for example covalent, bonds to the organic layer sequence.

[0008] In different embodiments of the invention, the structure of the structured layer can comprise striped, crossed striped, i.e. lattice-like, circular, triangular or rectangular, i.e. chequered regions, or regions of any geometry as a combination of the above-mentioned geometric forms. The structure of the structured layer can further comprise irregular patterns of regions, in particular patterns, wherein the first and second regions have variable dimensions and forms. In other words, a pattern of the structured layer is formed by a respective special arrangement of the first and second regions. The regions of the structured layer are preferably disposed laterally or side by side in the beam path of the optoelectronic device.

[0009] The dimensions of the regions, for example the resolution of the regions of the structured layer, can be in the order of magnitude of less than 1 mm, preferably in the order of magnitude of 100 μm to several 100 μm , and further preferably in the order of magnitude of less than 100 μm . In particular for light applications that do not use the optoelectronic device in combination with optical imaging technology or devices, it may be sufficient to impose only moderate requirements on the dimensions of the regions of the structured layer.

[0010] In a further embodiment of the invention, “wavelength spectrum” or “spectrum” or “partial spectrum” refers to a spectral distribution of electromagnetic radiation with at least one spectral portion having one wavelength, or to a plurality of spectral portions having a plurality of wavelengths and/or ranges of wavelengths. A first spectrum and a second spectrum are hereinafter the same when the spectral portions and their relative intensities are the same for the first and the second spectrum, wherein the absolute intensity of the first spectrum can deviate from the absolute intensity of the second spectrum.

[0011] In one embodiment of the invention, “partially” denotes a partial spectrum of a spectrum, for example of the first spectrum. In particular, the partial spectrum of a spectrum can consist of a portion of the spectral portions of that spectrum. Furthermore, “partially” can also refer to a part of an intensity of a spectrum or partial spectrum.

[0012] In another embodiment of the invention, “converting” can mean that the partial spectrum of electromagnetic radiation with the first spectrum, which is at least partially converted by the wavelength conversion layer into electromagnetic radiation with the second spectrum, and the second spectrum is not the same. This can in particular mean that the second spectrum has a spectral distribution different from the spectral distribution of the partial spectrum of the electromagnetic radiation with the first spectrum.

[0013] Furthermore, a wavelength conversion layer can have an absorption spectrum and an emission spectrum, wherein the absorption spectrum and the emission spectrum are advantageously not the same. The absorption spectrum preferably comprises the partial spectrum of the electromagnetic radiation with the first spectrum and the emission spectrum comprises the second spectrum. In particular, the absorption spectrum and the emission spectrum can each comprise additional spectral portions that are not contained in the partial spectrum of the electromagnetic radiation with the first spectrum or the second spectrum.

[0014] If electromagnetic radiation with a specific wavelength is now incident from the outside or from the active region of the semiconductor layer sequence onto the wavelength conversion layer and the absorption spectrum has a spectral component with said specific wavelength that can be absorbed by the wavelength conversion layer, the electromagnetic radiation with said specific wavelength is emitted again, or re-emitted as electromagnetic radiation with one or more other wavelengths different from said specific wavelength, wherein said other wavelengths are included in the emission spectrum. An electromagnetic radiation with the second wavelength spectrum is thus generated in the wavelength conversion layer from electromagnetic radiation with the first wavelength spectrum.

When radiation is incident from the outside onto the optoelectronic device and when the optoelectronic device is in a switched off state, it can then in particular also be the case that the wavelength conversion layer can - based on its absorption spectrum and its emission spectrum due to radiation incident from the outside onto the optoelectronic device, which can be reflected or emitted by a described absorption and re-emission process - create a color impression that may in and of itself be undesirable for an observer. This color impression can be undesirable, for example, because it can differ from the color impression of the electromagnetic radiation emitted during operation of the optoelectronic device.

[0015] In this respect, the filter layer can be particularly advantageous because the filter layer is opaque to a portion of the radiation incident from the outside of the optoelectronic device, wherein this portion substantially corresponds to a wavelength range of the second wavelength spectrum. The remaining part of the incident electromagnetic radiation, which can pass through the filter layer, is for example reflected in the organic layer sequence by the filter layer or by the organic layer sequence or an electrode, and is emitted back to the outside through the filter layer and/or the wavelength conversion layer. Preferably, the part of the electromagnetic radiation for which the filter layer is transmissive corresponds to electromagnetic radiation with a wavelength range of the first wavelength spectrum. Thus, even in the switched-off state, there is a superimposition of electromagnetic radiation with a wavelength range of the first wavelength spectrum and an electromagnetic radiation with the wavelength range of the second wavelength spectrum, thus achieving a desired, preferably non-yellowish color impression.

[0016] In different embodiments of the invention, the filter layer is configured to convert the electromagnetic radiation with the third wavelength spectrum into electromagnetic radiation from a non-visible wavelength range. For example, electromagnetic radiation from a yellow wavelength range is converted in the filter layer into electromagnetic radiation from an infrared wavelength range. The filter layer is preferably transparent to electromagnetic radiation with the first wavelength spectrum.

[0017] In other words, the filter layer is configured to convert electromagnetic radiation with the third wavelength spectrum into heat or heat radiation, while electromagnetic radiation with the first wavelength spectrum can preferably pass through the filter layer unhindered. This means in particular that the electromagnetic radiation emitted by the organic layer sequence during operation remains substantially unaffected by the filter layer.

[0018] The filter layer is thus for example configured to absorb the electromagnetic radiation with the third wavelength spectrum. For this purpose, the filter layer can have a molecular filter in different exemplary embodiments. The filter layer can therefore also be understood in different exemplary embodiments as an absorption layer for electromagnetic radiation with the third wavelength spectrum.

[0019] Such an embodiment can in particular be advantageous for applications that use light-emitting devices with organic light-emitting diodes (OLEDs), for example as a flashlight in mobile phone applications with camera. For example, such light-emitting devices can have blue OLEDs and a phosphorus conversion substance. It may be that the phosphorus conversion substance is visible from the outside through a transparent cover or a lens when such a light-emitting device is not in operation, which can lead to an undesired color impression, for example for aesthetic reasons. Such an undesired color impression can be reduced by Fresnel optics or micro lens arrays, but a disturbing color impression can still be retained.

[0020] Alternatively or additionally, the first spectrum can for example also have a green wavelength range, and the second spectrum can have a red wavelength range, thus also permitting a white illumination impression for an observer when the optoelectronic device is in operation. In particular, the first spectrum, the second spectrum, and the part of the radiation incident from the outside onto the optoelectronic device and reflected, and that is not filtered by the filter layer, can also be selected according to another desired color impression, when the optoelectronic device is in operation and in the switched-off state, respectively.

[0021] The organic layer sequence can furthermore in particular be configured as an organic light-emitting diode (OLED). An OLED can have an organic layer or a layer sequence having at least one organic layer, with an active region that can emit electromagnetic radiation during operation. An OLED can further comprise a first electrode and a second electrode, wherein the organic layer or the layer sequence can be disposed with at least one organic layer with the active region between the first and second electrode. The first and the second electrode can be suitable for injecting “holes” or electrons into the active region, which can recombine there while electromagnetic radiation is emitted.

[0022] The first electrode can furthermore be disposed on a substrate. The organic layer or the layer sequence with one or more functional layers made of organic materials can be applied above the first electrode. The functional layers, which can comprise the active region, can for example comprise electron transport layers, electroluminescent layers and/or hole transport layers. The second electrode can be applied above the functional layers or above the at least one organic layer.

[0023] For example, the substrate can comprise glass, quartz, plastic films, metal, metal films, silicon wafers or any other suitable substrate material. For example, the substrate can also be configured as a layer sequence or laminate of several layers. If the semiconductor layer sequence is configured as a so-called “bottom emitter”, i.e. the electromagnetic radiation generated in the active area can be emitted through the substrate, the substrate can advantageously have transparency for at least a part of the electromagnetic radiation. The wavelength conversion layer and the filter layer can be disposed on a side of the substrate facing away from the semiconductor layer sequence.

[0024] According to at least one embodiment, at least one of the electrodes has, or consists of, a transparent conductive oxide, a metal, or a conductive organic material.

[0025] In the bottom-emitter configuration, the first electrode can advantageously be transparent to at least a portion of the electromagnetic radiation. A transparent first electrode - which can be embodied as an anode and thus can act as a material injecting positive charges or “holes” - can, for example, comprise a transparent conductive oxide or consist of a transparent conductive oxide.

Transparent conductive oxides (TCOs) are transparent, conductive materials, usually metal oxides such as zinc oxide, tin oxide, cadmium oxide, titanium oxide, indium oxide or indium tin oxide (ITO). In addition to binary metal oxygen compounds, such as ZnO, SnO₂, or In₂O₃, ternary metal oxygen compounds, such as Zn₂SnO₄, CdSnO₃, ZnSnO₃, MgIn₂O₄, GaInO₃, Zn₂In₂O₅, or In₄Sn₃O₁₂, or mixtures of different transparent conductive also belong to the group of TCOs. Furthermore, the TCOs do not necessarily have to correspond to a stoichiometric composition and can also be p- or n-doped. Alternatively or additionally, the first electrode can also comprise a metal, for example silver.

[0026] The semiconductor layer sequence with at least one organic layer can comprise polymers, oligomers, monomers, organic small molecules (“organic small molecules”) or other organic non-polymer compounds, or combinations thereof. In particular, it can be advantageous if a functional layer of the layer sequence is configured as a hole transport layer in order to enable an effective hole injection into an electroluminescent layer or an electroluminescent region. Such structures concerning the active area or the further functional layers and areas are known to the person skilled in the art in particular with regard to materials, design, function and structure and are therefore not explained in more detail here.

[0027] The second electrode can be configured as a cathode and can thus act as an electron-inducing material. Among other things, aluminum, barium, indium, silver, gold, magnesium, calcium or lithium as well as compounds, combinations and alloys thereof can prove to be advantageous as the cathode material. Additionally or alternatively, the second electrode can also be configured as a transparent embodiment. This means in particular that the OLED can also be configured as a “top emitter” such that the electromagnetic radiation generated in the active region can be emitted on the side of the semiconductor layer sequence facing away from the substrate. The wavelength conversion layer and the filter layer can be disposed above the semiconductor layer sequence and in particular above the second electrode.

[0028] If an electrode comprising or consisting of the metallic layer is configured to be transmissive to the light emitted by the organic layer stack, it can be advantageous if the metallic layer is formed sufficiently thin. The thickness of such a semi-transparent metallic layer is preferably between 1 nm and 100 nm, wherein the boundaries are enclosed.

[0029] The first electrode can furthermore be configured as a cathode and the second electrode as an anode, wherein the semiconductor layer sequence can be configured as a bottom or top emitter. The semiconductor layer sequence can also be configured simultaneously as a top emitter and as a bottom emitter.

[0030] As an active region, the semiconductor layer sequence can for example have a conventional pn transition, a double heterostructure, a single quantum well structure (SQW structure) or a multiple quantum well structure (MQW structure). In addition to the active region, the semiconductor layer sequence can comprise further functional layers and functional regions, such as p- or n-doped charge carrier transport layers, i.e. electron or hole transport layers, p- or n-doped confinement or cladding layers, buffer layers and/or electrodes, as well as combinations thereof. Such structures concerning the active area or the further functional layers and areas are known to the person skilled in the art in particular with regard to design, function and structure and are therefore not explained in more detail here.

[0031] In a further embodiment, the wavelength conversion layer has at least one wavelength conversion substance. The wavelength conversion material can for example comprise particles from the group of CER-doped garnets, in particular CER-doped Yttrium Aluminum Garnet ($\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Ce}$, YAG:Ce), CER-doped Terbium Aluminum Garnet (TAG:Ce), CER-doped Terbium Yttrium Aluminum Garnet (TbYAG:Ce), CER-doped Gadolinium Yttrium Aluminium Garnet (GdYAG:Ce) and CER-doped Gadolinium Terbium Yttrium Aluminum Garnet (GdTbYAG:Ce). Other possible wavelength conversion materials can be the following, for example:

[0032] Garnets of rare earths and alkaline earth metals, as described for example in publication US 2004062699 A1, the disclosure content of which is included in this regard by reference,

[0033] Nitrides, Siones, and Sialones, as described for example in publication DE 10147040 A1, the disclosure content of which is included in this regard by reference,

[0034] Orthosilicates, Sulfides, and Vanadates, as described for example in publication WO 00/33390 A1, the disclosure content of which is included in this regard by reference,

[0035] Chlorosilicates, as described in publication DE 10036940 A1, for example, whose disclosure content is included in this regard by reference, and

[0036] Aluminates, Oxides, Halophosphates, as described for example in publication US 6,616,862 B2, the disclosure content of which is included in this regard by reference.

[0037] The wavelength conversion layer can furthermore also comprise suitable mixtures and combinations of said wavelength conversion materials.

[0038] The wavelength conversion layer can further comprise a transparent matrix material, wherein the wavelength conversion material can be embedded in, or chemically bonded to, the matrix material. The transparent matrix material can for example have a transparent plastic, such Silicones, Epoxies, Acrylates, Imides, Carbonates, Olefins or derivatives thereof. The wavelength conversion layer can be configured as a foil. In addition, the wavelength conversion layer can also be applied to a substrate that comprises, for example, glass or transparent plastic.

[0039] In a further embodiment of the invention, the second regions each have a scattering layer configured to transmit or emit electromagnetic radiation, in particular light, which impacts the layer directional, non-directional, i.e. with different directions.

[0040] The organic layer sequence usually emits directional electromagnetic radiation, i.e. the electromagnetic radiation emitted by the organic layer sequence primarily has a single direction that is substantially perpendicular to the layer arrangement of the organic layer sequence. The wavelength conversion layer can in different exemplary embodiments emit the electromagnetic radiation non-directional or isotropically. The scattering layer also causes the electromagnetic radiation with the first spectrum that is emitted by the organic layer sequence to also be emitted in a non-directional manner. Thus, a superimposition of respectively non-directional electromagnetic radiation results when the isotropically emitted electromagnetic radiation is superimposed with the second spectrum and the electromagnetic radiation scattered by the scattering layer is superimposed with the first spectrum. This advantageously leads to a uniform light impression of the optoelectronic device.

[0041] The scattering layer can be disposed downstream of the filter layer in the beam path of the electromagnetic radiation emitted by the organic layer sequence. Alternatively, the filter layer of the scattering layer can also be disposed downstream in the beam path of the electromagnetic radiation emitted by the organic layer sequence. The filter layer and the scattering layer can again alternatively be combined with one another in the second regions.

[0042] In a further exemplary embodiment, a directional electromagnetic radiation can also be emitted by the wavelength conversion layer. In this case in particular, it can be useful to provide a scattering layer that is disposed downstream of the structured layer, i.e. the first and the second regions, in the beam path of the electromagnetic radiation emitted by the organic layer sequence. Directed light or directional electromagnetic radiation from the first and second regions is in turn converted into non-directional radiation by the scattering layer. This can, for example, lead to a more pleasant color impression for an observer.

[0043] The scattering can be achieved in different exemplary embodiments in that the scattering layer has a roughened surface. In other exemplary embodiments, the scattering layer can comprise reflective particles for scattering that reflect incident light, for example at respectively different emission angles. The reflective particles can for example be formed by quartz glass, titanium dioxide, aluminum oxide, or similar transparent particles. The particles preferably have a particle size in the range of about 100 nm to a few μm . The particles are preferably embedded in a matrix, for example a foil or a silicone matrix. Alternatively, other transparent plastics can also be used as carrier material for the reflective particles.

[0044] In a further embodiment of the invention, the optoelectronic device comprises a second wavelength conversion layer disposed downstream of the first regions and/or the second regions in the beam path of the electromagnetic radiation emitted by the organic layer sequence. The second wavelength conversion layer is configured to at least partially convert electromagnetic radiation from a wavelength range that is below a wavelength range of the first spectrum into electromagnetic radiation from the wavelength range of the first spectrum. Converting the electromagnetic radiation from the wavelength range below the wavelength range of the first spectrum - and thus usually in an invisible wavelength range - to the wavelength range of the first spectrum can accordingly amplify the intensity of the electromagnetic radiation in the wavelength range of the first spectrum when electromagnetic radiation is incident from the outside onto the optoelectronic device. The light converted by the second wavelength conversion layer can be reflected by the second region as a function of the selected embodiment and emitted to the outside and/or can be converted in the first regions with the first wavelength conversion layer to electromagnetic radiation with a wavelength range corresponding to the second wavelength spectrum. The second wavelength conversion layer is preferably configured to convert electromagnetic radiation from an ultraviolet (UV) wavelength range into electromagnetic radiation from a blue wavelength range.

[0045] Thus, given an optoelectronic device according to one of the embodiments that is irradiated with sunlight, a UV portion of the sunlight can firstly be converted into electromagnetic radiation

from a blue wavelength range, which alone or together with a subsequent electromagnetic radiation converted into a yellow wavelength range increases an intensity of the illuminating impression of the optoelectronic device.

[0046] In a further exemplary embodiment of the invention, the first regions each comprise a second filter layer disposed downstream of the first wavelength conversion layer in the second regions in the beam path of the electromagnetic radiation emitted by the organic layer sequence. The second filter layer is at least partially opaque to electromagnetic radiation with a fourth wavelength spectrum that corresponds to at least a part of the first wavelength spectrum. The second filter layer can advantageously achieve that less or no electromagnetic radiation from a wavelength range that corresponds to the absorption spectrum of the first wavelength conversion layer is converted in this wavelength conversion layer into electromagnetic radiation with the second wavelength spectrum. The intensity of the electromagnetic radiation with the second wavelength spectrum emitted by the wavelength conversion layer can thus be reduced. This can lead to a less yellowish color impression of the optoelectronic device.

[0047] In different embodiments, the second filter layer can be configured to at least partially absorb the electromagnetic radiation with the fourth spectrum. Alternatively or additionally, the second filter layer can also be configured to at least partially reflect the electromagnetic radiation with the fourth spectrum.

[0048] For different exemplary embodiments of the invention in which the organic layer sequence is configured as a top emitter structure, the optoelectronic device can have an encapsulation disposed upstream or downstream of the structured layer in the beam path of the electromagnetic radiation emitted by the organic layer sequence. In other words, the structured layer can be encapsulated together with the organic layer sequence or can alternatively lie outside an encapsulation of the organic layer sequence. The encapsulation can be configured as a thin-film encapsulation.

[0049] The second wavelength conversion layer can have a similar structure to the first wavelength conversion layer. In particular, corresponding conversion substances can be provided in the second wavelength conversion layer, which, however, are configured in their arrangement and/or composition and/or concentration to the absorption spectrum and emission spectrum desired in the second wavelength conversion layer.

[0050] The filter layers can also be configured as corresponding conversion layers, wherein the respective portions of electromagnetic radiation to be filtered are respectively preferably converted into electromagnetic radiation from a non-visible wavelength range, preferably an infrared wavelength range. Alternatively, the filter layers can also be configured as pigment-based filters that have corresponding color pigments for filtering.

[0051] Further advantages and advantageous embodiments and further embodiments of the scope according to the invention can be seen in the exemplary embodiments described below in conjunction with the figures.

[0052] These show in

[0053] Figures 1A and 1B schematic illustrations of an optoelectronic device according to an exemplary embodiment during operation and in the switched-off state,

[0054] Figure 2 a first exemplary spectral diagram,

[0055] Figure 3 different embodiments of a structured layer,

[0056] Figures 4A, 4B and 4C schematic illustrations of an optoelectronic device according to further exemplary embodiments,

[0057] Figure 5 a schematic illustration of an optoelectronic device according to a further exemplary embodiment,

[0058] Figure 6 a schematic illustration of an optoelectronic device according to a further exemplary embodiment,

[0059] Figure 7 a schematic illustration of an optoelectronic device according to a further exemplary embodiment, and

[0060] Figure 8 a second exemplary spectral diagram.

[0061] In the exemplary embodiments and figures, components with the same or identical functioning are each labeled with the same reference symbols. The depicted elements and their sizes in relation to each other are categorically not considered to be to scale; individual elements, such as layers, can instead be illustrated at an exaggerated thickness for better illustration and/or for better comprehension.

[0062] Figures 1A and 1B show an exemplary embodiment for an optoelectronic device. In connection with Figure 1A, the optoelectronic device is described during operation, while Figure 1B shows the optoelectronic device in the switched-off state. The following description can refer equally to Figures 1A and 1B.

[0063] The optoelectronic device has an organic layer sequence 1 and an electrode 10 and an active region 11. The organic layer sequence 1 can have functional layers or layer sequences as stated in the general part of the description and is for example configured as an OLED. The active region 11 of the organic layer sequence 1 is in particular suitable for emitting electromagnetic radiation 15 having a first wavelength spectrum.

[0064] A structured layer comprising a first region 2A and a second region 2B is disposed in the beam path of the electromagnetic radiation 15 with the first wavelength spectrum. The first region 2A has a wavelength conversion layer 3 comprising a wavelength conversion substance 32. As illustrated in the exemplary embodiment, the wavelength conversion substance 32 can for example be embedded in a matrix material 31. The second region 2B comprises a fourth layer 4.

[0065] The wavelength conversion substance 32 is suitable for at least partially converting a partial spectrum of the electromagnetic radiation 15 with the first wavelength spectrum into electromagnetic radiation 16 with a second wavelength spectrum. In particular materials that have an absorption spectrum that contains at least one spectral component, in particular a wavelength range that is also contained in the first wavelength spectrum, can be suitable for the wavelength conversion substance 32. The absorbed electromagnetic radiation can then preferably be re-emitted with a wavelength other than the electromagnetic radiation 15 with the first wavelength spectrum.

[0066] The filter layer 4 is opaque to electromagnetic radiation with a third wavelength spectrum corresponding to at least a part of the second wavelength spectrum. In this exemplary embodiment, the electromagnetic radiation 15 with the first wavelength spectrum can pass through the filter layer 4 unhindered and substantially without changing its spectral portions. In other words, the filter layer 4 is transparent for electromagnetic radiation 15 with the first wavelength spectrum.

[0067] For example, spectral portions of an electromagnetic radiation 17 corresponding to the third wavelength spectrum and incident from the outside onto the optoelectronic device are converted into an electromagnetic radiation from a non-visible wavelength range (not illustrated in the present illustration for reasons of clarity). A remaining portion of spectral portions of the electromagnetic radiation 17 is alternatively reflected as electromagnetic radiation 18 or is transmitted through the filter layer 4 into the organic layer sequence 1, wherein in this case, this electromagnetic radiation 18 is reflected on the electrode 10 back through the filter layer 4. For example, the wavelength range of the electromagnetic radiation 18 corresponds to the wavelength range of the first wavelength spectrum of the electromagnetic radiation 15 emitted by the organic layer sequence. The electromagnetic radiation 15 or the electromagnetic radiation 18 can comprise a blue wavelength range.

[0068] In the first region 2A or in the conversion layer 3, spectral portions of the electromagnetic radiation 17 that correspond to the wavelength range of the first wavelength spectrum or the absorption spectrum of the wavelength conversion layer 3 are converted by the wavelength conversion substance 32 into electromagnetic radiation 16 with the second wavelength spectrum.

[0069] According to the exemplary embodiment illustrated in Figure 1A, the electromagnetic radiation emitted by the optoelectronic device while the device is in operation thus comprises components of the electromagnetic radiation 15 with the first wavelength spectrum, portions of the electromagnetic radiation 16 with the second wavelength spectrum, which results from the conversion of the electromagnetic radiation 15, portions of the electromagnetic radiation 18 filtered through the filter layer 4, and portions of the electromagnetic radiation 16a resulting from the conversion of the incident electromagnetic radiation 17. This advantageously results in an electromagnetic radiation from a yellow wavelength range combined with an electromagnetic radiation from a blue wavelength range, which results in a desired, for example whitish, emission characteristic.

[0070] As illustrated in the exemplary embodiment in Figure 1B, electromagnetic radiation 17 is again incident onto the device from the outside when the optoelectronic device is in the switched-off state. As described above, the electromagnetic radiation 17 is converted in the wavelength conversion layer 3 into electromagnetic radiation 16A, and the incident electromagnetic radiation 17 is filtered in the filter layer 4, resulting in the filtered electromagnetic radiation 18. Combining a yellowish portion of the electromagnetic radiation 16A and a blueish portion of the electromagnetic radiation 18 thus results in a non-yellow, preferably whitish, color impression for an observer of the optoelectronic device when the latter is in the switched-off state.

[0071] Figure 2 shows an exemplary spectral diagram with different transmission characteristics or emission characteristics as a function of a wavelength λ . An emission characteristic or an emission spectrum ES for example represents a spectral profile of the electromagnetic radiation 15 emitted by the organic layer sequence 1. The emission spectrum ES comprises a blue wavelength range. A conversion spectrum CS represents the wavelength spectrum emitted by the wavelength conversion layer 3, which is for example based on electromagnetic radiation 16, 16A. The conversion spectrum CS therefore comprises a yellow wavelength range or a red-green wavelength range. The profile labeled TS1 indicates a transmission spectrum of the filter layer 4. Accordingly, the filter layer 4 is transmissive to blue light and thus for the electromagnetic radiation 15 emitted by the organic layer sequence 1, while electromagnetic radiation with a yellow wavelength range or a red and green wavelength range is opaque. When the filter layer 4 is irradiated, for example with sunlight, which approximately has spectral portions in all visible wavelength ranges, a yellowish portion or reddish and greenish portion is thus filtered out. A yellowish color impression of the optoelectronic device can thus be reduced or avoided.

[0072] Figure 3 shows different exemplary embodiments of arrangements of first and second regions 2A, 2B. In a first pattern P1, the first and second regions 2A, 2B are disposed in stripe fashion, wherein a width of the respective stripes can influence a color impression of the optoelectronic device. In a second pattern P2, the first and second regions 2A, 2B are disposed in crossed striped fashion or in lattice-shaped fashion. In a third pattern P3, the first regions are disposed in a circular manner within the second regions 2B. In a further exemplary pattern P4, the first and second regions 2A, 2B have a square shape, thus for example resulting in a chequered pattern. In addition to the exemplary patterns illustrated here, the first and second regions 2A, 2B can also be provided in other forms or in a combination of these and other forms.

[0073] Figs. 4A, 4B and 4C show further exemplary embodiments of an optoelectronic device whose principal functioning corresponds to the exemplary embodiment according to Figs. 1A and 1B. The second regions each comprise a scattering layer 5 disposed downstream of the filter layer 4 in the beam path of the electromagnetic radiation 15 in Figure 4A, disposed upstream of the filter layer 4 in Figure 4B, and combined with the filter layer 4 in Figure 4C. The following description can refer equally to Figures 4A, 4B and 4C.

[0074] Electromagnetic radiation 15 emitted by the organic layer sequence 1 is usually emitted as directional radiation. When the electromagnetic radiation 15 impinges on the wavelength conversion substance 32 in the wavelength conversion layer 3, the radiation is absorbed and re-emitted as electromagnetic radiation 16 with the second spectrum. The re-emission occurs non-directional, i.e. the emission direction of the emitted radiation 16 occurs isotropically, for example. However, the electromagnetic radiation 15 passes through the filter layer 4 without any change in direction. In order to avoid a combination of directional and non-directional electromagnetic radiation, the scattering layer 5 for example comprises scattering particles 51, which cause a change in direction of the electromagnetic radiation 15 such that the latter is emitted as non-directional electromagnetic radiation 15a, 15b. A more homogenous, more uniform color impression can thus be realized for the optoelectronic device. The scattering layer 5 for example comprises a matrix material into which the reflective particles 51 are embedded. The particles can be formed from any transparent scattering material such as aluminum oxide, titanium dioxide or quartz glass.

[0075] The scattering effect of the scattering layer 5 also applies to an incident electromagnetic radiation 17 not illustrated here or to a reflected, filtered electromagnetic radiation 18. The scattering layer preferably has the same emission characteristic as the wavelength conversion layer 3.

[0076] Figure 5 shows a further exemplary embodiment of an optoelectronic device, wherein a scattering layer 5 is provided above the wavelength conversion layer 3 and also above the filter layer 4. In this exemplary embodiment, for example, the wavelength conversion layer 3 is configured to emit the electromagnetic radiation 16 with the second spectrum in a directional form. In this case, electromagnetic radiation exits from the wavelength conversion layer 3 and also from the filter layer 4 in a directional form. A scattering of the radiation 15, 16 in non-directional radiation 15A, 15B, 16A, 16B occurs through the scattering layer 5 in the beam path of this electromagnetic radiation. This in turn leads to a homogenous color impression of the optoelectronic device.

[0077] In this exemplary embodiment, the scattering layer also comprises reflective particles 51, which correspond in structure and function to the particles 51 of the exemplary embodiments illustrated in Figures 4A, 4B and 4C.

[0078] In further exemplary embodiments, the scattering layer 5 can also be realized as a layer with a roughened surface, wherein the electromagnetic radiation 15, 16 is in this case scattered by the roughened surface of the scattering layer 5. In this case, the provision of particles 51 is not mandatory.

[0079] Figure 6 shows a further exemplary embodiment of an optoelectronic device, wherein a second wavelength conversion layer 6 is disposed downstream of the organic layer sequence 1 and the structured layer 2. The second wavelength conversion layer 6 is configured to at least partially convert electromagnetic radiation from a wavelength range that is below a wavelength range of the first spectrum into electromagnetic radiation from the wavelength range of the first spectrum. For example, the second wavelength conversion layer 6 can convert electromagnetic radiation from an ultraviolet wavelength range into a blue wavelength range of the first spectrum.

[0080] In principle, the second conversion layer 6 has a construction or composition similar to the first wavelength conversion layer 3, wherein the absorption spectra and emission spectra of the first and second wavelength conversion layer 3, 6 each differ from one another. The second wavelength conversion layer 6 therefore for example comprises an absorption spectrum from the ultraviolet wavelength range and an emission spectrum from the blue wavelength range.

[0081] For example, when the optoelectronic device is in operation or in the switched-off state, electromagnetic radiation 17, for example sunlight, is incident on the second wavelength conversion layer 6 of the device. The spectral portions from the ultraviolet wavelength range of the electromagnetic radiation 17, which correspond to the absorption spectrum of the second wavelength conversion layer 6, are thus converted into electromagnetic radiation 19 according to the emission spectrum of the second wavelength conversion layer 6. Other spectral portions of the electromagnetic radiation 17 that do not correspond to the absorption spectrum of the second wavelength conversion layer 6 can, for example, pass substantially without being altered through the layer 6, wherein this is not illustrated in Figure 6 for reasons of clarity.

[0082] Since the emission spectrum of the wavelength conversion layer 6 substantially corresponds to the absorption spectrum of the first wavelength conversion layer 3, the electromagnetic radiation 19 in the first wavelength conversion layer 3 is converted into electromagnetic radiation 16 with the second spectrum and emitted. The electromagnetic radiation 19 can be reflected in the filter layer 4. Alternatively or additionally, the electromagnetic radiation 19 can also be allowed to pass through into the organic layer sequence 1 as electromagnetic radiation 19A with the same or altered wavelength spectrum, where it is reflected toward the outside, for example on the electrode 10. Since the converted electromagnetic radiation 16 from a yellow wavelength range and the converted electromagnetic radiation 19 or 19A from a blue wavelength range are emitted jointly, these radiation components in turn result in a whitish color impression of the optoelectronic device, in the switched-off state and also in the switched-on state.

[0083] In further embodiments, the second wavelength conversion layer 6 can also be disposed only above the first regions 2A or only above the second regions 2B.

[0084] In a further exemplary embodiment in Figure 7, a second filter layer of the first wavelength conversion layer 3 is disposed downstream in the beam path of the electromagnetic radiation 15 emitted by the organic layer sequence. The second filter layer 7 is opaque to electromagnetic radiation with a fourth wavelength spectrum that corresponds to at least a part of the first wavelength spectrum. This can advantageously prevent electromagnetic radiation with spectral portions from the absorption spectrum of the first wavelength conversion layer 3 from entering the wavelength conversion layer 3 from outside the optoelectronic device. Accordingly, these spectral portions also cannot be converted into electromagnetic radiation with the second wavelength spectrum. This leads to a reduction in the emission of electromagnetic radiation from a yellowish wavelength range.

[0085] The second filter layer 7 can, for example, reflect the electromagnetic radiation with the fourth spectrum. Alternatively or additionally, the second filter layer 7 can also absorb the electromagnetic radiation with the fourth spectrum. For example, the second filter layer 7 has a spectral characteristic complementary to the first filter layer 4.

[0086] In the exemplary embodiment in Figure 7, the electromagnetic radiation 15 emitted by the organic layer sequence is converted in the wavelength conversion layer 3 into electromagnetic radiation 16 with the second spectrum. Incident electromagnetic radiation 17 is for example reflected without being altered on the second filter layer 7, or is transmitted such that an electromagnetic radiation 20 with a remaining spectrum is incident on the first wavelength conversion layer 3. However, since the electromagnetic radiation 20 has substantially no spectral portions from the absorption spectrum of the wavelength conversion layer 3, converted electromagnetic radiation cannot be re-emitted.

[0087] Figure 8 shows a further exemplary spectral diagram with transmission or emission spectra. The emission spectrum ES of the organic layer sequence 1 and the conversion spectrum CS of the first wavelength conversion layer 3 for example correspond to the spectral profiles illustrated in Figure 2. A transmission spectrum TS2 represents the exemplary spectral profile of the second filter layer 7. The second filter layer is therefore opaque to electromagnetic radiation with the emission spectrum of the organic layer sequence, which substantially corresponds to the absorption spectrum of the wavelength conversion layer 3.

[0088] An optoelectronic device according to one of the exemplary embodiments illustrated can, for example, be suitable as a component for a flashlight, for a mobile phone application with a camera. Such an optoelectronic device can also be suitable for illumination devices.

[0089] The invention is not limited to this by the descriptions based on the exemplary embodiments. Rather, the invention comprises every new feature and every combination of features, which in particular includes every combination of features in the claims, even if this feature or combination itself is not explicitly specified in the patent claims or exemplary embodiments. In particular, the different embodiments of the scattering layers, the second wavelength conversion layer and the second filter layer can be combined with one another as desired in the optoelectronic device.

Claims

1. An optoelectronic device, comprising
 - an organic layer sequence (1) that during operation emits electromagnetic radiation (15) having a first wavelength spectrum;
 - a structured layer (2) disposed downstream of the organic layer sequence (1) in the beam path of the electromagnetic radiation (15) emitted by the organic layer sequence (1) and comprising first and second regions (2A, 2B); wherein
 - the first regions (2A) each have a wavelength conversion layer (3) configured to at least partially convert electromagnetic radiation with the first wavelength spectrum into electromagnetic radiation (16) with a second wavelength spectrum; and
 - the second regions (2B) each comprise a filter layer (4), which is at least partially opaque to electromagnetic radiation with a third wavelength spectrum corresponding to at least a part of the second wavelength spectrum.
2. The optoelectronic device as claimed in Claim 1, wherein the filter layer (4) is transparent for the electromagnetic radiation (15) with the first wavelength spectrum.
3. The optoelectronic device as claimed in Claim 1 or 2, wherein the first wavelength spectrum comprises a blue wavelength range and the second wavelength spectrum comprises a yellow wavelength range.

4. The optoelectronic device as claimed in any of Claims 1 through 3, wherein the optoelectronic device in a switched-off state generates a non-yellowish color impression for an observer.

5. The optoelectronic device as claimed in any of Claims 1 through 4, wherein the filter layer (4) is configured to convert the electromagnetic radiation with the third wavelength spectrum into electromagnetic radiation from a non-visible wavelength range.

6. The optoelectronic device as claimed in Claim 5, wherein the filter layer (4) is configured to absorb the electromagnetic radiation with the third wavelength spectrum.

7. The optoelectronic device as claimed in Claim 5 or 6, wherein the filter layer (4) comprises a molecular filter.

8. The optoelectronic device as claimed in any of Claims 1 through 7, wherein the wavelength conversion layer (3) comprises at least one of the following:

- an organic dye;
- an inorganic dye;
- perylene;
- kumarin;
- a fluorescent dye.

9. The optoelectronic device as claimed in any of Claims 1 through 8, wherein the wavelength conversion layer (3) comprises at least one wavelength conversion substance (32) from the group of the garnets.

10. The optoelectronic device as claimed in to Claim 9, wherein the wavelength conversion substance (32) is embedded in a matrix material (31) and the matrix material (31) comprises a transparent plastic.

11. The optoelectronic device as claimed in any of Claims 1 through 10, wherein the wavelength conversion layer (3) is formed as a foil.

12. The optoelectronic device as claimed in any of Claims 1 through 11, wherein the second regions (2B) each have a scattering layer (5).

13. The optoelectronic device as claimed in to Claim 12, wherein the scattering layer (5) of the filter layer (4) is disposed downstream in the beam path of the electromagnetic radiation (15) emitted by the organic layer sequence (1).

14. The optoelectronic device as claimed in to Claim 12, wherein the filter layer (4) of the scattering layer (5) is disposed downstream in the beam path of the electromagnetic radiation (15) emitted by the organic layer sequence (1).

15. The optoelectronic device as claimed in to Claim 12, wherein the filter layer (4) and the scattering layer (5) are combined with one another in the second regions (2B).

16. The optoelectronic device as claimed in any of Claims 1 through 11, wherein a scattering layer (5) is provided that is disposed downstream of the structured layer (2) in the beam path of the electromagnetic radiation (15) emitted by the organic layer sequence (1).

17. The optoelectronic device as claimed in any of Claims 12 through 16, wherein the scattering layer (5) comprises a roughened surface.

18. The optoelectronic device as claimed in any of Claims 12 through 17, wherein the scattering layer (5) comprises reflective particles (51).

19. The optoelectronic device as claimed in Claim 18, wherein the reflective particles (51) comprise at least one of the following:

- quartz glass;
- titanium dioxide;
- aluminum oxide.

20. The optoelectronic device as claimed in any of Claims 1 through 19, comprising a second wavelength conversion layer (6), disposed downstream of the first regions (2A) and/or the second regions (2B) in the beam path of the electromagnetic radiation (15) emitted by the organic layer sequence (1), and configured to at least partially convert electromagnetic radiation from a wavelength range that is below a wavelength range (15) of the first wavelength spectrum into electromagnetic radiation from the wavelength range of the first wavelength spectrum.

21. The optoelectronic device as claimed in to Claim 20, wherein the second wavelength conversion layer (6) is configured to convert electromagnetic radiation from an ultraviolet wavelength range into electromagnetic radiation from a blue wavelength range.

22. The optoelectronic device as claimed in any of Claims 1 through 21, wherein the first regions (2A) each have a second filter layer (7) disposed downstream of the wavelength conversion layer (3) in the beam path of the electromagnetic radiation (15) emitted by the organic layer sequence (1) and which is at least partially opaque to electromagnetic radiation with a fourth wavelength spectrum corresponding to at least a part of the first wavelength spectrum.

23. The optoelectronic device as claimed in Claim 22, wherein the second filter layer (7) is configured to at least partially absorb the electromagnetic radiation with the fourth wavelength spectrum.

24. The optoelectronic device as claimed in Claim 22 or 23, wherein the second filter layer (7) is configured to at least partially reflect the electromagnetic radiation with the fourth wavelength spectrum.

25. The optoelectronic device as claimed in any of Claims 1 through 24, wherein the organic layer sequence (1) is configured as a bottom-emitter structure.

26. The optoelectronic device as claimed in any of Claims 1 through 24, wherein the organic layer sequence (1) is configured as a top emitter structure.

27. The optoelectronic device as claimed in Claim 26, comprising an encapsulation disposed upstream or downstream of the structured layer (2) in the beam path of the electromagnetic radiation (15) emitted by the organic layer sequence (1).

28. The optoelectronic device as claimed in Claim 27, wherein the encapsulation is configured as a thin-film encapsulation.

29. The optoelectronic device as claimed in any of Claims 1 through 28, wherein the electromagnetic radiation emitted by the optoelectronic device and perceived by an observer corresponds to a superimposition of the electromagnetic radiation (15) with the first wavelength spectrum and the electromagnetic radiation (16) with the second wavelength spectrum.

30. The optoelectronic device as claimed in any of Claims 1 through 29, wherein the structured layer (2) comprises striped or crossed striped or circular or triangular or rectangular regions, or a combination of the said regions.

31. The optoelectronic device as claimed in any of Claims 1 through 30, wherein the first and second regions (2A, 2B) of the structured layer (2) are disposed laterally in the beam path of the optoelectronic device.

Abstract

Optoelectronic device

An optoelectronic device comprises an organic layer sequence (1), which in operation emits electromagnetic radiation (15) having a first wavelength spectrum, as well as a structured layer (2) disposed downstream of the organic layer sequence (1) in the beam path of the electromagnetic radiation (15) emitted by the organic layer sequence (1) and comprises first and second regions (2A, 2B). The first regions (2A) each have a wavelength conversion layer (3) configured to at least partially convert electromagnetic radiation (15) with the first wavelength spectrum into electromagnetic radiation (16) with a second wavelength spectrum. Furthermore, the second regions (2B) each have a filter layer (4) opaque to electromagnetic radiation with a third wavelength spectrum that corresponds to at least a part of the second wavelength spectrum.

Significant figure: Figure 1A

FIG. 1A

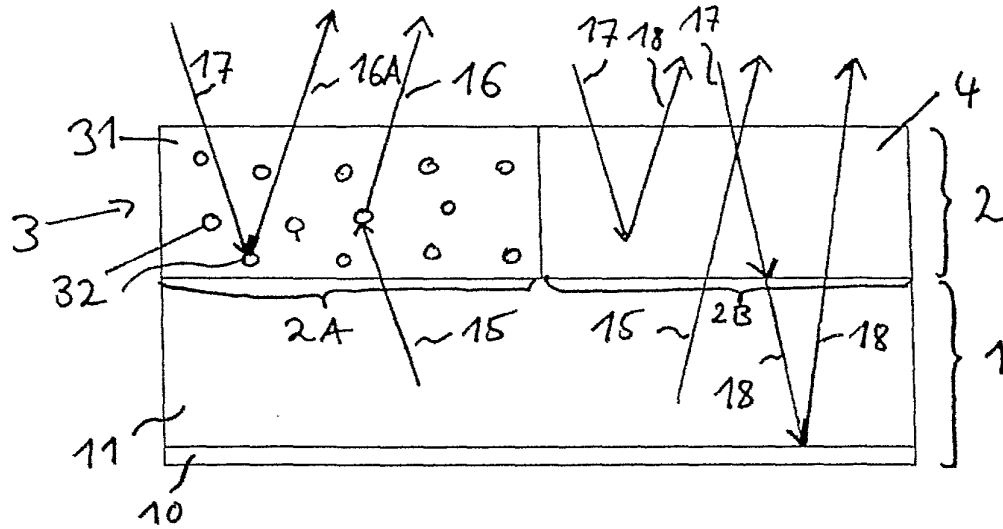


FIG. 1B

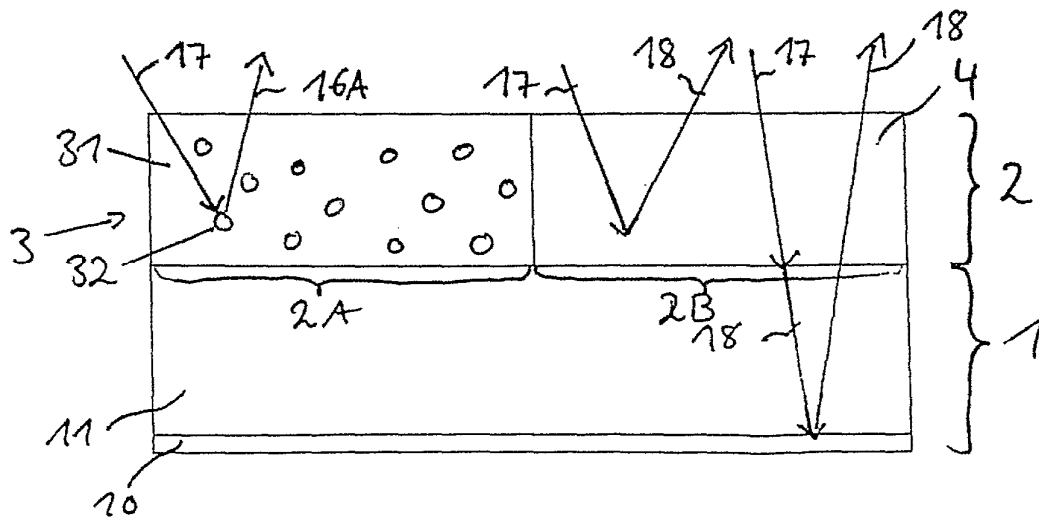


FIG 2

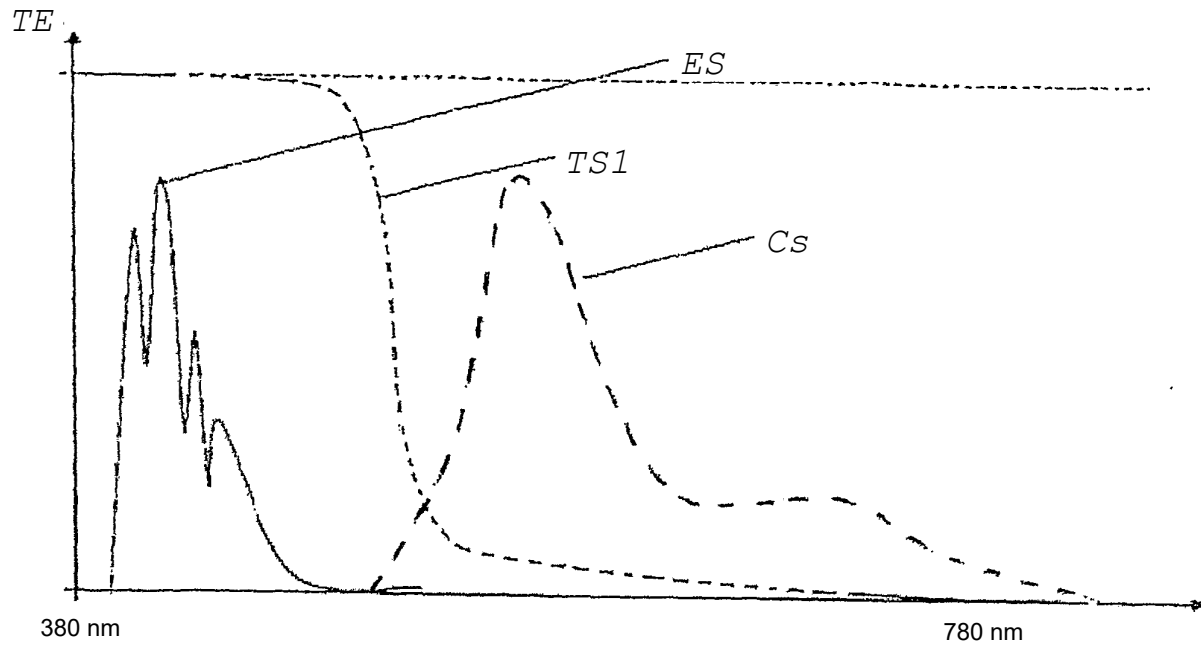


FIG 3

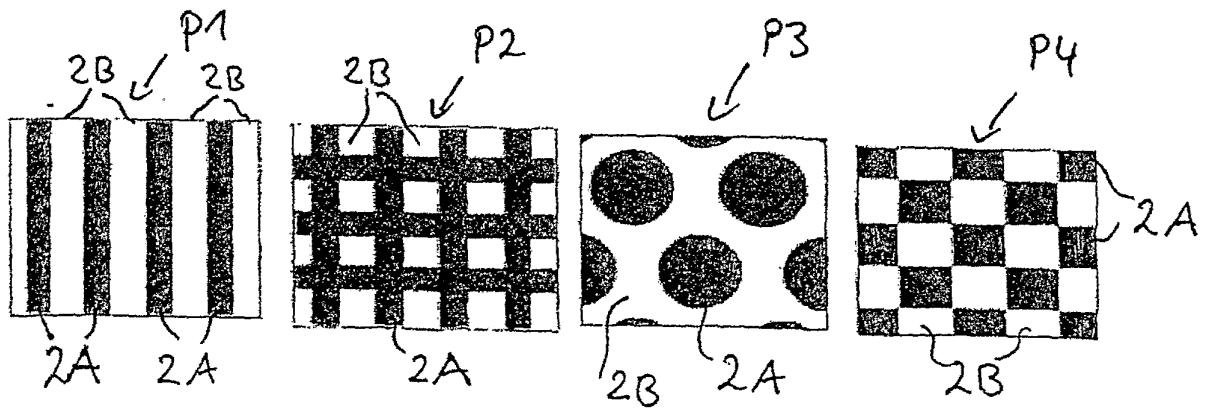


FIG 4A

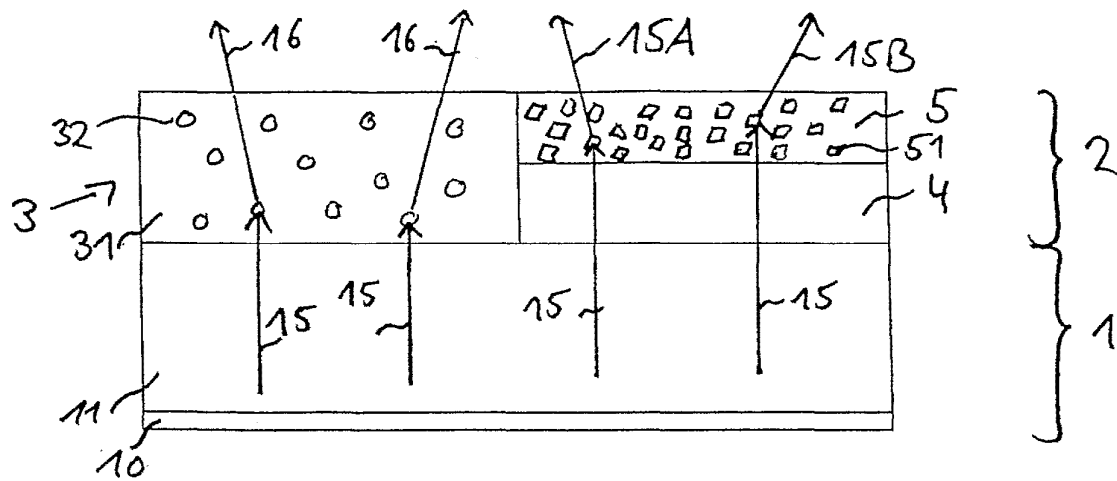


FIG 4B

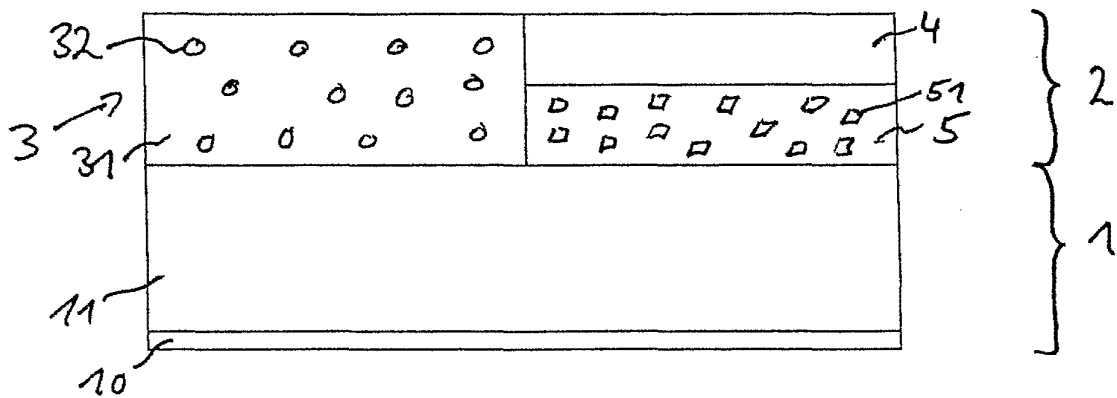


FIG. 4C

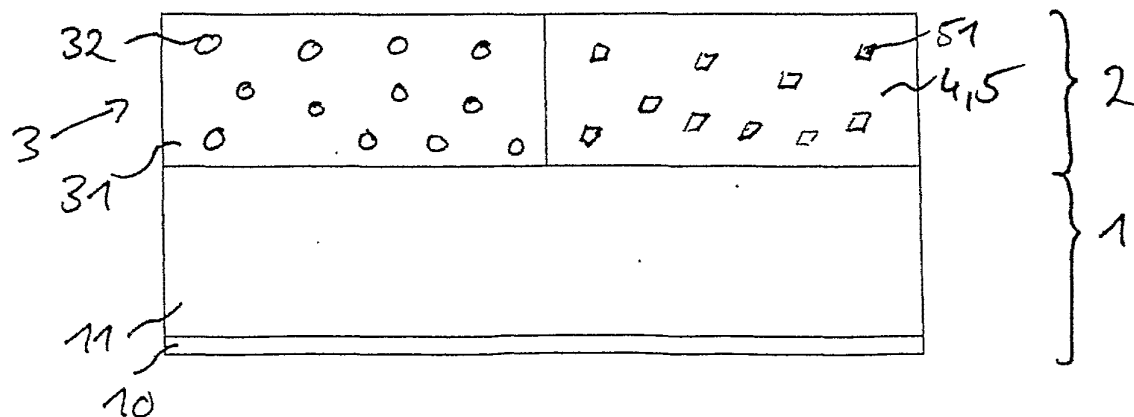


FIG 5

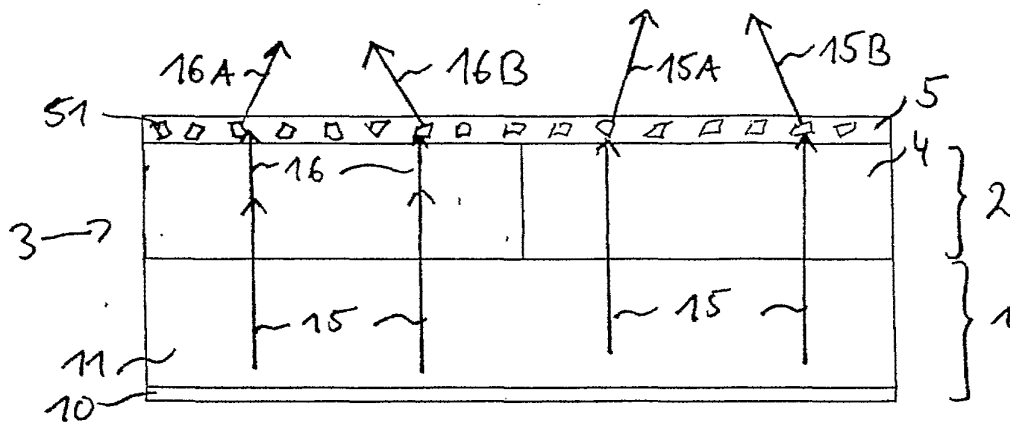


FIG 6

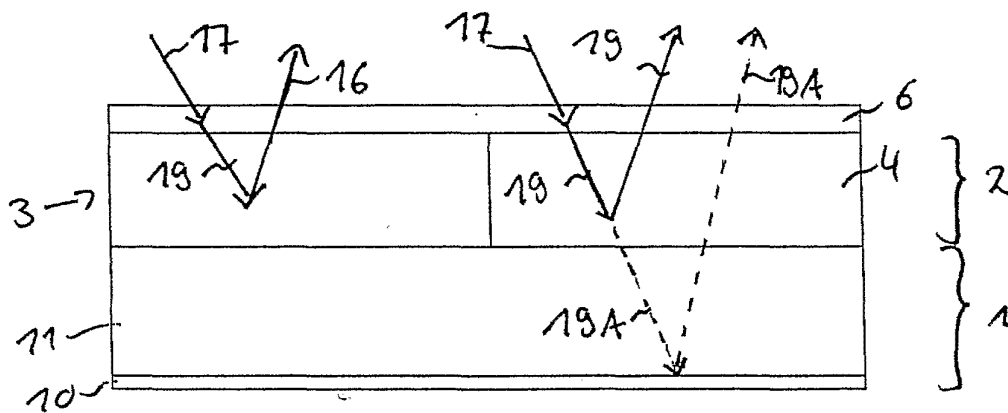


FIG 7

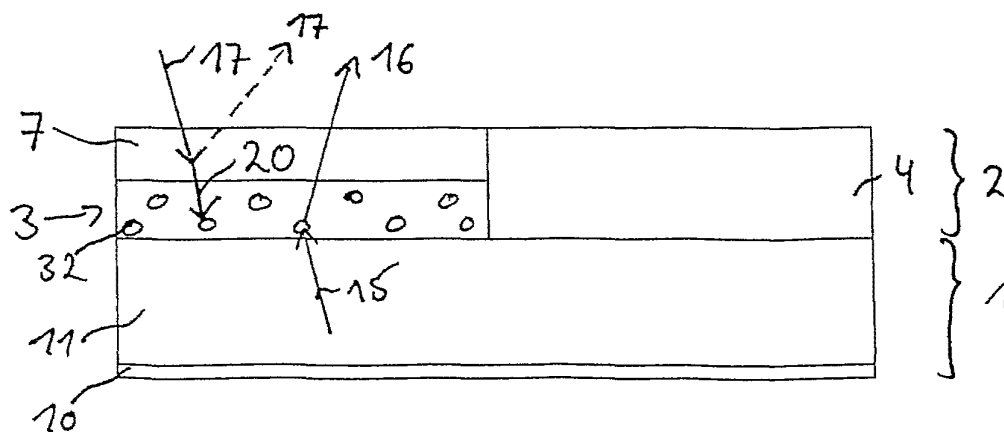


FIG 8

