US009221273B1

(12) **United States Patent**
Hyde et al.

(10) **Patent No.: US 9,221,273 B1**
(45) **Date of Patent: Dec. 29, 2015**

(54) **TIME-DEPENDENT IDENTIFICATION SYSTEMS, METHODS, AND USES THEREOF**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/470,657**

(22) Filed: **Aug. 27, 2014**

(51) **Int. Cl.**
G06K 19/06 (2006.01)
B41J 3/01 (2006.01)

(52) **U.S. Cl.**
CPC ***B41J 3/01*** (2013.01)

(58) **Field of Classification Search**
CPC G06K 19/06037; G06K 7/14; G06K 19/07749; G07F 7/1008; B42D 15/10; G06Q 20/341; G06Q 30/02
USPC 235/494, 492, 487, 380, 375
See application file for complete search history.

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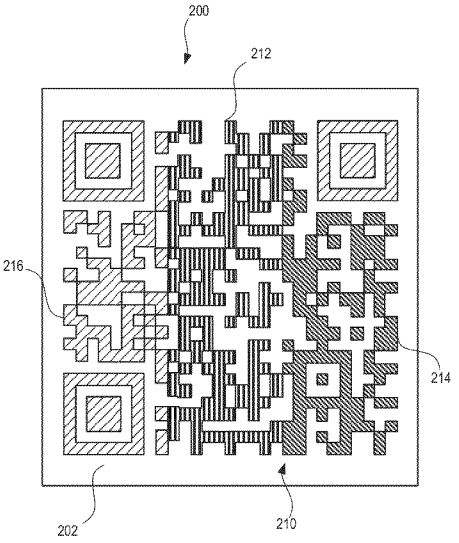
Primary Examiner — Karl D Frech

(57) **ABSTRACT**

The present disclosure provides for identification systems and related methods of use. The disclosed identification systems can include a first ink and a second ink, each of which can comprise one or more time-dependent properties. The first and second inks can be disposed in a spatial pattern on a substrate. A time-dependent property of the first ink and a time-dependent property of the second ink can cause a characteristic of the spatial pattern to change over time. For example, the spatial pattern can change from a first state at a first time to a second state at a second time. Evaluation and/or interpretation of the state of the spatial pattern at a second time can provide information about a product. Additionally, one or more of the first and second inks can include known time- and temperature-dependent properties that can be used to derive temperature related information.

41 Claims, 6 Drawing Sheets



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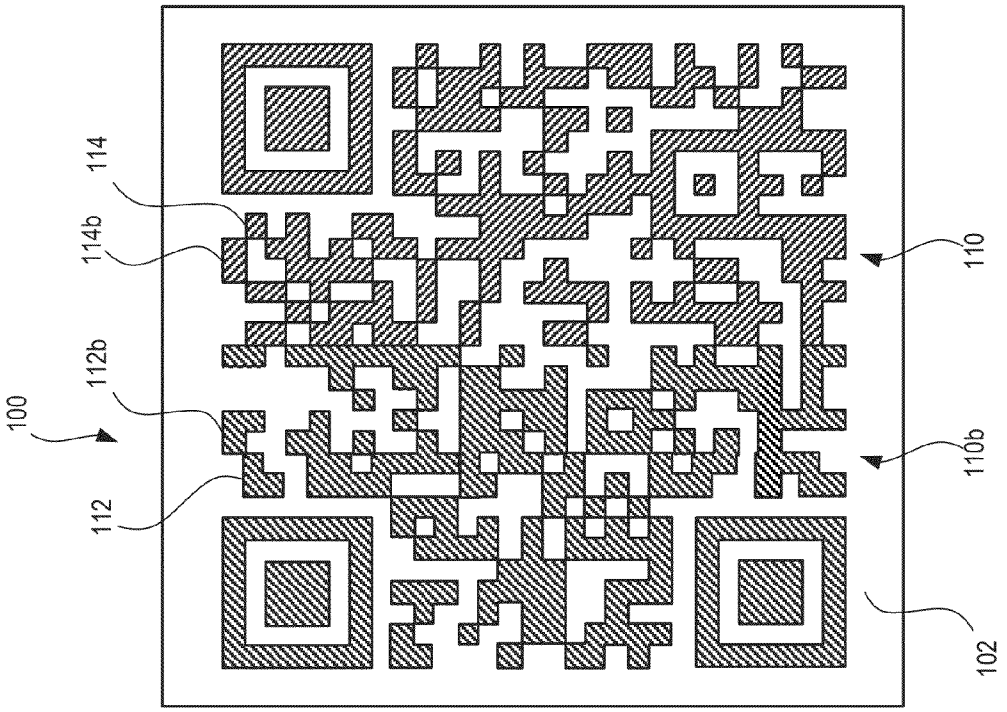
100
112
112b
114b
114
110b
110
102

FIG. 1B

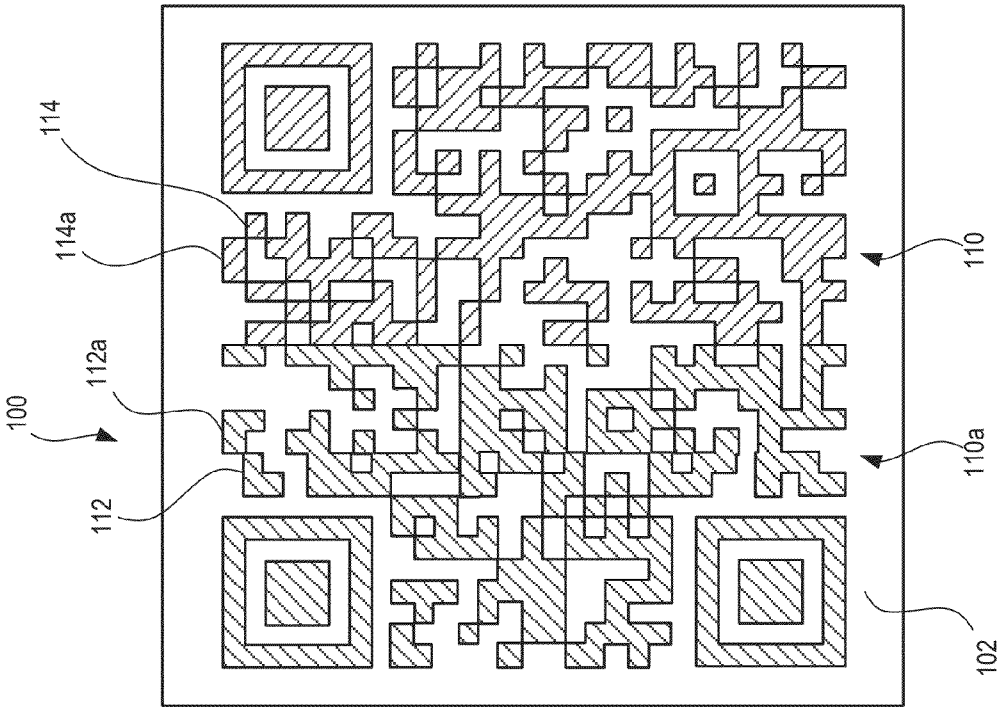
100
112
112a
114a
114
110a
110
102

FIG. 1A

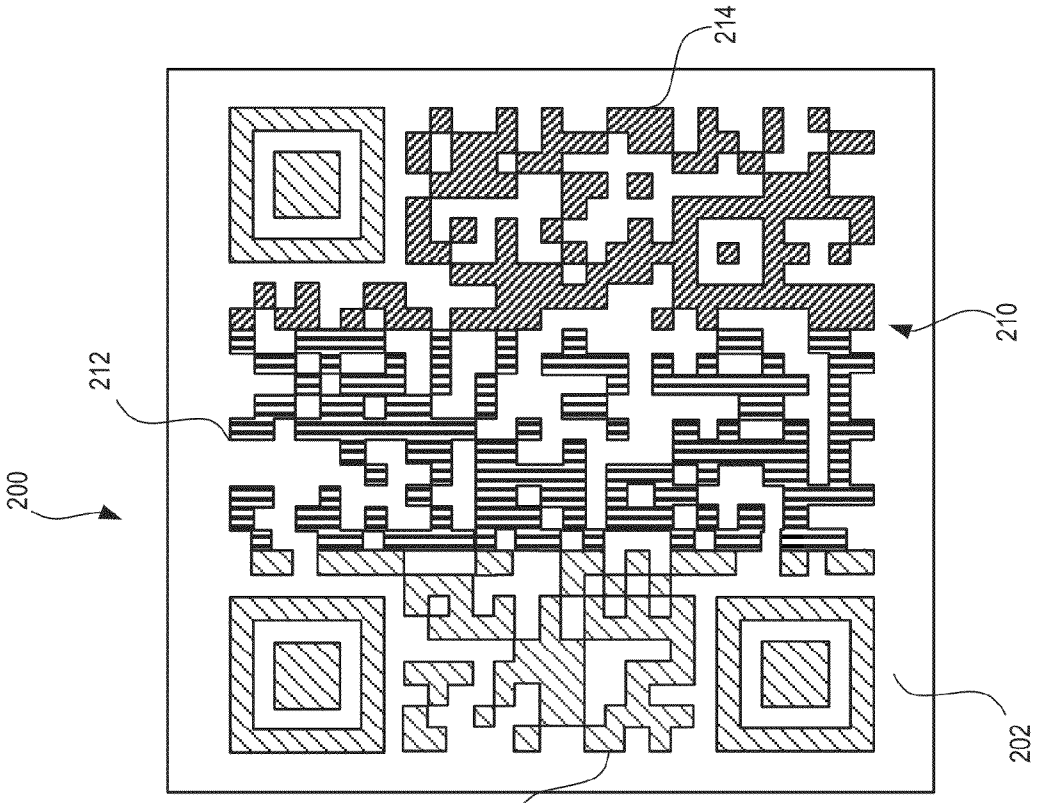

FIG. 2B

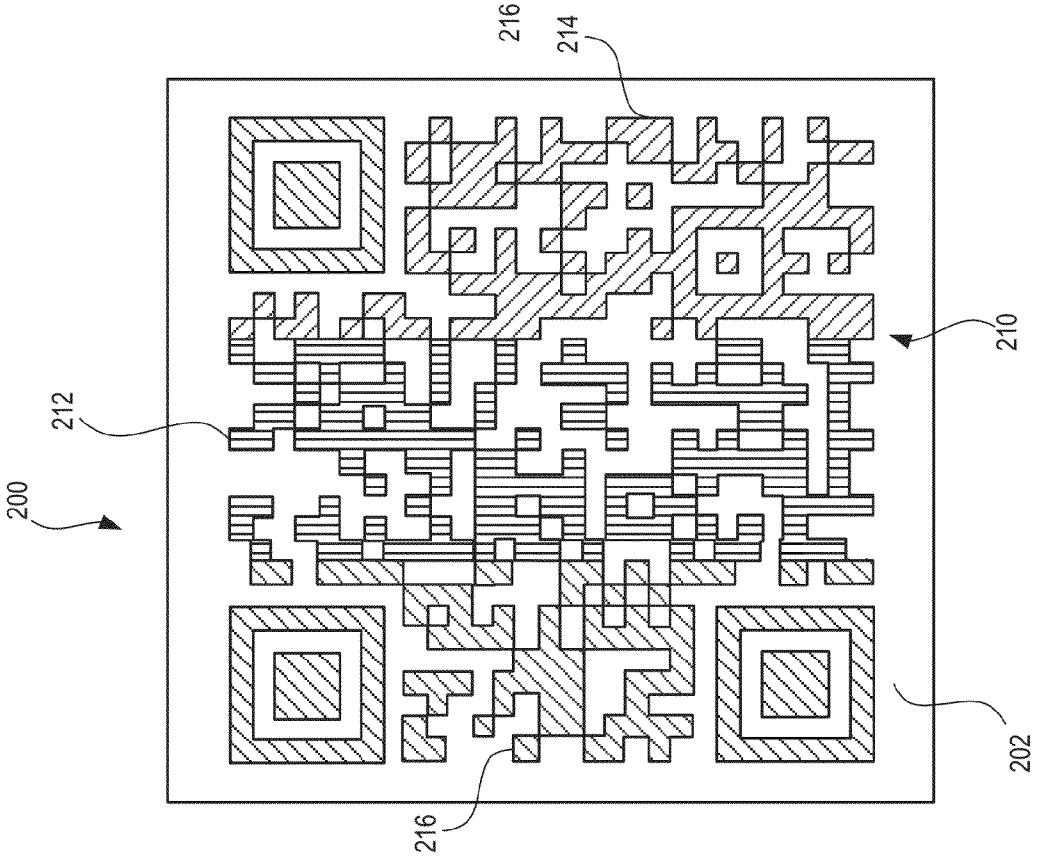

FIG. 2A

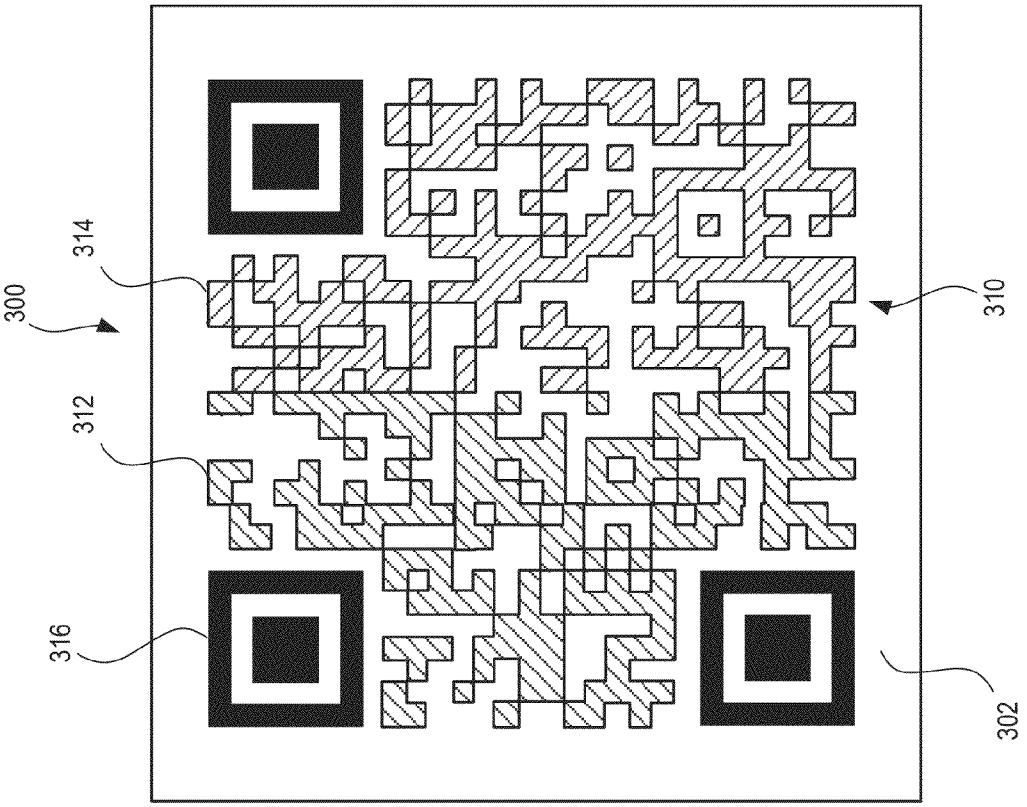

FIG. 3A

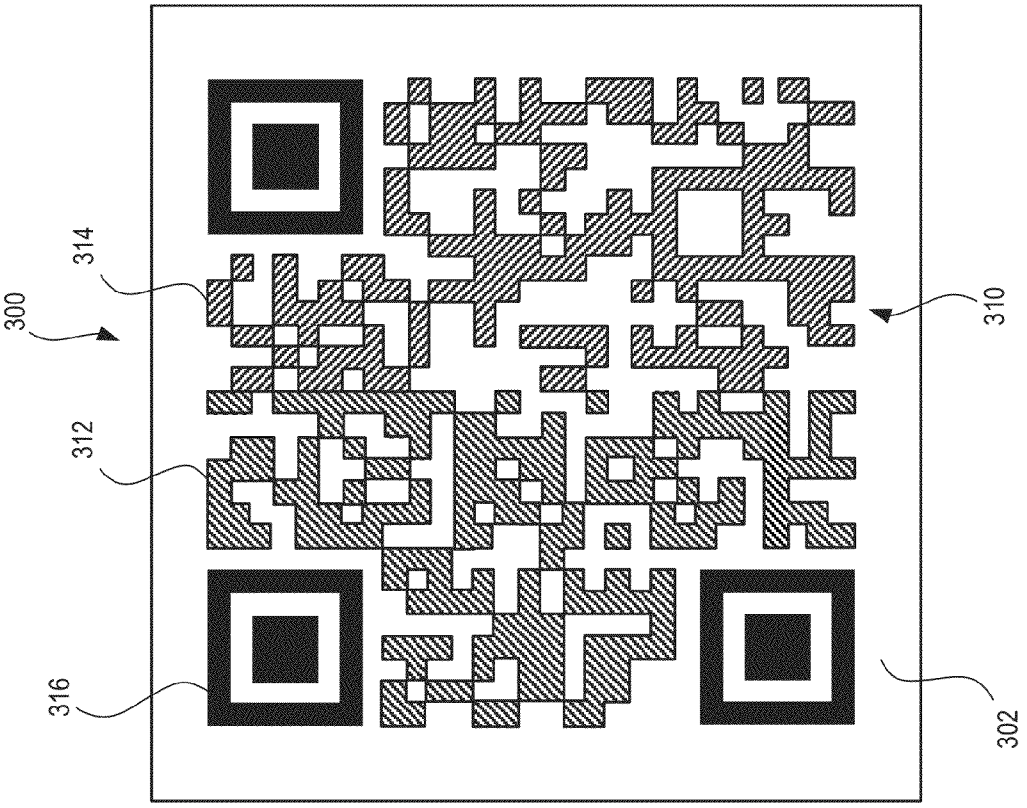

FIG. 3B

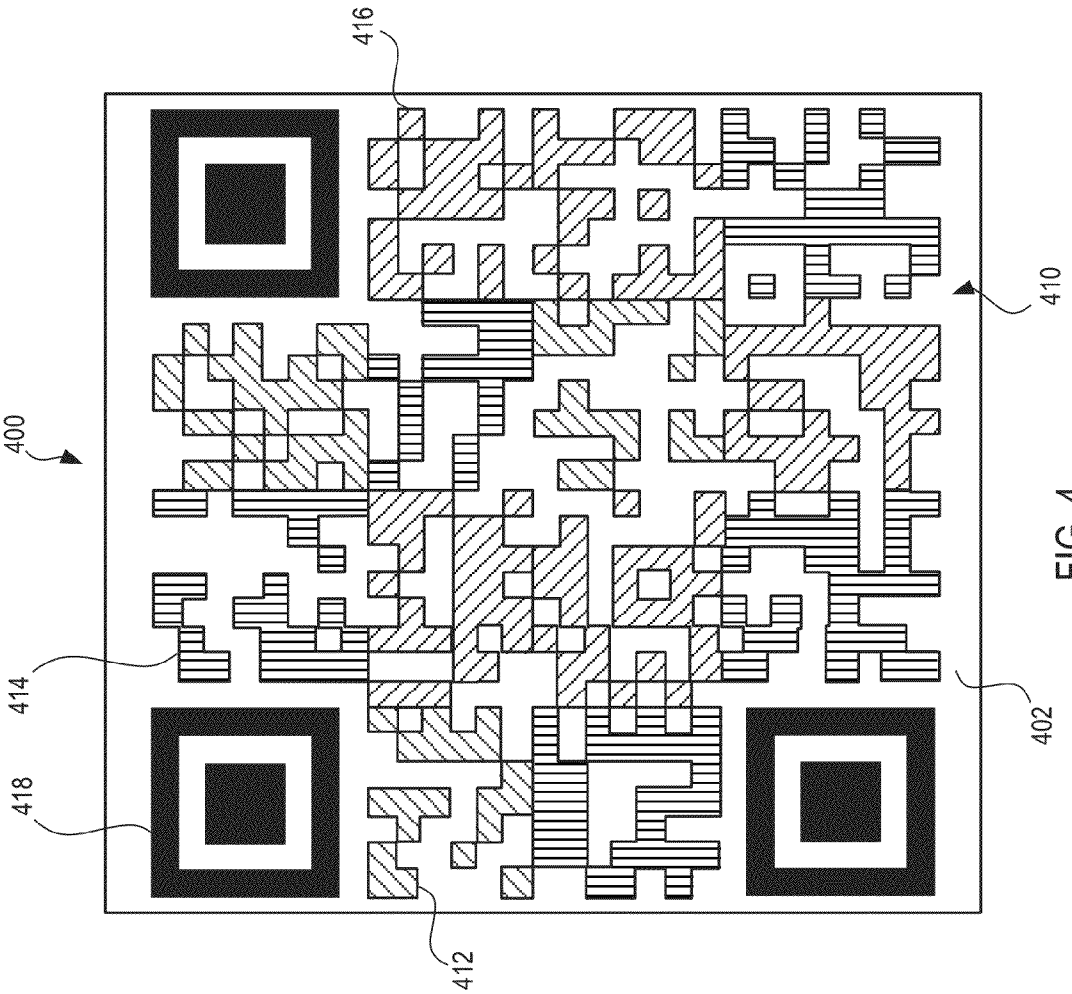

FIG. 4

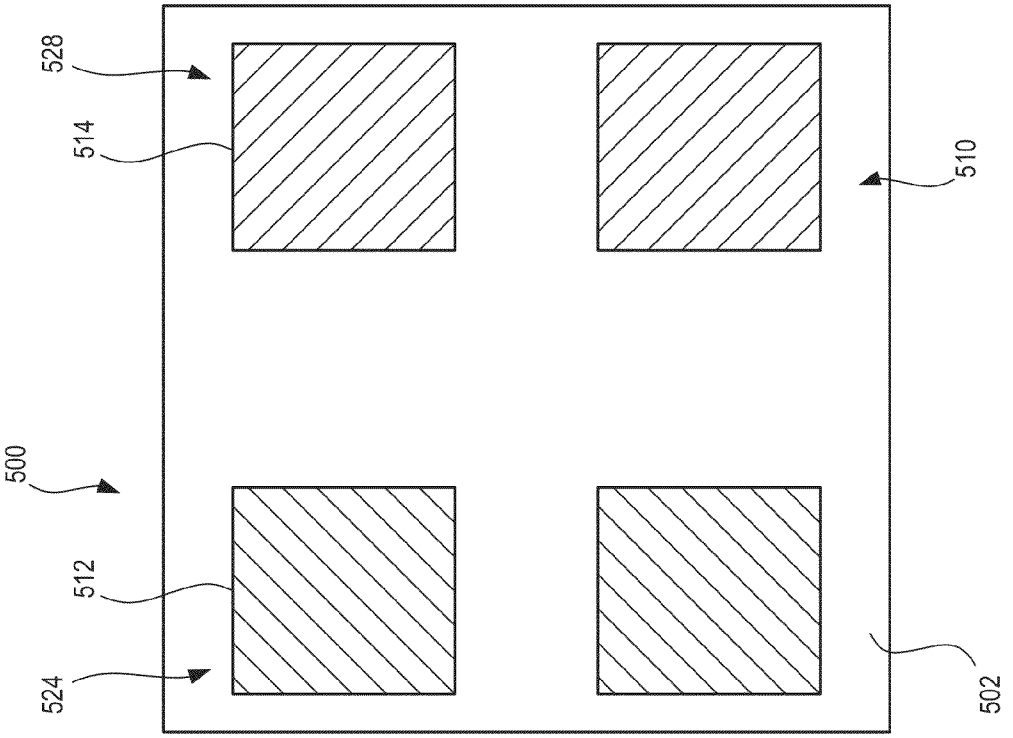

FIG. 5B

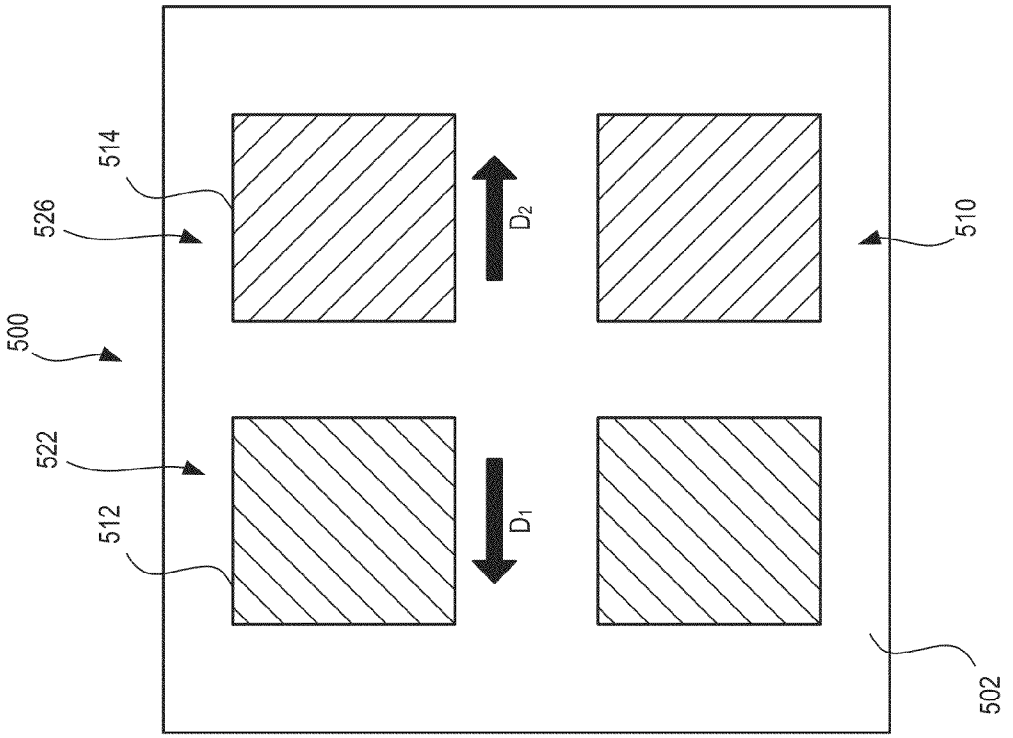

FIG. 5A

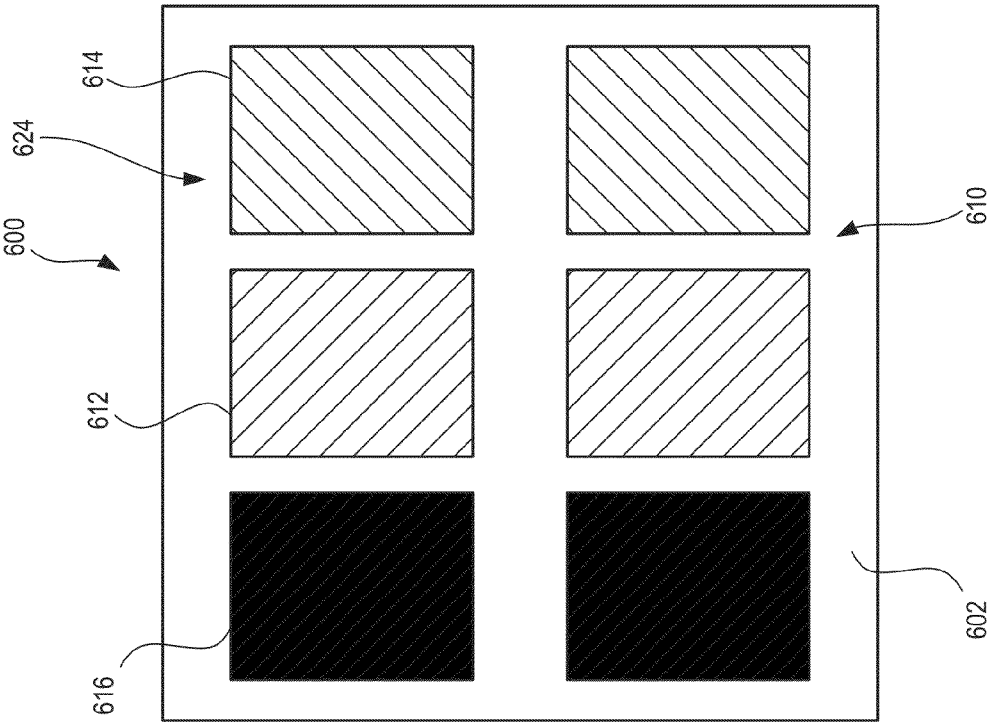

FIG. 6B

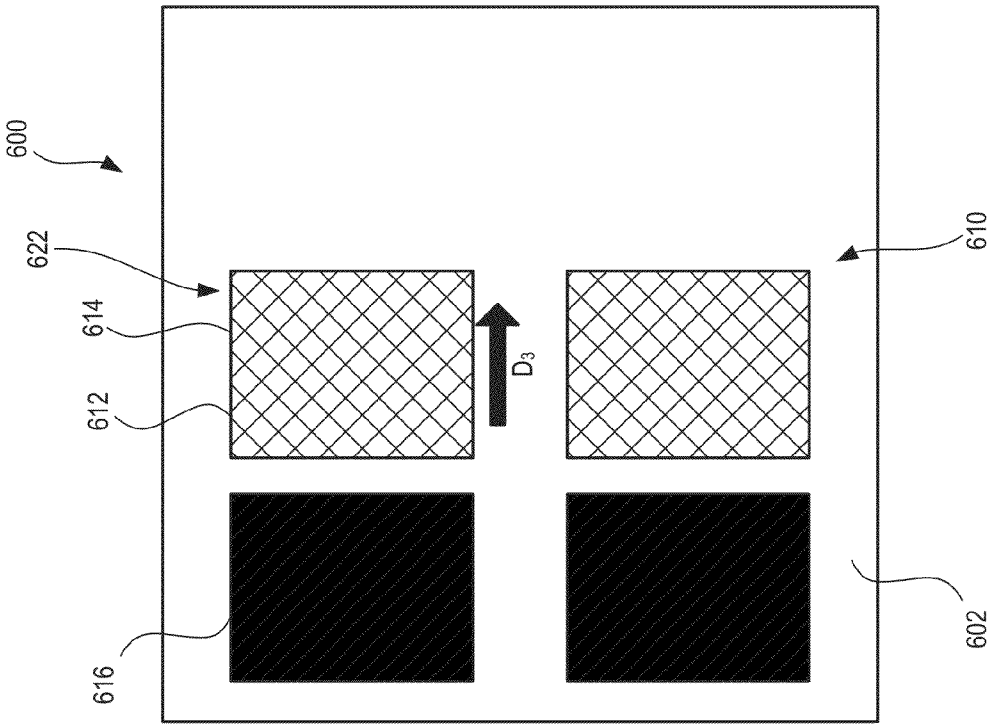

FIG. 6A

TIME-DEPENDENT IDENTIFICATION SYSTEMS, METHODS, AND USES THEREOF

If an Application Data Sheet (ADS) has been filed on the filing date of this application, it is incorporated by reference herein. Any applications claimed on the ADS for priority under 35 U.S.C. §§119, 120, 121, or 365(c), and any and all parent, grandparent, great-grandparent, etc. applications of such applications, are also incorporated by reference, including any priority claims made in those applications and any material incorporated by reference, to the extent such subject matter is not inconsistent herewith.

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of the earliest available effective filing date(s) from the following listed application(s) (the "Priority Applications"), if any, listed below (e.g., claims earliest available priority dates for other than provisional patent applications, or claims benefits under 35 USC §119(e) for provisional patent applications, for any and all parent, grandparent, great-grandparent, etc. applications of the Priority Application(s)).

PRIORITY APPLICATIONS

None.

If the listings of applications provided above are inconsistent with the listings provided via an ADS, it is the intent of the Applicant to claim priority to each application that appears in the Domestic Benefit/National Stage Information section of the ADS and to each application that appears in the Priority Applications section of this application.

All subject matter of the Priority Applications and of any and all applications related to the Priority Applications by priority claims (directly or indirectly), including any priority claims made and subject matter incorporated by reference therein as of the filing date of the instant application, is incorporated herein by reference to the extent such subject matter is not inconsistent herewith.

TECHNICAL FIELD

This disclosure relates to identification systems, methods, and uses thereof. Specifically, this disclosure relates to identification systems that include time-dependent inks.

SUMMARY

The present disclosure is related to identification systems, methods, and uses thereof. As detailed below, the identification systems can comprise a plurality of inks comprising time-dependent properties. The plurality of time-dependent inks can be disposed in a spatial pattern on a substrate. Illustrative spatial patterns include, but are not limited to, QR codes and other barcodes, text, images, and icons. The time-dependent properties of the inks can cause a characteristic of the spatial pattern to change over time. For example, the spatial pattern can change from a first state at a first time to a second state at a second time. Interpretation of the spatial pattern in the second state and/or at a second time can provide identifying information about the spatial pattern and/or a product associated therewith.

Various characteristics of the time-dependent inks and/or the spatial pattern can change over time, including, but not limited to, color, reflectivity, and location. For example, the time-dependent inks can change from visible colors to other visible colors, non-visible colors to other non-visible colors, or visible colors to non-visible colors, and vice versa. The reflectivity of the time-dependent inks and/or the spatial pattern can also change. The location of the time-dependent inks and/or the spatial pattern can also change from location to another.

In some embodiments, the characteristics of the time-dependent inks can change due to an atmospheric reaction. For example, the characteristics of the time-dependent inks can change due to oxidation reactions and/or evaporation reactions. In other embodiments, the characteristics of the time-dependent inks can change due to chemical reactions comprising one or more components of the inks.

In some embodiments, the time-dependent inks can comprise known time- and temperature-related information, and information about the temperature of the inks can be derived from evaluation of the ink. For example, evaluation and/or interpretation of the state of a characteristic of an ink at a second time can provide information about whether the temperature of the ink exceeded a threshold temperature between the first time and the second time.

In some embodiments, the temperature-related information derived from the inks can provide calibration information for interpreting changes to the spatial pattern. For example, temperature-related information and/or calibration information can provide a baseline for differentiating between changes in the spatial pattern that are caused by temperature (or temperature fluctuations) and changes that are caused by time.

Information can be derived from the spatial pattern at any time. For example, information can be determined by evaluating and/or interpreting the state of the spatial pattern at a given time. Interpretation of the spatial pattern can be accomplished by visual inspection of the spatial pattern. For example, the spatial pattern can be viewed and/or compared with a control or standard image. Interpretation of the spatial pattern also can be accomplished by a computing device, such as a smart phone. For example, a computing device can scan or capture an image of the spatial pattern, submit the spatial pattern to a website, and provide identifying information about the spatial pattern and/or a product associated therewith.

In certain embodiments, the spatial pattern can be evaluated to determine whether the spatial pattern is authentic. In some embodiments, a date can be encoded in the spatial pattern. The date can correspond to various events, including, but not limited to, the date on which the inks were disposed on the substrate, the manufacturing date of a product, the packaging date of the product, and an expiration date of a product. Other dates and/or information can also be encoded in the spatial pattern.

In some embodiments, the spatial pattern further comprises one or more reference inks. The reference inks can be static inks, or inks that are substantially devoid of time-dependent properties. The reference inks can be used as a baseline reference for interpreting the characteristic change of the time-dependent inks. In some embodiments, the reference inks can include temperature calibration inks. The reference inks can also include anti-counterfeiting characteristics. These and other embodiments are described in detail below.

The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE FIGURES

FIGS. **1**A-**1**B are schematic illustrations of an identification system, according to an embodiment of the present disclosure.

FIGS. **2**A-**2**B are schematic illustrations of an identification system, according to another embodiment of the present disclosure.

FIGS. **3**A-**3**B are schematic illustrations of an identification system, according to another embodiment of the present disclosure.

FIG. **4** is a schematic illustration of an identification system, according to another embodiment of the present disclosure.

FIGS. **5**A-**5**B are schematic illustrations of an identification system, according to another embodiment of the present disclosure.

FIGS. **6**A-**6**B are schematic illustrations of an identification system, according to another embodiment of the present disclosure.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented here.

Thus, the following detailed description of the embodiments of the systems and methods of the disclosure is not intended to limit the scope of the disclosure, as claimed, but is merely representative of possible embodiments. In addition, the steps of a method do not necessarily need to be executed in any specific order, or even sequentially, nor do the steps need to be executed only once.

The present disclosure is related to identification systems, methods, and uses thereof. As detailed below, the identification systems can comprise a plurality of inks comprising time-dependent properties. The plurality of time-dependent inks can be disposed in a spatial pattern on a substrate. Illustrative spatial patterns include, but are not limited to, QR codes and other barcodes, text, images, and icons. The time-dependent properties of the inks can cause a characteristic of the spatial pattern to change over time. For example, the spatial pattern can change from a first state at a first time to a second state at a second time. Interpretation of the spatial pattern in the second state and/or at a second time can provide identifying information about the spatial pattern and/or a product associated therewith. In some circumstances, the presence of a time varying spatial pattern can make an identification system harder to counterfeit, as a simple static counterfeit pattern can only be "correct" at a single time, and a "successful" counterfeit must match not only a single value of the spatial pattern, but its time dependent progression as well.

Various characteristics of the time-dependent inks and/or the spatial pattern can change over time, including, but not limited to, color, reflectivity, and location. For example, the time-dependent inks can change from visible colors to other visible colors, non-visible colors to other non-visible colors, or visible colors to non-visible colors, and vice versa. The reflectivity of the time-dependent inks and/or the spatial pattern can also change. The location of the time-dependent inks and/or the spatial pattern can also change from location to another.

In some embodiments, the characteristics of the time-dependent inks can change due to an atmospheric reaction. For example, the characteristics of the time-dependent inks can change due to oxidation reactions and/or evaporation reactions. In other embodiments, the characteristics of the time-dependent inks can change due to chemical reactions comprising one or more components of the inks.

In some embodiments, the time-dependent inks can comprise known time- and temperature-related information, and information about the temperature of the inks can be derived from evaluation of the ink. For example, evaluation and/or interpretation of the state of a characteristic of an ink at a second time can provide information about whether the temperature of the ink exceeded a threshold temperature between the first time and the second time.

In some embodiments, the temperature-related information derived from the inks can provide calibration information for interpreting changes to the spatial pattern. For example, temperature-related information and/or calibration information can provide a baseline for differentiating between changes in the spatial pattern that are caused by temperature (or temperature fluctuations) and changes that are caused by time.

Information can be derived from the spatial pattern at any time. For example, information can be determined by evaluating and/or interpreting the state of the spatial pattern at a given time. Interpretation of the spatial pattern can be accomplished by visual inspection of the spatial pattern. For example, the spatial pattern can be viewed and/or compared with a control or standard image.

Interpretation of the spatial pattern also can be accomplished by a computing device, such as a smart phone. For example, a computing device can scan or capture an image of the spatial pattern, submit the spatial pattern to a website, and provide identifying information about the spatial pattern and/or a product associated therewith. In some embodiments, the website can compare the received spatial pattern to a database or program determination of what the spatial pattern should be (e.g., given the image date, the printing date, the ink characteristics, etc.) and provide a determination as to whether the marked item is counterfeit or not.

In certain embodiments, the spatial pattern can be evaluated to determine whether the spatial pattern is authentic. In some embodiments, a date can be encoded in the spatial pattern. The date can correspond to various events, including, but not limited to, the date on which the inks were disposed on the substrate, the manufacturing date of a product, the packaging date of the product, and an expiration date of a product. Other dates and/or information can also be encoded in the spatial pattern.

In some embodiments, the spatial pattern further comprises one or more reference inks. The reference inks can be static inks, or inks that are substantially devoid of time-dependent properties. The reference inks can be used as a baseline reference for interpreting the characteristic change of the time-dependent inks. In some embodiments, the reference inks can include temperature calibration inks. The reference inks can also include anti-counterfeiting characteristics. These and other embodiments are described in detail below.

FIGS. **1**A-**1**B are schematic illustrations of an identification system **100**, according to an embodiment of the present disclosure. As shown in FIGS. **1**A-**1**B, the identification system **100** can comprise a plurality of inks **112**, **114** disposed in a spatial pattern **110** on a substrate **102**. For example, in the

illustrated embodiment, the identification system **100** comprises a first ink **112** and a second ink **114**. Additional inks (e.g., third, fourth, fifth, etc.) can also be used. The inks **112**, **114** can each comprise one or more time-dependent properties. Time-dependent properties are properties that vary or change as a function of time. In such embodiments, the inks **112**, **114** can be referred to as time-dependent inks **112**, **114**.

In some embodiments, the time-dependent properties of the inks **112**, **114** are different. For example, a time-dependent property of a first ink **112** can differ from a time-dependent property of a second ink **114**. In such embodiments, one portion of the spatial pattern **110** can change over time differently than another portion of the spatial pattern **110**. In other embodiments, the time-dependent properties of the inks **112**, **114** are substantially the same. In still other embodiments, at least one time-dependent property of a first ink **112** differs from at least one time-dependent property of a second ink **114**, and at least one time-dependent property of the first ink **112** is substantially the same as at least one time-dependent property of the second ink **114**.

The time-dependent properties of the inks **112**, **114** each can comprise, or otherwise be associated with, a rate of progression. The rate of progression is the rate at which a time-dependent property changes as a function of time (e.g., change/time (seconds, minutes, hours, days, years, etc.)). In some embodiments, the rate of progression of the time-dependent properties of the inks **112**, **114** is known. For example, the rate of progression can be known at specified conditions (e.g., temperatures and pressures), including, but not limited to, Standard Temperature and Pressure Conditions ("STP") (0° C. and 100 kPa) and Standard Ambient Temperature and Pressure Conditions ("SATP") (25° C. and 100 kPa). The rate of progression can also be known, or otherwise derived for, other conditions. As can be appreciated, the rate of progression can be relatively fast, or relatively slow as desired.

In some embodiments, a known rate of progression can be used to identify or otherwise determine information about the inks **112**, **114** and/or the spatial pattern **110**. For example, by knowing the rate of progression, the inks **112**, **114** and/or the spatial pattern **110** can be analyzed or otherwise evaluated at any given time to determine the date on which the ink **112**, **114** and/or the spatial pattern **110** was disposed on the substrate **102**. Other information about the inks **112**, **114** and/or the spatial pattern **110** can also be derived by knowing the rate of progression, as detailed below.

In some embodiments, the rate of progression of the time-dependent properties of the inks **112**, **114** is different. For example, the rate of progression of a time-dependent property of a first ink **112** can differ from the rate of progression of a time-dependent property of a second ink **114**. In other embodiments, the rate of progression of the time-dependent properties of the inks **112**, **114** is substantially the same. In still other embodiments, the rate of progression of at least one time-dependent property of a first ink **112** differs from the rate of progression of at least one time-dependent property of a second ink **114**, and the rate of progression of at least one time-dependent property of the first ink **112** is substantially the same as the rate of progression of at least one time-dependent property of the second ink **114**.

In some embodiments, the rate of progression of the time-dependent properties of the inks **112**, **114** is variable or otherwise capable of being varied or changed. For example, the rate of progression of a time-dependent property of an ink **112**, **114** can be configured to be relatively fast, or relatively slow, depending on the desired use of the identification system **100**. For instance, if an identification system **100** is used to authenticate a product being mailed, a relatively fast rate of progression may be desired. If an identification system **100** is used to authenticate currency or indicate that a product has expired, a relatively slow rate of progression may be desired.

The rate of progression of the time-dependent properties of the ink **112**, **114** can be varied by modifying one or more components of the ink **112**, **114**. For example, one or more reagents or other compounds can be added that can accelerate or decelerate the rate of progression. In some embodiments, the one or more components of the ink **112**, **114** can be modified prior to disposing the ink **112**, **114** on the substrate **102**. In other embodiments, the one or more components of the ink **112**, **114** are modified while the ink **112**, **114** is being disposed on the substrate **102**. For example, one or more components of the ink **112**, **114** can be mixed with additional reagents or compounds while the ink **112**, **114** is being disposed on the substrate **102**. In yet other embodiments, one or more components of the ink **112**, **114** can be modified after the ink **112**, **114** has been disposed on the substrate **102**. For example, a reagent or other compound can be applied to an ink **112**, **114** that has previously been disposed on a substrate **102**.

As can be appreciated, varying the rate of progression of a time-dependent property of an ink **112**, **114** can vary the rate of change of a particular characteristic of the ink **112**, **114** and/or the spatial pattern **110**. For example, increasing the rate of progression of a time-dependent property of an ink **112**, **114** can increase the rate of change of a characteristic of the ink **112**, **114** and/or the spatial pattern **110**. Analogously, decreasing the rate of progression of a time-dependent property of an ink **112**, **114** can decrease the rate of change of a characteristic of the ink **112**, **114** and/or the spatial pattern **110**. In some embodiments, the rate of progression can be varied, or otherwise configured, such that a characteristic of an ink **112**, **114** and/or the spatial pattern **110** changes to a particular state on a predetermined date, for example, to authenticate a product or indicate that an expiration date has passed.

In some embodiments, the time-dependent properties of the inks **112**, **114** can be described in relation to a characteristic change that is taking place with the ink **112**, **114** and/or the spatial pattern **110**. In particular, the time-dependent properties of the inks **112**, **114** can cause various characteristics of the inks **112**, **114** and/or the spatial pattern **110** to change over time. For example, a time-dependent property of an ink **112**, **114** can cause a characteristic of an ink **112**, **114** and/or the spatial pattern **110** to change from one state at a first time to another state at a second time. For convenience, a first time and a second time can be used to reference and distinguish between two different times. However, it will be appreciated that the first time and the second time are not intended to be limiting in any way. For example, the first time and second time are not associated with any fixed date or event, but can be representative of any time. In some embodiments, the first time can be representative of the time at which the inks **112**, **114** were disposed on the substrate **102**.

Additionally, throughout this disclosure, reference may be made to a particular state (e.g., first, second, third, fourth, etc.). For example, reference may be made to a spatial pattern **110** being in a first state at a first time and a second state at a second time. Analogously, reference may also be made to a first ink **112** being in a third state at the first time and a fourth state at the second time, and reference may be made to the second ink **114** being in a fifth state at the first time and a sixth state at the second time. The recitation of particular states may be merely used to differentiate between other states (e.g., a state of the spatial pattern **110**, a state of the first ink **112**, and

a state of a second ink **114**), and is not intended to be limiting in any way. For example, the recitation of a particular state is not intended to indicate the existence of other states. Thus, recitation of a third state does not indicate the existence of a first, second, or fourth state, etc. And the recitation of a state is not intended to indicate that the ink **112**, **114** and/or spatial pattern **110** is in a fixed state. Rather, the recitation of a state is merely indicative of the current state of an ink **112**, **114** and/or the spatial pattern **110** at a particular time, and the ink **112**, **114** and/or the spatial pattern **110** can continue to change as time progresses.

It will also be appreciated that reference to a particular state need not be mentioned. For example, discussion of an ink **112**, **114** and/or the spatial pattern **110** at a particular time can imply that the ink **112**, **114** and/or the spatial pattern **110** is in a particular state. For example, discussion of an ink **112**, **114** and/or the spatial pattern **110** at a first time or second time can imply that the ink **112**, **114** and/or the spatial pattern in is one state at the first time and another state at the second time. Thus, changes in the ink **112**, **114** and/or the spatial pattern **110** from one time to another can also imply changes from one state to another state.

Illustrative changes to characteristics of the inks **112**, **114** and/or the spatial pattern **110** over time are depicted in FIGS. **1**A-**1**B. In FIG. **1**A, the inks **112**, **114** and the spatial pattern **110** are depicted at a first time. At the first time, the spatial pattern **110***a* can be described as being in a first state, the first ink **112***a* can be described as being in a third state, and the second ink **114***a* can be described as being in a fifth state. The time-dependent properties of the inks **112**, **114** cause the inks **112**, **114** and the spatial pattern **110** to change as time progresses, as depicted in FIG. **1**B. At the second time, depicted in FIG. **1**B, the spatial pattern **110***b* can be described as being in a second state, the first ink **112***b* can be described as being in a fourth state, and the second ink **114***b* can be described as being in a sixth state. As can be appreciated, and as also shown in FIGS. **1**A-**1**B, the spatial pattern **110**, which comprises the inks **112**, **114**, can change from one state to another state (e.g., a first state to a second state) as the inks **112**, **114** change from one state to another state (e.g., a third state to a fourth state, and a fifth state to a sixth state). Thus, any disclosure herein relating to the inks **112**, **114** individually is also applicable to the spatial pattern **110** or at least a portion of the spatial pattern **110**.

Illustrative characteristics of the inks **112**, **114** and/or the spatial pattern **110** that can be affected and/or changed by the time-dependent properties of the inks **112**, **114** include, but are not limited to, color, reflectivity, and location. For example, in one embodiment, a characteristic of an ink **112**, **114** and/or spatial pattern **110** that is affected by the time-dependent property of the ink **112**, **114** comprises color. Specifically, the color of an ink **112**, **114** can change from one color at the first time to another color at the second time.

In some embodiments, the color of at least one ink **112**, **114** changes from one visible color to another visible color. Typically, a visible color is a color that is in the spectrum (i.e., visible spectrum) that can be detected by the human eye. The visible spectrum typically includes wavelengths between about 390 nm and about 700 nm, but other wavelengths visible to the human eye can also be included. In other embodiments, the color of at least one ink **112**, **114** changes from a non-visible color to another non-visible color. Non-visible colors include infrared wavelengths (e.g., greater than about 700 nm) and ultraviolet wavelengths (e.g., less than about 390 nm). In yet another embodiment, the color of at least one ink **112**, **114** changes from one visible color to a non-visible color, or vice versa.

Combinations of the above-mentioned color changes are also contemplated. For example, in further embodiments, the color of one ink **112**, **114** changes from one visible color to another visible color, and the color of another ink **112**, **114** changes from one non-visible color to another non-visible color. In other embodiments, the color of each ink **112**, **114** changes from one visible color to another visible color, or the color of each ink **112**, **114** changes from one non-visible color to another non-visible color. In still further embodiments, the color of one ink **112**, **114** changes from one visible color to a non-visible color (or vice versa), and the color of another ink **112**, **114** changes from one visible color to another visible color (or one non-visible color to another non-visible color).

In another embodiment, a characteristic of the ink **112**, **114** and/or spatial pattern **110** that is affected by the time-dependent properties of the inks **112**, **114** comprises reflectivity. For example, the reflectivity of an ink **112**, **114** can change from one reflectivity at a first time to another reflectivity at a second time. In some embodiments, the reflectivity of an ink **112**, **114** increases over time. In other embodiments, the reflectivity of an ink **112**, **114** decreases over time. In other words, the reflectivity of an ink **112**, **114** at a first time can be greater than the reflectivity of the ink **112**, **114** at a second time, and vice versa. Changes in reflectivity can manifest as an overall brightening of the ink **112**, **114** (e.g., increasing reflectivity), or an overall fading of the ink **112**, **114** (e.g., decreasing reflectivity). In particular embodiments, the reflectivity of an ink **112**, **114** changes from one polarization (or polarization dependence) at a first time to another polarization (or polarization dependence) at a second time.

The reflectivity can comprise various components, including, but not limited to, specular and diffuse components, that can change over time. For example, in some embodiments, a specular component (or specular reflection) of the reflectivity at a first time is greater than the specular component (or specular reflection) of the reflectivity at a second time. In other embodiments, a specular component (or specular reflection) of the reflectivity at a first time is less than the specular component (or specular reflection) of the reflectivity at a second time. In other words, the specular component of the reflectivity (e.g., a first reflectivity) of an ink **112**, **114** at a first time can be greater than the specular component of the reflectivity (e.g., a second reflectivity) of an ink **112**, **114** at a second time, and vice versa. Analogously, the diffuse component of the reflectivity of an ink **112**, **114** at a first time can be greater than the diffuse component of the reflectivity of an ink **112**, **114** at a second time, and vice versa.

The reflectivity can also be described as including a refractivity or refractive component. The refractivity, or refractive component, can also be quantified by itself, independent of the reflectivity. The refractivity, or refractive component of an ink **112**, **114** can change over time. For example, the refractivity of an ink **112**, **114** can comprise one refractivity at a first time and another refractivity at a second time. More specifically, the refractivity (e.g., a first refractivity) of an ink **112**, **114** at a first time can be greater than the refractivity (e.g., a second refractivity) of the ink **112**, **114** at a second time. In other embodiments, the refractivity of an ink **112**, **114** at a first time can be less than the refractivity of the ink **112**, **114** at a second time.

The diffractive component of the ink **112**, **114** can also change in an analogous manner. For example, the diffractive component of an ink **112**, **114** at a first time can be greater than the diffractive component of the ink **112**, **114** at a second time. And in other embodiments, the diffractive component of an ink **112**, **114** at a first time can be less than the diffractive component of the ink **112**, **114** at a second time. Examples of

inks with diffractive components can be seen in U.S. Pat. No. 5,912,767, titled 'Diffractive Indicia for a Surface,' filed Nov. 23, 1994, and U.S. Pat. No. 7,729,026, titled 'Security Device with Metameric Features Using Diffractive Pigment Flakes,' filed Dec. 12, 2006, each of which is incorporated by reference in its entirety.

In yet another embodiment, a characteristic of the ink **112**, **114** that is affected by the time-dependent property comprises location, e.g., a spatial location in the spatial pattern **110** on the substrate **102**. For example, a portion of the ink **112**, **114** can be disposed at one location at a first time, and another location at a second time, as detailed below.

The characteristic changes of the inks **112**, **114** can be caused by many things. For example, in some embodiments, the characteristic change of the inks **112**, **114** can be caused by, or otherwise attributed to, one or more reactions. Illustrative reactions include, but are not limited to, atmospheric reactions and chemical reactions. In some embodiments, the reactions can progress relatively slowly over time such that the ink **112**, **114** appears to change indefinitely. In other embodiments, the reactions can progress relatively quickly.

In certain embodiments, the characteristic of ink **112**, **114** changes due to an atmospheric reaction comprising one or more components of the ink **112**, **114**. Illustrative types of atmospheric reactions include, but are not limited to, oxidation reactions and evaporation reactions. For example, U.S. Pat. No. 5,759,246, titled 'Ink with Time Dependent Characteristics,' filed Dec. 17, 1996, which is incorporated by reference in its entirety, discusses a variety of inks which change color due to pH shifts caused by the evaporation of one component of the ink. One example of such an ink involves a phenolsulfonphthalein dye (phenol red) whose color changes from red to yellow depending on pH. The pH can be determined by a solvent in the ink; for instance, triethanolamine is an alkaline solvent that slowly evaporates, changing the ink's pH and hence its color from red to yellow. This patent discuss a variety of dyes and solvents involving different color shifts occurring over different time scales. U.S. Pat. No. 5,759,246 also discusses a variety of inks which change color due to oxidation. One example of such an ink involves a combination of an unstable dye such as rhodamine B in a stable solvent such copper phthalocyanine. For example, in some embodiments, the ink **112**, **114** can oxidize by interacting with the air, or components (e.g., oxygen) in the air. In other embodiments, the characteristic of the ink **112**, **114** can change as portions of the ink **112**, **114** evaporate. For example, liquid components of the ink **112**, **114** can evaporate or otherwise vaporize, causing a characteristic of the ink **112**, **114** to change.

In various embodiments, the characteristics of the ink **112**, **114** change due to a chemical reaction comprising one or more components of the ink **112**, **114**. Examples of such reactions for use in color changing inks can be found in European Patent Application No. EP 0 117 390, titled 'Process for Monitoring Incremental Environmental Exposures of Products that Undergo Progressive Quality Changes in Response to Environment Stimuli,' filed Jan. 3, 1984, which is incorporated by reference in its entirety, based on diacetylene materials; International Patent Publication No. WO 1999039197, titled 'Substrate for Packaging Perishable Goods or for Application onto Same and Method for Determining the Quality of Said Goods,' filed Jan. 27, 1999, which is incorporated by reference in its entirety, describing a reversible indicator having photochromic properties based on transfer reactions; and U.S. Pat. No. 7,754,273, titled 'Method of Printing a Time-Temperature Indicator Based on Azo Coupling Reactions onto a Susbtrate [sic],' filed Aug. 3, 2005, which is incorporated by reference in its entirety, based on azo coupling reactions. For example, a chemical reaction can comprise a reaction between a first component of an ink **112**, **114** and a second component of the ink **112**, **114**. U.S. Pat. No. 7,255,508, titled 'Writing System and Ink Pen Having Time-Dependent Characteristics,' filed Dec. 7, 2005, which is incorporated by reference in its entirety, discusses a number of such inks, some of which involve mixtures of oxidizer and reducer components. In some embodiments, the components (e.g., first and second components) are mixed together prior to being disposed in a spatial pattern **110** on the substrate **102**. In other embodiments, the components can be mixed together while being disposed in the spatial pattern **110** on the substrate **102**. In yet other embodiments, the components can mix or otherwise interact with each other after they are disposed on the substrate **102**, or as they are disposed on the substrate **102**. For example, the components of the ink **112**, **114** can be disposed at substantially similar locations (e.g., pixel locations) on the substrate **102**, such that they interact with one another on the substrate **102**. The components of the ink **112**, **114** can also be disposed at adjacent locations on the substrate **102** such that they interact with each other after being disposed on the substrate **102**. For example, a first component of an ink **112**, **114** can be disposed at a first location on the substrate **102** and a second component of the ink **112**, **114** can be disposed at a second location on the substrate **102** that is adjacent to the first location such that the first and second components of the ink **112**, **114** interact with each other on the substrate **102**.

In other embodiments, the characteristics of the ink **112**, **114** change due to a chemical reaction comprising one or more components of a first ink **112** and one or more components of a second ink **114**. The components of the inks **112**, **114** can be mixed together prior to being disposed in a spatial pattern **110** on the substrate **102**. In other embodiments, the components of the inks **112**, **114** can be mixed together while being disposed in the spatial pattern **110** on the substrate **102**. In yet other embodiments, the components of the inks **112**, **114** can mix or otherwise interact with each other after they are disposed on the substrate **102**, or as they are disposed on the substrate **102**. For example, the components of the inks **112**, **114** can be disposed at substantially similar locations (e.g., pixel locations) on the substrate **102**, such that they interact with one another on the substrate **102**. The components of the inks **112**, **114** can also be disposed at adjacent locations on the substrate **102** such that they interact with each other after being disposed on the substrate **102**. For example, a component of a first ink **112** can be disposed at a first location on the substrate **102** and a component of a second ink **114** can be disposed at a second location on the substrate **102** that is adjacent to the first location such that the components of the first and second inks **112**, **114** interact with each other on the substrate **102**.

In still other embodiments, the characteristic of the ink **112**, **114** changes due to a chemical reaction between one or more components of the ink **112**, **114** and a component of the substrate **102**. For example, a component of the ink **112**, **114** can interact with a component of the substrate **102** after being disposed on the substrate **102**.

In some embodiments, the characteristic of the ink **112**, **114** begins changing the moment the ink **112**, **114** is disposed on the substrate **102**. In other embodiments, the characteristic of the ink **112**, **114** begins changing before the ink **112**, **114** is disposed on the substrate **102**. In yet other embodiments, the characteristic of the ink **112**, **114** begins changing at a specified time (or event) after the ink **112**, **114** has been disposed on the substrate **102**. For example, in some embodiments, a seal

may be used to cover the ink **112**, **114**, which can be disposed on a substrate **102**, until a specified time (or event) (e.g., a packaging date, a shipping date, etc.). At the specified time (or event) (e.g., the packaging date, a shipping date, etc.), the seal may be removed from the ink **112**, **114**, or otherwise broken, causing the characteristic of the ink **112**, **114** to begin changing at the specified time (or event) (e.g., the packaging date, the shipping date, etc.). For example, the ink **112**, **114** can begin changing due to an atmospheric reaction (e.g., reaction with oxygen, air, water vapor, etc.) after the seal has been removed or otherwise broken. In such embodiments, the seal can comprise a thin plastic film or other covering that can protect the ink **112**, **114** from reacting or otherwise changing prior to the specified time (or event) (e.g., the packaging date, the shipping date, etc.). As can be appreciated, the specified time (or event) can be any time at the user's discretion.

Other methods of delaying the change in the characteristic of the ink **112**, **114** can also be used. For example, in some embodiments, the ink **112**, **114** can be disposed on the substrate **102** in a dry powder form. At a specified time (or event) (e.g., a packaging date, a shipping date, etc.), the ink **112**, **114** can be dipped into a liquid, or a liquid can be applied to the ink **112**, **114**, causing the characteristic of the ink **112**, **114** to begin changing. In still other embodiments, a reagent (e.g., a liquid reagent) can be applied to an ink **112**, **114** at a specified time (or event) (e.g., a packaging date, a shipping date, etc.), causing the characteristic of the ink **112**, **114** to begin changing. In such embodiments, the liquid or reagent can be held in a separate reservoir until being released or applied onto the ink **112**, **114**.

Delaying the time-dependent property, or characteristic change, of the ink **112**, **114** can be useful in many instances. For example, delaying the time-dependent property, or characteristic change, of the ink **112**, **114** can be useful in situations where the ink **112**, **114** is disposed on the substrate **102** prior to, for example, shipping, packaging, delivering, or manufacturing a product. For example, in some embodiments, a product may be packaged long before it is shipped or delivered. In another example, the ink **112**, **114** may be disposed on a substrate **102** used for packaging prior to placing a product in the package. In other embodiments, one company may dispose the ink **112**, **114** onto a substrate **102**, and another company may use the substrate **102** to label (or package) their product. As can be appreciated, other situations are also contemplated.

In some embodiments, the inks **112**, **114** can comprise known time- and temperature-related information. In such embodiments, information about the temperature of the inks **112**, **114** can be derived from evaluation of a characteristic of the ink **112**, **114** at a second time. For example, in some embodiments, evaluation and/or interpretation of the state of the characteristic of an ink **112**, **114** at a second time can provide information about whether the temperature of the ink **112**, **114** and/or the spatial pattern **110** exceeded a threshold temperature between the first time and the second time. For example, in some embodiments, evaluation and/or interpretation of a characteristic of the ink **112**, **114** provides information about whether the temperature of the ink **112**, **114** was heated above a threshold temperature. In other embodiments, evaluation and/or interpretation of a characteristic of the ink **112**, **114** provides information about whether the temperature of the ink **112**, **114** was cooled below a threshold temperature. As can be appreciated, any of the above-mentioned characteristics of the inks **112**, **114** can change when a threshold temperature has been exceeded, including, for example, the color of the ink **112**, **114**.

In some embodiments, the temperature-related information derived from the inks **112**, **114** can provide calibration information for interpreting changes to the spatial pattern **110**. For example, temperature-related information and/or calibration information can provide a baseline for differentiating between changes in the spatial pattern **110** that are caused by temperature (or temperature fluctuations) and changes that are caused by time.

Temperature-related information can be derived from the inks **112**, **114** in various ways. For example, a computing device can evaluate the state of a characteristic of the ink **112**, **114** at a second time and isolate temperature-related information from the ink **112**, **114**. The temperature-related information can then be subtracted from the change in the spatial pattern **110**, minimizing the effects of temperature on the changes to the spatial pattern **110**. In some embodiments, a temperature stable ink can be employed by combining two inks having opposite temperature coefficients for at least one specified characteristic (e.g., color or reflectivity). The specified characteristic of this ink will vary with respect to time, but not with temperature, (within a specified range of temperatures). One or more reference inks can also be used to derive a baseline and/or temperature-related information, as detailed below.

The plurality of inks **112**, **114** can be disposed on various substrates **102**, including, but not limited to, packaging materials, labels, pharmaceutical medications, legal documents, confidential documents, currency, lottery tickets, and products and/or portions of products or items. The plurality of inks **112**, **114** can also be disposed on the substrate **102** in various ways. For example, the plurality of inks **112**, **114** can be printed on the substrate **102**. The plurality of inks **112**, **114** can also be stamped onto the substrate. Other ways of disposing the plurality of inks **112**, **114** on the substrate **102** can also be employed.

The plurality of inks **112**, **114** can also be disposed in various spatial patterns **110** on the substrate **102**. In some embodiments, the spatial pattern **110** is a predetermined pattern. In the predetermined pattern, a first ink **112** (or a portion thereof) can be disposed at a first location on the substrate **102**, and a second ink **114** (or a portion thereof) can be disposed at a second location on the substrate **102**. The first and second locations can be different. For example, the first location and the second location can be at different pixel locations. In other embodiments, the first and second locations can be at a substantially similar location (e.g., similar pixel location). In such embodiments, any difference between the first and second locations can be minimal and/or non-resolvable by visual inspection by a human.

In some embodiments, the spatial pattern **110** can be machine readable. For example, the spatial pattern **110** can be scanned and/or photographed. The spatial pattern **110** can be scanned and/or photographed with various types of computing devices, including, but not limited to, scanners and smart phones.

In some embodiments, such as the illustrated embodiment of FIGS. **1A-1B**, the spatial pattern **110** can comprise a quick response code (i.e., QR code). Other spatial patterns **110** are also contemplated, including, but not limited to, various types of other barcodes (e.g., one-dimensional barcodes, two-dimensional barcodes, linear barcodes, universal product codes (i.e., UPC), matrix barcodes, etc.), text, images, and icons. Other spatial patterns **110** are also contemplated.

In some embodiments, the spatial pattern **110** is unique, or the spatial pattern **110** comprises a unique pattern. A unique pattern (or a unique spatial pattern **110**) can comprise a randomized arrangement of inks **112**, **114** on the substrate **102**.

For example, the randomized arrangement of inks **112**, **114** can comprise a randomized arrangement of color on a pixel-by-pixel basis through a portion of the spatial pattern **110**. Pixels can refer to discrete units of ink disposed on discrete areas of a substrate **102**. In some embodiments, the randomized arrangement of the inks **112**, **114** can comprise a randomized arrangement of time-progression characteristics on a pixel-by-pixel basis throughout a portion of the spatial pattern **110**. In still other embodiments, the unique pattern (or unique spatial pattern **110**) can be unique to each printing.

If desired, one or more dates (e.g., time stamps) can also be encoded or otherwise disposed in the spatial pattern **110**. In some embodiments, for example, a date disposed in the spatial pattern **110** can correspond to a date on which the inks **112**, **114** are disposed on the substrate **102**. In some embodiments, a date can correspond to at least one of a manufacturing date of a product, a packaging date of a product, and an expiration date of a product. Other dates can also be encoded in the spatial pattern **110** as desired.

The disclosed identification systems **100** have various uses. For example, in some embodiments, the identification system **100** can provide information (e.g., identifying information) about the spatial pattern **110** or a product associated therewith. In some embodiments, information can be derived from the spatial pattern **110** at any time. In particular, evaluation and/or interpretation of the state of a characteristic of an ink **112**, **114** and/or the spatial pattern **110** at a given time (e.g., a second time) can provide identifying information about the spatial pattern **110** and/or a product associated with the spatial pattern **110**. In some embodiments, a spatial pattern **110** can be evaluated to verify the authenticity of a product. The identification system **100** can also comprise, or otherwise be configured as, a counterfeit protection system.

In some embodiments, interpretation of the state of a characteristic of the spatial pattern **110** at a second time comprises a comparison between the state of the characteristic of the spatial pattern **110** at the second time and the state of the characteristic of the spatial pattern **110** at a first time. In other embodiments, interpretation of a characteristic of the spatial pattern **110** comprises a comparison between the state of the characteristic of the spatial pattern **110** at a second time and a control image of how the state of the characteristic of the spatial pattern **110** should appear at the second time. In further embodiments, interpretation of the characteristic of the spatial pattern **110** comprises a comparison between the state of the characteristic of the spatial pattern **110** at a second time and a standard or control, such as an image or color. In yet other embodiments, interpretation of the state of the characteristic of the spatial pattern **110** at a second time comprises capturing an image of the spatial pattern **110** and submitting the image to a website. In some embodiments, the website can evaluate the spatial pattern **110** and provide information about the spatial pattern **110** (e.g., the date on which the spatial pattern **110** was printed).

In some embodiments, interpretation of the characteristic of the spatial pattern **110** can be done by a human, for example, through a visual evaluation. For instance, one can visually compare the state of the characteristic of the spatial pattern **110** at a given time with a standard or control image of how the characteristic of the spatial pattern **110** should look at the given time. The standard or control image can be obtained, for example, from a website. In some embodiments, the visual comparison is performed by merely looking at the spatial pattern **110** and the standard or control image with the naked eye. Enhancement mechanisms can also be used, including, but not limited to, lenses, magnifiers, polarizing lenses, etc.

In other embodiments, interpretation of the characteristic of the spatial pattern **110** comprises an evaluation by a computing device, including, but not limited to, a smart phone. For example, one can capture an image of the spatial pattern **110** with a computing device, such as a smart phone, and upload or otherwise submit the image to a website. The website can perform an evaluation of the image (e.g., by comparing it to a control image or formula, etc.) and provide identifying information about the spatial pattern **110**. In some embodiments, the identifying information includes a date. The date can correspond to a date on which the spatial pattern **110** was disposed on the substrate **102**. The date can also correspond to at least one of a manufacturing date of the product, a packaging date of the product, and an expiration date of the product. In some embodiments, the date can be used to authenticate the product.

In some embodiments, the identifying information obtained from the spatial pattern **110** comprises encoded information that changes over time, including, but not limited to, dosage related information. For example, in some embodiments, the spatial pattern **110** is disposed on a substrate **102** that is associated with a pharmaceutical medication. The efficacy, and thus recommended dosage, of the pharmaceutical medication can change over time as the medication ages. In such embodiments, the dosage information at any given time can be obtained by evaluating the spatial pattern **110**. For example, evaluation of the state of a characteristic of the spatial pattern **110** at a first time can indicate a first dosage amount, and evaluation of the state of the characteristic of the spatial pattern **110** at a second time can indicate a second dosage amount. Further, evaluation of the state of the characteristic of the spatial pattern **110** at a third, fourth, fifth time, etc. can indicate a third, fourth, fifth dosage amount, etc. In some embodiments, the recommended dosage amount can change discontinuously, despite the state of the characteristic changing continuously, e.g., for values of the state of the characteristic between a first and a second value, the dosage is A, whereas for values of the state of the characteristic between the second and a third value, the dosage is B. As can be appreciated, the spatial pattern **110** can also be evaluated at any given time to determine the age of the pharmaceutical medication.

In certain embodiments, the spatial pattern **110** can comprise encoded information about a website. For example, in some embodiments, the spatial pattern **110** comprises a QR code. The QR code can be configured to direct a user to a particular website. In some embodiments, the spatial pattern **110** can change over time such that the QR code changes, and the user is directed to a different website. For example, the state of a characteristic of a QR code at a first time can direct a user to one website, and the state of the characteristic of the QR code at a second time can direct a user to another website, and so forth. Other types of information can also be encoded in the spatial pattern **110** as desired.

FIGS. **2**A-**2**B are schematic illustrations of an identification system **200**, according to another embodiment of the present disclosure. As shown in FIGS. **2**A-**2**B, the identification system **200** can comprise a plurality of inks **212**, **214** having time-dependent properties disposed in a spatial pattern **210** on a substrate **202**. For example, the spatial pattern **210** comprises a first time-dependent ink **212** and a second time-dependent ink **214**, which are analogous to the time-dependent inks **112**, **114** disclosed above in relation to FIGS. **1**A-**1**B.

As further shown in FIGS. **2**A-**2**B, in some embodiments, the identification system **200** further comprises one or more reference inks **216**. In some embodiments, the reference ink

216 can be used as a baseline reference, for example, in the interpretation of the spatial pattern 210. In some embodiments, the reference ink 216 can comprise a static ink that is substantially devoid of time-dependent properties. As can be appreciated, however, static inks can still change to a minimal degree over time, for example, due to aging of the ink 216 and/or the substrate 202. Static inks can also change due to various environmental conditions, including, but not limited to, humidity, temperature, pressure, etc. During or prior to evaluation of the spatial pattern 210, a static ink can be used (e.g., evaluated) to obtain a baseline for determining the changes that occurred to the time-dependent inks 212, 214.

In other embodiments, the reference ink 216 can comprise, or be used as, a color reference. For example, the reference ink 216 can comprise a certain color that does not substantially change over time. The color of the reference ink 216 can be used to compare with time-dependent inks 212, 214 that may change color to provide helpful information about the product.

In further embodiments, the reference ink 216 comprises a calibration ink. For example, the reference ink 216 can comprise temperature calibration inks Temperature calibration inks can comprise known time- and temperature-dependent properties. Temperature calibration inks can also comprise known temperature coefficients. Temperature calibration inks can also be used to differentiate changes due to temperature from those due to time.

Temperature-related information can be derived from the calibration ink in many ways. For example, a computing device can evaluate the calibration at a second time and isolate temperature-related information from the calibration ink. The temperature-related information can then be subtracted from the time-dependent inks 212, 214 to minimize the effects of temperature on the changes to the time-dependent inks 212, 214.

In certain embodiments, the reference ink 216 comprises one or more anti-counterfeiting characteristics. Illustrative anti-counterfeiting characteristics include, but are not limited to, temperature sensitivities, moisture sensitivities, radiation sensitivities, and pressure sensitivities. In some embodiments, the anti-counterfeiting characteristics can comprise a characteristic that changes upon exposure to an abnormal environmental condition, or a condition that extends beyond a certain threshold. For example, the reference ink 216 can change upon exposure to a condition above or below a specified temperature, moisture, radiation, and pressure. In such embodiments, the reference ink 216 can indicate whether the spatial pattern 210 has been tampered with, for example, if the ink 216 has been exposed to increased temperatures in an effort to alter the time-dependent properties of the inks 212, 214.

In certain embodiments, the reference ink 216 can comprise one or more anti-counterfeiting characteristics that change upon exposure to a counterfeit detection test. For example, in some embodiments, a test compound can be applied to the spatial pattern 210 to determine whether the spatial pattern 210 is authentic. Illustrative test compounds can include, but are not limited to, powders, liquids, solvents, solids, and other reagents. When applied to the reference ink 216, the test compound can cause the reference ink 216 to change, either temporarily or permanently, to indicate the existence of the reference ink 216, an indication that the spatial pattern 210 is authentic. Upon exposure to a fraudulent or counterfeit spatial pattern, the test compound may not react, or may react differently, indicating that the spatial pattern and associated identification system are fraudulent.

It will also be appreciated that in some embodiments, a time-dependent ink 212, 214 can be used as a calibration ink, and/or an anti-counterfeiting ink, analogous to the reference ink 216 discussed above. Thus, the discussion re calibration inks and anti-counterfeiting inks can be in relation to a reference ink 216, and/or a time-dependent ink 212, 214.

FIGS. 3A-3B are schematic illustrations of an identification system 300, according to another embodiment of the disclosure. As shown in FIGS. 3A-3B, the identification system 300 comprises a plurality of inks 312, 314 having time-dependent properties disposed in a spatial pattern 310 on a substrate 302. For example, the spatial pattern 310 comprises a first time-dependent ink 312, and a second time-dependent ink 314, which are analogous to the time-dependent inks 112, 114 disclosed above in relation to FIGS. 1A-1B.

As further shown in FIGS. 3A-3B, in some embodiments, the characteristic of the ink 312, 314 that is affected by the time-dependent property comprises location, such as a spatial location in the spatial pattern 310 on the substrate 302. For example, the ink 312, 314, or a portion thereof, can change locations over time, as shown in FIGS. 3A-3B. In FIG. 3A, the inks 312, 314 are disposed at one location at a first time to form a first QR code, and in FIG. 3B, the inks 312, 314 are disposed at a different location at a second time to form a second QR code. In such embodiments, a portion of the spatial pattern 310 can be described as being disposed at one location in a first state, and another location in a second state.

In certain embodiments, the inks 312, 314 can migrate from one location to another location on the substrate 302. U.S. Pat. No. 5,602,804, titled 'Long Term Rapid Color Changing Time Indicator,' filed Aug. 3, 1995 and U.S. Pat. No. 5,822,280, titled 'Long Term Rapid Color Changing Time Indicator Employing Dye Absorbing Layer,' filed May 6, 1996, each of which is incorporated by reference in its entirety, describe two different indicator systems based on migration of ink components relative to a substrate. The inks 312, 314 can migrate over time relatively quickly, or slowly, as desired. In some embodiments, the ink 312, 314 migrates via wicking through the substrate 302. In further embodiments, the characteristic of the ink 312, 314 changes over time due to migration of only a component of the ink 312, 314. For example, a liquid or aqueous component of the ink 312, 314 can migrate from one location to another, for example, by wicking through the substrate 302. In further embodiments, the characteristic of the ink 312, 314 changes from one state to another state because of migration of a component of another ink from one location to another. For example, a component of the second ink 314 can migrate and interact with a component of the first ink 312 in one location or another.

In some embodiments, the inks 312, 314 migrate at a different rate. In other embodiments, the inks 312, 314 migrate at substantially similar rates. The rate of migration of the inks 312, 314 can also be variable or otherwise capable of being varied or changed. For example, the rate of migration of an ink 312, 314 can be configured to be relatively fast, or relatively slow, depending on the desired use of the identification system 300.

The rate of migration of the ink 312, 314 can be varied by modifying one or more components of the ink 312, 314. For example, one or more reagents or other compounds can be added that can accelerate or decelerate the rate of migration. In some embodiments, the one or more components of the ink 312, 314 can be modified prior to disposing the ink 312, 314 on the substrate 302. In other embodiments, the one or more components of the ink 312, 314 are modified while the ink 312, 314 is being disposed on the substrate 302. For example,

one or more components of the ink **312**, **314** can be mixed with additional reagents or compounds while the ink **312**, **314** is being disposed on the substrate **302**. In yet other embodiments, one or more components of the ink **312**, **314** can be modified after the ink **312**, **314** has been disposed on the substrate **302**. For example, a reagent or other compound can be applied to an ink **312**, **314** that has previously been disposed on a substrate **302**.

As can be appreciated, varying the rate of migration of an ink **312**, **314** can vary the rate of change of a particular characteristic of the ink **312**, **314** and/or the spatial pattern **310**. For example, increasing the rate of migration of an ink **312**, **314** can increase the rate of change of a characteristic of the ink **312**, **314** and/or the spatial pattern **310**. Analogously, decreasing the rate of migration of an ink **312**, **314** can decrease the rate of change of a characteristic of the ink **312**, **314** and/or the spatial pattern **310**. In some embodiments, the rate of migration can be varied, or otherwise configured, such that a characteristic of an ink **312**, **314** and/or the spatial pattern **310** changes to a particular state on a predetermined date, for example, to authenticate a product or indicate that an expiration date has passed.

As further shown in FIGS. **3**A-**3**B, in some embodiments, the identification system **300** further comprises one or more reference inks **316**. As discussed above, the reference ink **316** can be used as a baseline reference for interpretation of the spatial pattern **310**. In some embodiments, the reference ink **316** can be a non-migrating ink, such that it remains disposed in one location while the time-dependent inks **312**, **314** move over time.

In some embodiments, the spatial pattern **310** changes such that it can direct a user to a particular website at a particular time. For example, as shown in FIGS. **3**A-**3**B, the spatial pattern **310** can comprise a QR code. In FIG. **3**A, the spatial pattern **310** is disposed in a first QR code and can direct a user to one website, and in FIG. **3**B, the spatial pattern **310** is disposed in a second QR code and can direct a user to a different website.

FIG. **4** is a schematic illustration of an identification system **400**, according to another embodiment of the disclosure. As shown in FIG. **4**, the identification system **400** comprises a plurality of inks **412**, **414** having time-dependent properties disposed in a spatial pattern **410** on a substrate **402**. For example, the spatial pattern **410** comprises a first time-dependent ink **412**, and a second time-dependent ink **414**, which are analogous to the time-dependent inks **112**, **114** disclosed above in relation to FIGS. **1**A-**1**B. In some embodiments, the spatial pattern **410** further comprises a third time-dependent ink **416**, which can also be analogous to the time-dependent inks **112**, **114** disclosed above in relation to FIGS. **1**A-**1**B. In some embodiments, such as the illustrated embodiment of FIG. **4**, the identification system **400** further comprises a reference ink **418** that is substantially devoid of time-dependent properties.

FIGS. **5**A-**5**B are schematic illustrations of an identification system **500**, according to another embodiment of the disclosure. As shown in FIGS. **5**A-**5**B, the identification system **500** comprises a plurality of inks **512**, **514** having time-dependent properties disposed in a spatial pattern **510** on a substrate **502**. For example, the spatial pattern **510** comprises a first time-dependent ink **512**, and a second time-dependent ink **514**, which are analogous to the time-dependent inks **112**, **114** disclosed above in relation to FIGS. **1**A-**1**B.

As shown in FIGS. **5**A-**5**B, various types of spatial patterns **510** can be employed. For example, in FIGS. **1**A-**1**B, **2**A-**2**B, **3**A-**3**B, and **4**, the spatial patterns **110**, **210**, **310**, **410** were generally in the form of a QR code. In FIGS. **5**A-**5**B, the spatial pattern **510** can be representative of another barcode, an image, an icon, or another type of spatial pattern **510**.

Further, as shown in FIGS. **5**A-**5**B, the first and second inks **512**, **514** can migrate over time. For example, in FIG. **5**A, a first ink **512** (or a portion thereof) is disposed at a first location **522**, and a second ink **514** (or a portion thereof) is disposed at a second location **526**. As indicated by the reference arrows, D**1** and D**2**, the inks **512**, **514** (or portions thereof) can migrate over time to a different location on the substrate **502**, as illustrated in FIG. **5**B. In FIG. **5**B, the first ink **512** (or a portion thereof) has moved to a new location **524**, and the second ink **514** (or a portion thereof) has moved to a new location **528**. In some embodiments, the distance the inks **512**, **514** have moved can be evaluated to determine information about the spatial pattern **510**, e.g., information such as the date on which the spatial pattern **510** was disposed on the substrate **502**.

FIGS. **6**A-**6**B are schematic illustrations of an identification system **600**, according to another embodiment of the disclosure. As shown in FIGS. **6**A-**6**B, the identification system **600** comprises a plurality of inks **612**, **614** having time-dependent properties disposed in a spatial pattern **610** on a substrate **602**. For example, the spatial pattern **610** comprises a first time-dependent ink **612**, and a second time-dependent ink **614**, which are analogous to the time-dependent inks **112**, **114** disclosed above in relation to FIGS. **1**A-**1**B. The spatial pattern **610** further comprises a reference ink **616** that is substantially devoid of time-dependent properties.

As shown in FIG. **6**A, in some embodiments, the first and second inks **612**, **614** can be disposed at a substantially similar location **622** on the substrate **602**. Further, one or more of the inks **612**, **614** can be configured to migrate over time, as indicated by the reference arrow D**3**. In FIG. **6**B, the second ink **614** has migrated to a new location **624** at a second time such that it is no longer disposed in the same spatial location as the first ink **612**. An evaluation of the inks **612**, **614** can then provide identifying information about the spatial pattern **610**.

Methods for labeling a substrate with an identification system are also provided herein. In particular, it is contemplated that any of the components, principles, and/or embodiments discussed above may be utilized by either a system or a method. For example, in an embodiment, a method for labeling a substrate may comprise a step of disposing a first ink comprising a time-dependent property and a second ink comprising a time-dependent property onto the substrate, wherein the first and second inks are disposed onto the substrate to form a spatial pattern. The time-dependent property of the first ink and the time-dependent property of the second ink can cause a characteristic of the spatial pattern to change from a first state at a first time to a second state at a second time. Further, in some embodiments, the characteristic of the spatial pattern in the second state can provide identifying information about the spatial pattern and/or a product associated with the spatial pattern. In further embodiments, a characteristic of the first ink can change from a third state at the first time to a fourth state at the second time, and the first ink can comprise known time- and temperature-dependent properties such that interpretation of the first ink in the fourth state can provide information about the temperature of the first ink between the first time and the second time. Additional steps, and/or methods, can also be employed.

Reference throughout this specification to "an embodiment" or "the embodiment" means that a particular feature, structure, or characteristic described in connection with that embodiment is included in at least one embodiment. Thus, the

quoted phrases, or variations thereof, as recited throughout this specification are not necessarily all referring to the same embodiment.

Similarly, it should be appreciated that in the above description of embodiments, various features are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure. This method of disclosure, however, is not to be interpreted as reflecting an intention that any claim require more features than those expressly recited in that claim. Rather, as the following claims reflect, inventive aspects lie in a combination of fewer than all features of any single foregoing disclosed embodiment.

The claims following this written disclosure are hereby expressly incorporated into the present written disclosure, with each claim standing on its own as a separate embodiment. This disclosure includes all permutations of the independent claims with their dependent claims. Moreover, additional embodiments capable of derivation from the independent and dependent claims that follow are also expressly incorporated into the present written description.

While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. An identification system, comprising:

a first ink comprising a time-dependent property; and

a second ink comprising a time-dependent property;

the first ink and second ink being disposed in a spatial pattern on a substrate;

wherein the time-dependent properties of the first and second inks cause a characteristic of the spatial pattern to change from a first state at a first time to a second state at a second time,

wherein interpretation of the characteristic of the spatial pattern in the second state provides identifying information about a product, and

wherein a characteristic of the first ink changes from a third state at the first time to a fourth state at the second time, and a characteristic of the second ink changes from a fifth state at the first time to a sixth state at the second time, wherein the first ink comprises known time- and temperature-dependent properties such that interpretation of the first ink in the fourth state provides information about the temperature of the first ink between the first time and the second time.

2. The system of claim **1**, wherein interpretation of the first ink in the fourth state provides information about whether the temperature of the first ink exceeded a threshold temperature between the first time and the second time.

3. The system of claim **1**, wherein interpretation of the first ink in the fourth state provides information about whether the temperature of the first ink decreased below a threshold temperature between the first time and the second time.

4. The system of claim **1**, wherein the temperature information derived from interpreting the first ink in the fourth state provides calibration information for interpretation of the spatial pattern in the second state.

5. The system of claim **1**, wherein interpretation of the first ink in the fourth state comprises interpretation by a computing device.

6. The system of claim **5**, wherein the computing device is configured to isolate the temperature-related information from the time-related information from the first ink and to provide calibration information for interpretation of the spatial pattern in the second state.

7. The system of claim **1**, wherein the characteristic of the first ink comprises at least one of color, reflectivity, and location.

8. The system of claim **7**, wherein the characteristic of the second ink comprises at least one of color, reflectivity, and location.

9. The system of claim **1**, wherein the spatial pattern comprises a pattern selected from the group consisting of a barcode, a one-dimensional barcode, a two-dimensional barcode, a linear barcode, a universal product code, a matrix barcode, a quick response code, text, and an icon.

10. The system of claim **1**, wherein a date is encoded in the spatial pattern.

11. The system of claim **1**, wherein interpretation of the characteristic of the spatial pattern in the second state comprises an evaluation of the spatial pattern in the second state and a determination of whether the spatial pattern is authentic.

12. The system of claim **1**, wherein interpretation of the characteristic of the spatial pattern in the second state comprises a comparison between the characteristic of the spatial pattern in the second state and the characteristic of the spatial pattern in the first state.

13. The system of claim **1**, wherein interpretation of the characteristic of the spatial pattern in the second state comprises a comparison between the characteristic of the spatial pattern in the second state and a control image of how the characteristic of the spatial pattern should appear at the second time.

14. The system of claim **1**, wherein interpretation of the characteristic of the spatial pattern in the second state comprises a comparison between the characteristic of the spatial pattern in the second state and a standard.

15. The system of claim **1**, wherein interpretation of the characteristic of the spatial pattern in the second state comprises an evaluation by a computing device.

16. The system of claim **15**, wherein evaluation by a computing device comprises capturing an image of the spatial pattern in the second state and submitting the image to a website.

17. The system of claim **1**, further comprising:

one or more reference inks disposed in the spatial pattern.

18. The system of claim **17**, wherein a reference ink comprises a static ink that is substantially devoid of time-dependent properties.

19. The system of claim **17**, wherein a reference ink provides a baseline reference for the interpretation of the characteristic of the spatial pattern in the second state.

20. The system of claim **17**, wherein one or more reference inks comprise an anti-counterfeiting characteristic.

21. A counterfeit protection system, comprising:

a first ink comprising a time-dependent property;

a second ink comprising a time-dependent property; and

a third ink comprising known time- and temperature-dependent properties;

the first ink, the second ink, and the third ink being disposed in a spatial pattern on a substrate;

wherein the time-dependent properties of the first and second inks cause a characteristic of the spatial pattern to change from a first state at a first time to a second state at a second time, wherein the characteristic of the spatial pattern in the second state provides identifying information about a product, and

wherein a characteristic of the first ink changes from a third state at the first time to a fourth state at the second time,

a characteristic of the second ink changes from a fifth state at the first time to a sixth state at the second time, and a characteristic of the third ink changes from a seventh state at the first time to an eighth state at the second time, and wherein interpretation of the third ink in the eighth state provides identifying information about the temperature of the third ink between the first time and the second time.

22. A method of labeling a substrate, comprising:

disposing a first ink comprising a time-dependent property onto a substrate; and

disposing a second ink comprising a time-dependent property onto the substrate;

wherein the first ink and the second ink are disposed onto the substrate to form a spatial pattern,

wherein the time-dependent properties of the first and second inks cause a characteristic of the spatial pattern to change from a first state at a first time to a second state at a second time, wherein interpretation of the characteristic of the spatial pattern in the second state provides identifying information about a product, and

wherein a characteristic of the first ink changes from a third state at the first time to a fourth state at the second time, and a characteristic of the second ink changes from a fifth state at the first time to a sixth state at the second time, wherein the first ink comprises known time- and temperature-dependent properties such that interpretation of the first ink in the fourth state provides information about the temperature of the first ink between the first time and the second time.

23. The method of claim **22**, wherein interpretation of the first ink in the fourth state provides information about whether the temperature of the first ink exceeded a threshold temperature between the first time and the second time.

24. The method of claim **22**, wherein interpretation of the first ink in the fourth state provides information about whether the temperature of the first ink decreased below a threshold temperature between the first time and the second time.

25. The method of claim **22**, wherein the temperature information derived from interpreting the first ink in the fourth state provides calibration information for interpretation of the spatial pattern in the second state.

26. The method of claim **22**, wherein interpretation of the first ink in the fourth state comprises interpretation by a computing device.

27. The method of claim **26**, wherein the computing device is configured to isolate the temperature-related information from the time-related information from the first ink and to provide calibration information for interpretation of the spatial pattern in the second state.

28. The method of claim **22**, wherein the characteristic of the first ink comprises at least one of color, reflectivity, and location.

29. The method of claim **28**, wherein the characteristic of the second ink comprises at least one of color, reflectivity, and location.

30. The method of claim **22**, wherein the spatial pattern comprises a pattern selected from the group consisting of a barcode, a one-dimensional barcode, a two-dimensional barcode, a linear barcode, a universal product code, a matrix barcode, a quick response code, text, and an icon.

31. The method of claim **22**, wherein a date is encoded in the spatial pattern.

32. The method of claim **22**, wherein the identifying information is determined by evaluating the characteristic of the spatial pattern in the second state.

33. The method of claim **22**, wherein the identifying information is determined by comparing the characteristic of the spatial pattern in the second state with the characteristic of the spatial pattern in the first state.

34. The method of claim **22**, wherein the identifying information is determined by comparing the characteristic of the spatial pattern in the second state with a control image of how the characteristic of the spatial pattern should appear at the second time.

35. The method of claim **22**, wherein the identifying information is determined by comparing the characteristic of the spatial pattern in the second state with a standard.

36. The method of claim **22**, wherein the identifying information is determined by evaluating the characteristic of the spatial pattern in the second state by a computing device.

37. The method of claim **36**, wherein an evaluation by a computing device comprises capturing an image of the spatial pattern in the second state and submitting the image to a website.

38. The method of claim **22**, further comprising:

disposing one or more reference inks in the spatial pattern.

39. The method of claim **38**, wherein a reference ink comprises a static ink that is substantially devoid of time-dependent properties.

40. The method of claim **38**, wherein a reference ink provides a baseline reference for the interpretation of the characteristic of the spatial pattern in the second state.

41. The method of claim **38**, wherein one or more reference inks comprise an anti-counterfeiting characteristic.

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