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(54) OPTICAL ANTI-COUNTERFEITING ELEMENT AND DESIGN METHOD THEREFOR, ANTI-COUNTERFEITING PRODUCT, AND DATA CARRIER

(57) Provided are an optical anti-counterfeiting element and a design method thereof, an anti-counterfeiting product, and a data carrier. The optical anti-counterfeiting element (1) has a diffuse reflection region (2); the diffuse reflection region can reflect incident light into the range of at least a preset observation angle set Ωv; the diffuse reflection region comprises a plurality of reflection facets (3); the plurality of reflection facets comprise modified reflection facets that are globally or locally modified, and unmodified reflection facets, the modified reflection facets and the unmodified reflection facets have different reflection characteristics, wherein the modified reflection facets correspond to a pattern area (71, 81); and when the diffuse reflection region is illuminated by the incident light, the modified reflection facets are collectively presented as a pattern of a dynamic feature, and the unmodified reflection facets are collectively presented as a background area (72, 82) of the dynamic feature. The optical anti-counterfeiting element is simple in manufacturing process, and can flexibly implement a dynamic feature such as color and/or light-dark contrast.

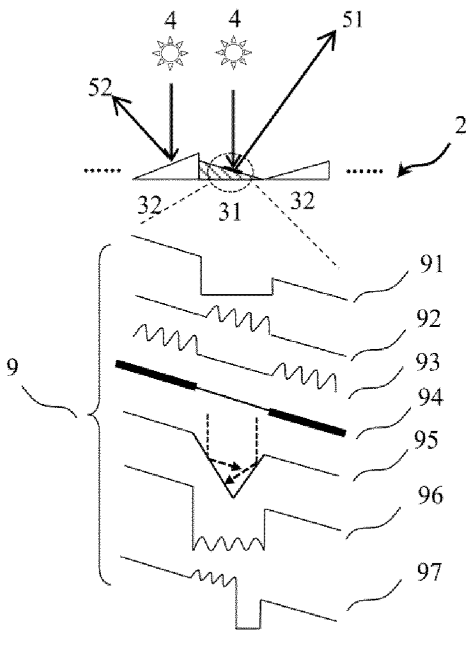

Fig. 6

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Description

Cross-Reference to Related Application

[0001] This application claims priority to Chinese Patent Application No. 202110449753.0 filed to the China National Intellectual Property Administration on April 25, 2021 and entitled "Optical Anti-Counterfeiting Element, Design Method thereof, Anti-Counterfeiting Product and Data Carrier", the present invention of which is hereby incorporated by reference in its entirety.

Technical Field

[0002] The present invention relates to the technical field of anti-counterfeiting, in particular to an optical anti-counterfeiting element, a design method thereof, an anti-counterfeiting product and a data carrier.

Background

[0003] In order to prevent counterfeiting generated by means of scanning, copying and the like, an optical anti-counterfeiting technology is widely adopted in various high-safety or high-added-value products such as banknotes, financial bills and the like, and a very good effect is achieved.

[0004] Currently, an attractive technology is to combine a microstructure determined by plate making with an optically variable layer, as disclosed in Chinese patents CN 102712207 A and CN 107995894 A, the brightness distribution of reflected light is modulated by a pre-designed micro-reflective surface, thereby realizing a dynamic effect, and combination of color change and dynamic effect may be realized by overlapping an interference coating. This may often produce a variety of motion effects in patterns such as lines, circles, curves or text, and may produce a three-dimensional stereoscopic effect. However, in most cases, the color and the hue of the pattern and background are only the same, and the contrast relationship between light and shade is basically single, so that it is difficult to realize dynamic characteristic of various colors or any relationship between light and shade.

[0005] A display map with a three-dimensional depth effect may also be produced by a Moir magnification configuration based on microlenses and micropatterns, as described for example in document WO 2005/052650 A2. Here, a periodic display map composed of many small micropatterns is magnified with a grid composed of microlenses having similar, but not identical, periods. In this way, a stereoscopic impression that is clearly in front of or behind an actual surface may be produced, or so-called orthogonal parallax motion may be produced. However, the Moir magnification configuration is disadvantageous in that it is relatively complicated to manufacture, requiring two embossing steps for the microlenses and the micropatterns, and precise alignment between the two steps.

[0006] Finally, as described for example in WO2014/108303A1, magnetically arranged reflective pigments are aligned with correspondingly shaped magnets, thereby producing a bright (especially ring-shaped) dynamic effect that may include a certain depth effect. The effect is very bright and easily visible, but a required magnetic ink is expensive, and the type and resolution of the effect are limited by available magnets and difficult to adjust at random.

[0007] Therefore, there is a need to develop an optical anti-counterfeiting element simple in manufacturing process and capable of flexibly realizing dynamic characteristic of color and/or light-shade contrast.

Summary

[0008] The present invention provides an optical anti-counterfeiting element and a design method thereof, an anti-counterfeiting product and a data carrier, and the optical anti-counterfeiting element is simple in manufacturing process and capable of flexibly realizing dynamic characteristics of color and/or light-shade contrast and the like.

[0009] In order to achieve the purpose, the present invention provides an optical anti-counterfeiting element, which presents dynamic characteristic, the dynamic characteristic is pre-designed to be a reproduction of a set of animation frames visible at a preset observation angle set Ωv, and each of the set of animation frames includes a pattern area and a background area forming optical contrast with the pattern area; the optical anti-counterfeiting element is provided with a diffuse reflection region, and the diffuse reflection region reflects incident light to at least a range of the preset observation angle set Ωv; the diffuse reflection region includes a plurality of reflection surface elements including modified reflection surface elements that each of the modified reflection surface elements is wholly or partially modified and unmodified reflection surface elements, the modified reflection surface elements and the unmodified reflection surface elements have different reflection characteristics, and the modified reflection surface elements correspond to the pattern area; and when the diffuse reflection region is illuminated by the incident light, the modified reflection surface elements together appear as a pattern of dynamic characteristic, and the unmodified reflection surface elements together appear as a background of dynamic characteristic.

[0010] In an embodiment mode, the angle of each of the plurality of reflection surface elements is randomly selected within a preset angle set Ωs, and elements in the preset observation angle set Ωv, elements in the preset angle set Ωs and an angle of the incident light are related through a set reflection law.

[0011] In an embodiment mode, the angle of each of the plurality of reflection surface elements is determined by an inclination angle and an azimuth angle of each of the plurality of reflection surface elements, and the inclination angle is preferably 0-20° and/or the azimuth angle is preferably 0-360 ° .

[0012] In an embodiment mode, the angle of each of the plurality of reflection surface elements is obtained by randomly selecting the elements in the preset angle set Ωs with equal probability; and/or the angle of each of the plurality of reflection surface elements is randomly selected from the preset angle set Ωs by using a pseudo-random number generation program.

[0013] In an embodiment mode, a transverse dimension of each of the plurality of reflection surface elements is 3-100 μm, preferably 10-30 μm.

[0014] In an embodiment mode, each of the plurality of reflection surface elements is plane or curved.

[0015] In an embodiment mode, at least part of each of the unmodified reflection surface elements is smooth or has a secondary structure; and/or at least part of the diffuse reflection region is provided with a plating or a coating.

[0016] In an embodiment mode, each of the modified reflection surface elements is wholly or partially modified by one or more of following ways: a secondary structure is added to each of the modified reflection surface elements; each of the modified reflection surface elements is enabled to be smooth; each of the modified reflection surface elements is flattened; each of the modified reflection surface elements is disposed to be convex or concave compared with the unmodified reflection surface elements; an angle of each of the modified reflection surface elements is adjusted so that the incident light is reflected beyond the range of the preset observation angle set Ωv; or a thickness of the plating or the coating of each of the modified reflection surface elements is adjusted to be different from that of the unmodified reflection surface elements.

[0017] In an embodiment mode, in a case that each of the modified reflection surface elements is modified by two or more of the ways, the two or more of the ways exist in a parallel combination and/or a serial combination.

[0018] In an embodiment mode, a transverse characteristic dimension of the secondary structure is 0.2-5 μm.

[0019] In an embodiment mode, a width of a modified area of each of the modified reflection surface elements is 0.5-30 μm, preferably, 2-10 μm.

[0020] In an embodiment mode, different reflection characteristics refer to one or a combination of different reflection colors, different reflection brightness, or different reflection textures between each of the modified reflection surface elements and the unmodified reflection surface elements when illuminated by the incident light.

[0021] In an embodiment mode, the present invention further provides a design method of an optical anti-counterfeiting element, which includes: a dynamic characteristic is designed, the dynamic characteristic is a reproduction of a set of animation frames visible at a preset observation angle set Ωv, and each of the set of animation frames includes a pattern area and a background area forming optical contrast with the pattern area; a diffuse reflection region configured for the optical anti-counterfeiting element is designed, and the diffuse reflection region reflects incident light to at least a range of the preset observation angle set Ωv, and the diffuse reflection region includes a plurality of reflection surface elements; based on an observation angle of each of the set of animation frames, the reflection surface elements corresponding to the pattern area of each of the set of animation frames are modified to form the modified reflection surface elements, so that the modified reflection surface elements and the unmodified reflection surface elements have different reflection characteristics; and when the diffuse reflection region is illuminated by incident light, the modified reflection surface elements together appear as a pattern of dynamic characteristic, and the unmodified reflection surface elements together appear as a background of dynamic characteristic.

[0022] In an embodiment mode, an angle of each of the plurality of reflection surface elements is randomly selected within the preset angle set Ωs, and elements in the preset observation angle set Ωv, elements in the preset angle set Ωs and an angle of incident light are related through a set reflection law.

[0023] In an embodiment mode, the angle of each of the plurality of reflection surface elements is determined by an inclination angle and an azimuth angle of the reflection surface element, and the inclination angle is preferably 0-20° and/or the azimuth angle is preferably 0-360°.

[0024] In an embodiment mode, the angle of each of the plurality of reflection surface elements is randomly selected within the preset angle set Ωs includes: the angle of each of the plurality of reflection surface elements is obtained by randomly selecting the elements in the preset angle set Ωs with equal probability; and/or the angle of each of the plurality of reflection surface elements is randomly selected from the preset angle set Ωs by using a pseudo-random number generation program.

[0025] In an embodiment mode, the transverse dimension of each of the plurality of reflection surface elements is 3-100 μm, preferably 10-30 μm.

[0026] In an embodiment mode, each of the plurality of reflection surface elements is plane or curved.

[0027] In an embodiment mode, the design method further includes: at least part of each of the unmodified reflection surface elements is smooth or has a secondary structure; and/or at least part of the diffuse reflection region is provided with a plating or a coating.

[0028] In an embodiment mode, that the reflection surface elements corresponding to the pattern area of each of the set of animation frames are modified to form the modified reflection surface elements includes: each of the set of animation frames is pixelated; a first azimuth angle and a first pitch angle of each of the set of animation frames are determined, and the first azimuth angle and the first pitch angle are determined according to the observation angle of each of the set of animation frames; a second azimuth angle and a second pitch angle of each of the reflection surface elements in the diffuse reflection region are determined; the following steps are carried out for each of the set of animation frames: in a position, corresponding to pixels of the pattern area of each of the set of animation frames, of the diffuse reflection region, reflection surface elements corresponding to the second azimuth angle and the second pitch angle matching the first azimuth angle and the first pitch angle of each of the set of animation frames are found, so as to determine the reflection surface elements corresponding to the pattern area of each of the set of animation frames in the diffuse reflection region; and the reflection surface elements corresponding to the pattern area of each of the set of animation frames determined in the diffuse reflection region are modified.

[0029] In an embodiment mode, that in the position, corresponding to the pixels of the pattern area of each of the set of animation frames, of the diffuse reflection region, the reflection surface elements corresponding to the second azimuth angle and the second pitch angle matching the first azimuth angle and the first pitch angle of each of the set of animation frames are found includes: within a preset distance range of the position, corresponding to the pixels of the pattern area of each of the set of animation frames, of the diffuse reflection region, the reflection surface elements corresponding to the second azimuth angle having an angle difference with the first azimuth angle within a range of the first preset angle difference and the second pitch angle having an angle difference with half of the first pitch angle within a range of a second preset angle difference are found.

[0030] In an embodiment mode, a preset distance range refers to that a distance from the position, corresponding to the pixels of the pattern area of each of the set of animation frames is less than 100 μm, preferably less than 50 μm; and/or the range of the first preset angle difference refers to that an angle difference from the first azimuth angle is less than 3°, preferably less than 0.5°; and/or the range of the second preset angle difference refers to that an angle difference from the first pitch angle is less than 3°, preferably less than 0.5°.

[0031] In an embodiment mode, that the reflection surface elements corresponding to the pattern area of each of the set of animation frames are modified to form the modified reflection surface elements includes: a secondary structure is added to each of the modified reflection surface elements; each of the modified reflection surface elements is enabled to be smooth; each of the modified reflection surface elements is flattened; each of the modified reflection surface elements is disposed to be convex or concave compared with the unmodified reflection surface elements; an angle of each of the modified reflection surface elements is adjusted so that the incident light is reflected beyond the range of the preset observation angle set Ωv; or a thickness of a plating or a coating of each of the modified reflection surface elements is adjusted to be different from that of the unmodified reflection surface elements.

[0032] In an embodiment mode, the dynamic characteristic is one or a combination of translation, rotation, zoom, deformation, looming, and Yin/Yang conversion; and/or the optical contrast is one or a combination of different colors, different brightness and different textures that are visible to human eyes.

[0033] In an embodiment mode, a width of a modified area of each of the modified reflection surface elements is 0.5-30 μm, preferably, 2-10 μm.

[0034] In an embodiment mode, the present invention further provides an anti-counterfeiting product using the optical anti-counterfeiting element.

[0035] In an embodiment mode, the present invention further provides a data carrier, having the optical anti-counterfeiting element, or the anti-counterfeiting product described above.

[0036] The optical anti-counterfeiting element provided by the embodiments of the present invention is simple in manufacturing process and capable of flexibly realizing dynamic characteristics of color and/or light-shade contrast and the like, in addition, it presents a variety of multi-color dynamic characteristic on a macro level, and at the same time, it does not have directly recognizable arrangement rules on the micro level, thus enhancing the difficulty of counterfeiting in multi-dimensions such as microstructure design and manufacturing process.

[0037] Further features and advantages of the embodiments of the present invention will be explained in detail in the embodiments which follow.

Brief Description of the Drawings

[0038] The drawings serve to provide a further understanding of the embodiments of the present invention and constitute a part of this specification, and together with the following detailed description of the embodiments, serve to explain the embodiments of the present invention but do not constitute a limitation of the embodiments of the present invention. In the drawings, the illustrations are not drawn to scale for clarity. In the drawings:

Fig. 1 is a schematic diagram of a diffuse reflection effect of a diffuse reflection region of an optical anti-counterfeiting element on incident light.

Fig. 2 is a schematic diagram of a design method of a pitch angle and an azimuth angle of a reflection surface element.

Fig. 3 is another schematic diagram of a design method of a pitch angle and an azimuth angle of a reflection surface element.

Fig. 4 is an embodiment in which a modified reflection surface element is determined according to an animation frame.

Fig. 5 is another embodiment in which a modified reflection surface element is determined according to an animation frame.

Fig. 6 is a schematic diagram of partial or whole modification mode of a modified reflection surface element.

Fig. 7 is a schematic diagram of use of the optical anti-counterfeiting element on a banknote.

Detailed Description of the Embodiments

[0039] The detailed description of the embodiments of the present invention will be described in detail below with reference to the drawings. It is to be understood that the detailed description of the embodiments described herein are for the purpose of illustrating and explaining the embodiments of the present invention only and are not intended to limit the embodiments of the present invention.

[0040] In an aspect of the embodiments of the present invention, an optical anti-counterfeiting element is provided, which presents dynamic characteristic, the dynamic characteristic is pre-designed to be a reproduction of a set of animation frames visible at a preset observation angle set Ωv, and each of the set of animation frames includes a pattern area and a background area forming optical contrast with the pattern area; the optical anti-counterfeiting element is provided with a diffuse reflection region, and the diffuse reflection region reflects incident light to at least a range of the preset observation angle set Ωv; the diffuse reflection region includes a plurality of reflection surface elements including modified reflection surface elements that each of the modified reflection surface elements is wholly or partially modified and unmodified reflection surface elements, the modified reflection surface elements and the unmodified reflection surface elements have different reflection characteristics, and the modified reflection surface elements correspond to the pattern area; and when the diffuse reflection region is illuminated by the incident light, the modified reflection surface elements together appear as a pattern of dynamic characteristic, the unmodified reflection surface elements together appear as a background of dynamic characteristic, namely, the modified reflection surface elements together reproduce the pattern of dynamic characteristic, and the unmodified reflection surface elements together reproduce the background of dynamic characteristic.

[0041] The different reflection characteristics refer to one or a combination of different reflection colors, different reflection brightness, or different reflection textures between the modified reflection surface elements and the unmodified reflection surface elements when illuminated by incident light.

[0042] When the diffuse reflection region is illuminated by the incident light, each of the set of animation frames is observed under a corresponding observation angle of the each of the set of animation frames, and a pattern of an observed animation frame is presented by the modified reflection surface elements, and a background of the observed animation frame is presented by the unmodified reflection surface elements.

[0043] "A set of animation frames visible at a preset observation angle set Ωv" in the embodiments of the present invention refers to that observation angles correspond to animation frames one by one, and one observation angle corresponds to one animation frame.

[0044] The dynamic characteristic of the embodiments of the present invention essentially refer to the dynamic characteristic that occur when the observation angle is changed. In principle, the observation angle may be an angle of one or more of three elements: a light source (i.e., the incident light), the optical anti-counterfeiting element, and an observer. For example, in the case that positions of an illumination light source and human eyes remain unchanged, the optical anti-counterfeiting element or an article with the optical anti-counterfeiting element is held in hand, by rocking the optical anti-counterfeiting element back and forth or left and right, an angle of the optical anti-counterfeiting element is changed, and the dynamic characteristic of the design is seen. In order to simplify the statement, the present invention defines an observation direction through a line between eyes of the observer and an observation point, thus defining the observation angle. It is to be noted that the definition will not essentially affect or limit any relevant content of the embodiments of the present invention. The observation angle is a three-dimensional space parameter, so it needs to be decomposed into at least two angles for accurate description. For example, the pitch angle and the azimuth angle may be configured to describe together, or included angles with three coordinate axes x, y, and z of the observation direction may be configured to describe together. In an xyz coordinate defined in the embodiments of the present invention, the xy plane is the plane where the optical anti-counterfeiting element is located, the x axis may be a longitudinal direction of the optical anti-counterfeiting element, the y axis may be a transverse direction of the anti-counterfeiting element, and the z axis may be an axis perpendicular to the optical anti-counterfeiting element.

[0045] The pattern of each of the set of animation frames may be designed as letters, numbers, characters, symbols, or geometric shapes (especially circles, ovals, triangles, rectangles, hexagons, or stars). The dynamic characteristic above generally refer to any one of translation, rotation, zoom, deformation, looming, and Yin/Yang conversion of a design pattern presented by the optical anti-counterfeiting element, which is visible to human eyes, and also may be any combination of these dynamic characteristics. Translation may be designed as the design pattern translates in a specific direction, or also may be designed as it translates in a plurality of directions, with a translation direction associated with the observation direction. A common combination characteristic is that when a position of the pattern of each of the set of animation frames changes, its shape also changes, such as a circle turns into a square. The dynamic characteristic may have the orthogonal parallax motion behavior of a pattern, namely, a motion direction of the pattern is always perpendicular to a change of the observation direction, which further attracts the attention of the observer through counter-intuitive phenomena. A motion of the pattern of each of the set of animation frames creates the stereoscopic effect of floating above or below the plane of the optical anti-counterfeiting element through the principle of binocular horizontal parallax. Each of the patterns may also include a plurality of sub-patterns presenting the same or different motion behaviors and/or the same or different floating heights or floating depths. In particular, the pattern may include at least a first curve and a second curve which, when observed from a first or second observation direction, appear as a first or second target curve at the center of a first or second area, respectively. When the optical anti-counterfeiting element inclines, the first curve and the second curve preferably move in different (preferably opposite) directions, producing a particularly dynamic appearance. It should be understood that, in the same manner, the pattern of the optical anti-counterfeiting element may also include more than two curves, which may move in the same or different directions when the optical anti-counterfeiting element inclines. For example, the curve in the form of letters, numbers and character strings may alternately present different motion behaviors, such as floating alternately above or below a plane of a plane pattern area, and moving according to its floating height when inclining. The specific principles of various dynamic characteristics may refer to the existing patent documents CN 102712207 A, CN 107995894 A, WO 2005/052650 A2, etc. The terms "pattern" and "pattern area" in the embodiments of the present invention may be interchangeable.

[0046] The dynamic characteristic in specific design may be represented by a set of pictures generated by computer software, such as mathematical calculation software, pattern processing software, etc. For example, a bitmap in bmp format is configured to reflect design patterns of different colors and the common background of the design patterns through 0-255 gray values. Each picture corresponds to the visual information presented to human eyes at a specific observation angle, which is called an animation frame of designed dynamic characteristic.

[0047] The preset observation angle set Ωv refers to that all the preset dynamic characteristics are seen when the observation angle of the human eyes change within the preset observation angle set Ωv. The optical anti-counterfeiting element may reflect illumination light outside the preset observation angle set Ωv, but reflected light outside the preset observation angle set Ωv may not be associated with the designed dynamic characteristics, or may provide darker or blacker visual information for the dynamic characteristic. The preset observation angle set Ωv may be described by azimuth angle and pitch angle, for example, the azimuth angle may be designed to be 0 -360°, while the pitch angle may be 0 -35° or 10-50°, etc., that is, the dynamic characteristic is seen when human eyes are in a cone-shaped area. The setting of an angle parameter depends on purpose of a designer, lighting environment of the observer, observation habit and so on.

[0048] The reflection surface element of the diffuse reflection region specifically may be a plane, a characteristic of each of the reflection surface element is that it has a certain dip angle relative to a plane where a pattern area of the dynamic characteristic is located, and it has a certain rotation angle relative to the x-axis, and Therefore, the orientation of the reflection surface element (also called an angle of the reflection surface element) is determined by using the pitch angle and the azimuth angle. Of course, other parameters may also be configured to determine the orientation of the reflection surface element, particularly parameters that are orthogonal to one another, such as two orthogonal components of the orientation of the reflection surface element. In an embodiment mode, the reflection surface element of the diffuse reflection region may specifically be a curved surface. Mathematically, the curved surface may further be broken down into a plurality of surface elements that are closer to a plane and smaller in area, with no essential difference in a specific design of the curved surface from the plane. To produce sufficiently fine patterns and continuously varying dynamic characteristic, a dimension of the reflection surface element is preferably smaller than the recognition capability of human eyes, which is typically about 100 μm at a photopic distance, and a closer distance improves the resolution capability. Therefore, the dimension of the reflection surface element should not be larger than 100 μm. On the other hand, an excessively small reflection surface element produces significant diffraction of light, affecting a color stability of the dynamic characteristic. The reflection surface element with the transverse dimension of 3-100 μm does not produce significant diffractive iridescence while producing sufficiently fine characteristics, and the transverse dimension may further preferably be 10-30 μm. The projection of the reflection surface element onto a plane of a dynamic pattern is typically chosen to be rectangular, but may also be any pattern that facilitates tiling of the plane, such as a triangular, hexagonal, irregular, etc.

[0049] In the embodiments of the present invention, each of the unmodified reflection surface elements may be smooth or has a secondary structure. It will be appreciated that an unmodified portion may also exist in each of the modified reflection surface elements, and the unmodified portion may be smooth or have a secondary structure. In some alternative embodiments, and it may be disposed as that at least part of the diffuse reflection region is provided with a plating or a coating.

[0050] A main function of the reflection surface element constituting the diffuse reflection is to produce uniform reflected light at least at the preset observation angle set Ωv, similar to visual impression of diffuse reflection produced by ordinary office paper. In order to achieve the purpose, the orientation of the reflection surface element is varied or selected irregularly within the preset angle set Ωs, in particular in a random or pseudo-random manner (i.e., may be selected randomly within the preset angle set Ωs). Pseudo-random numbers are number strings that look random but are computed by a deterministic algorithm, so in a strict sense they are not truly random numbers. However, the pseudo-random numbers are widely used because pseudo-randomly chosen statistical properties (such as equal probability of individual numbers or statistical independence of successive numbers) are generally sufficient for practical purposes, and unlike true random numbers, pseudo-random numbers are easy to generate by computers.

[0051] Specifically, the random change of the orientation of the reflection surface element within the preset angle set Ωs may be realized by a random change or selection of the pitch angle and a random change or selection of the azimuth angle. Elements in the preset observation angle set Ωv, elements in the preset angle set Ωs and incident light angle ωi are related through a set reflection law. The preset angle set Ωs is selected to reflect the incident light uniformly at least into the preset observation angle set Ωv, and Therefore, Ωs needs to cover a minimum set determined by the incident light angle ωi and the preset observation angle set Ωv together. Equivalently, a reflection area formed by a plurality of reflection surface elements reflects incident light to an angle set Ωr, which covers the preset observation angle set Ωv, i.e., Ωv is a subset or proper subset of Ωr. Preferably, Ωs is designed as a minimum set determined by the incident light angle ωi and the preset observation angle set Ωv, that is, Ωv and Ωr are the same. For example, when incident light is normally incident on the surface of the optical anti-counterfeiting element, that is, the optical anti-counterfeiting element is on an xy plane, the incident light is along the z direction, according to the geometric reflection law, an azimuth angle of the preset angle set Ωs is the same as that of the preset observation angle set Ωv, and a pitch angle of the preset angle set Ωs is half that of the preset observation angle set Ωv.

[0052] In order to realize change characteristics, it is necessary to modify the diffuse reflection region according to each pixel of each of the set of animation frames, so as to change a uniform reflected light distribution in the preset observation angle set Ωv. A size of the diffuse reflection region needs to be larger than an area occupied by all animation frames when they are presented together, so that each of the set of animation frames corresponds to the diffuse reflection region without zoom, Therefore, each of the pixels of the pattern area of each of the set of animation frames finds a corresponding position point in the diffuse reflection region, and the position point will be modified.

[0053] According to a position of the pattern area of each of the set of animation frames Pv and an observed angle of the pattern area of each of the set of animation frames ωv, a position of the reflection surface element to be modified Ps and an angle of the reflection surface element to be modified ωs are found, for example, the position of the reflection surface element to be modified and the angle of the reflection surface element to be modified may be found every pixel. In principle, Pv and Ps should be in the same position, and ωv, ωs and incident light angle ωi should satisfy the reflection law of geometric optics, that is, the incident light, the reflected light and the normal line of the reflection surface element are in the same plane, and the incident angle is equal to the reflection angle. Here, ωs = f(ωv, ωi) is configured to indicate that there is a quantitative relationship among the three, and the specific calculation formulas may be found in general optical textbooks, such as Born's Optical Principles: Electromagnetic Theory of Light Propagation, Interference and Diffraction. In actual design, as an angle of the reflection surface element is randomly selected within the preset angle set Ωs, when PV=PS, at this position the angle of the reflection surface element to be modified ωs may not exactly satisfy the geometric reflection law with ωv and ωi. Therefore, the reflection surface element to be modified may be found in a certain position range and a certain angle range, that is:

$$Ps \in (Pv-\Delta P,\ Pv+\Delta P)$$

$$\omega s \in (f(\omega v,\ \omega i)-\Delta\omega,\ f(\omega v,\ \omega i)+\Delta\omega)$$

[0054] The selection of position deviation ΔP and angle deviation Δω is specifically determined according to the size of reflection surface element, a resolution for angle and size by human eyes, and the designed dynamic characteristic, the principle is that at least one reflection surface element to be modified may be found, and at the same time, it does not have any difference from the design pattern that may be distinguished by human eyes. Generally, the position deviation ΔP is less than 100 μm, preferably less than 50 μm. The angle deviation Δω is defined as an included angle between a normal direction of each of the modified reflection surface elements and a normal direction of the reflection surface element corresponding to the preset observation angle of the pattern, and the angle deviation Δω should be less than 3°, preferably less than 0.5°.

[0055] Generally, pitch angles of two reflection surface elements are set to be θ_1 and θ_2 respectively, azimuth angles are respectively cp, and φ_2, and an included angle between the normal lines of the two reflection surface elements may be calculated by the following formula:

$$\Delta\omega = (180/\pi)\left[\left(\sin\theta_1\cos\varphi_1 - \sin\theta_2\cos\varphi_2\right)^2 + \left(\sin\theta_1\sin\varphi_1 - \sin\theta_2\sin\varphi_2\right)^2 + \left(\cos\theta_1 - \cos\theta_2\right)^2\right]^{1/2}$$

[0056] In the specific implementation, each of the set of animation frames may be pixelated. Alternatively, only the pattern area of each of the set of animation frames may be pixelated. The essence of pixelation is to divide each of the set of animation frames into, for example, N×M small areas, and the area of each of the small areas may be very small for example. For example, in the embodiments of the present invention, a width of each of the small areas may be 0.5-10 μm, preferably 2-4 μm, and correspondingly, a length of each of the small areas may be 0.5-10 μm, preferably 2-4 μm. Finding the reflection surface element to be modified is finding the reflection surface elements corresponding to pixels of the pattern area.

[0057] Furthermore, the first azimuth angle and the first pitch angle of each of the set of animation frames may be determined, each of the set of animation frames corresponds to a specific observation angle one by one, so the first azimuth angle and the first pitch angle may be determined according to the observation angle of each of the set of animation frames. In the embodiments of the present invention, the observation angle is a direction vector in a rectangular coordinate system. An included angle between the direction vector and the xy plane is defined as the pitch angle (also known as a complementary angle of an included angle with the z axis). The direction vector is projected onto the xy plane to form a projection vector, and an included angle between the projection vector and the x axis is defined as the azimuth angle.

[0058] Furthermore, the second azimuth angle and the second pitch angle of each of the reflection surface elements in the diffuse reflection region may be determined. Each element in the preset angle set Ωs may be composed of azimuth angle and pitch angle, so that the second azimuth angle and the second pitch angle of each of the reflection surface elements may be pre-stored. Therefore, the second azimuth angle and the second pitch angle of each of the reflection surface elements in the diffuse reflection region may be obtained from a database.

[0059] The following steps may be carried out aiming at each of the set of animation frames: in a position, corresponding to pixels of the pattern area of each of the set of animation frames, of the diffuse reflection region, reflection surface elements corresponding to the second azimuth angle and the second pitch angle matching the first azimuth angle and the first pitch angle of each of the set of animation frames are found, and thus the reflection surface elements corresponding to the pattern area of each of the set of animation frames is determined in the diffuse reflection region. For example, a set of animation frames is projected vertically on the diffuse reflection region in equal proportion, thus determining the position, corresponding to each of the pixels in each of the set of animation frames, on the diffuse reflection region. Reflection surface elements corresponding to the second azimuth angle and the second pitch angle matching the first azimuth angle and the first pitch angle of each of the set of animation frames are found includes: within a preset distance range of the position, corresponding to the pixels of the pattern area of each of the set of animation frames, of the diffuse reflection region, the reflection surface elements corresponding to the second azimuth angle having an angle difference with the first azimuth angle within a range of the first preset angle difference and the second pitch angle having an angle difference with half of the first pitch angle within a range of a second preset angle difference are found. In an embodiment mode, with very small pitch angle, the difference in azimuth angles becomes unimportant. Therefore, in the case that the pitch angle is very small, the azimuth angle may not be considered, and only within a preset distance range, the reflection surface elements corresponding to the second azimuth angle having an angle difference with half of the first pitch angle within the range of a second preset angle difference are found. In an embodiment mode, when the pitch angle is generally less than 2°, it may be considered that the difference in orientation caused by the difference in azimuth angles is not obvious, so the azimuth angle may not be considered. The preset distance range refers to that the distance between the positions, corresponding to the pixels of the pattern area in each of the set of animation frames, of the diffuse reflection region is less than 100 μm, preferably less than 50 μm. The range of first preset angle difference refers to that an angle difference with the first azimuth angle is less than 3°, preferably less than 0.5°. The range of second preset angle difference refers to that the angle difference with half of the first pitch angle is less than 3°, preferably less than 0.5°. For a pixel in the pattern area, one or more qualified reflection surface elements may be found in the diffuse reflection region, and the one or more qualified reflection surface elements may be modified. After the reflection surface element matching each of the pixels of the pattern area of each of the set of animation frames is found in the diffuse reflection region, these matching reflection surface elements form the reflection surface elements corresponding to the pattern area of each of the set of animation frames. The reflection surface elements, corresponding to the pattern area of each of the set of animation frames, formed in the diffuse reflection region are modified to form the modified reflection surface elements.

[0060] A modification of the reflection surface element may add a secondary structure to each of the modified reflection surface elements, and the characteristic dimension of the secondary structure is obviously smaller than that of the reflection surface element, so it may be spread on the surface of the reflection surface element along the direction of the reflection surface element. A transverse characteristic dimension of the secondary structure is 0.2-5 μm, which may produce a diffraction effect or an absorption effect on visible light. For the absorption effect, incident light of a specific frequency set may be absorbed by a subwavelength scale grating structure through the principle of surface plasmon resonance absorption, so as to change the color of the reflected light, and meanwhile, the original reflection direction is maintained. Usually, when the depth of the subwavelength structure is relatively deep, such as 300-700 nm, it can produce effective absorption in a wider frequency set, thus significantly reducing the brightness of the reflected light in this direction, that is, the subwavelength structure becomes an optical absorption or optical black structure.

[0061] Each of the modified reflection surface elements may be integrated with a secondary structure before modification to produce a uniform distribution of reflected light within a preset observation angle set Ωv, and provide specific color or brightness characteristics. Thus, the modification on the reflection surface element may smooth a part or the whole of each of the modified reflection surface elements. For example, the secondary structure of each of the modified reflection surface elements is removed so that it produces specular reflection with high reflectivity on the whole band of visible light. In an embodiment mode, at least part of each of the unmodified reflection surface elements is disposed to be smooth or has a secondary structure.

[0062] In an embodiment mode, the modification for the reflection surface element is to flatten each of the modified reflection surface elements so that each of the modified reflection surface elements only reflects incident light to a specific direction. At other observation angles, this modified area provides little or no reflected light, resulting in a darker or blacker visual perception than other areas.

[0063] In an embodiment mode, the modification for the reflection surface element is to adjust an angle of each of the modified reflection surface elements so that each of the modified reflection surface elements reflects all light incident to the reflection surface element onto a direction beyond the preset observation angle set Ωv. Generally, if the pitch angle of the reflection surface element is increased and exceeds a minimum set determined by the incident light directions ωi and Ωv, the incident light will be reflected to the set determined beyond Ωv. This modified reflection surface element provides little or no reflected light, resulting in a darker or blacker visual perception than other areas.

[0064] In order to produce a pattern of sufficient contrast, the surface on which the modified reflection surface elements are located or the surface opposite to the surface on which the modified reflection surface elements are located (e.g., an unmodified reflection surface element) may have a plating or a coating. A reflection enhanced coating (especially a metallized layer), a reflection enhanced plating, a reflection ink layer, an absorption ink layer, a high index material coating and high index material plating are also included. The reflection enhanced coating, the reflection enhanced plating or the reflection ink layer preferably have a color shift effect, that is, a hue change in color at different observation angles, such as the use of Fabry-Perot interference structure. Alternatively, a reflection area and a reflection surface element may also be embossed in the reflection ink layer or the absorption ink layer.

[0065] In an embodiment mode, the modification for the reflection surface element is that each of the modified reflection surface elements is enabled to be convex or concave compared with an unmodified area on the periphery; or the modification for the reflection surface element is that a thickness of the plating or the coating of each of the modified reflection surface elements is different from that of the unmodified area. For example, each of the modified reflection surface elements has a reflective plating, coating or ink, and each of the unmodified reflection surface elements has no reflective plating, coating or ink; or each of the modified reflection surface elements has no reflective plating, coating or ink, and each of the unmodified reflection surface elements has a reflective plating, coating or ink.

[0066] In an embodiment mode, the modification for the reflection surface element is a serial combination of the above modification modes. For example, each of the modified reflection surface elements forms a lower depression than each of the unmodified reflection surface elements, then a secondary structure is added in the lower depression, and finally, a reflective plating in the secondary structure area is removed (that is, have a different thickness with a reflective plating of each of the unmodified reflection surface elements); or, each of the modified reflection surface elements forms a lower depression than each of the unmodified reflection surface elements, and the lower depression is filled with color ink, and its thickness is significantly greater than a thickness of the ink of each of the unmodified reflection surface elements. In an embodiment mode, the modification for the reflection surface element is a parallel combination of the above modification modes. For example, a flat depression is formed on a part of a modified reflection surface element, and a secondary structure is added on the other part of the modified reflection surface element along the orientation of the reflection surface element. In an embodiment mode, the modification for the reflection surface element is a recombination of a serial combination and a parallel combination of the above modification modes.

[0067] The modified area exists on a part or the whole of each of the modified reflection surface elements. For an ideal planar reflection surface element, the modified area is equal to the reflection surface element. For a curved reflection surface element, the modified area exists on a part of the reflection surface element. In the embodiments of the present invention, according to the visibility of a generated pattern, a width of the modified area is 0.5-20 μm, and preferably 2-10 μm. Each of the modified reflection surface elements has one or a combination of different reflection colors, different reflection brightness and different reflection textures than each of the unmodified reflection surface elements. Or, the modified area has one or a combination of different reflection colors, different reflection brightness and different reflection textures than an unmodified area.

[0068] For the optical anti-counterfeiting element, in the preset observation angle set Ωv, the modified reflection surface elements together appear as a pattern of each of the set of animation frames, and the unmodified reflection surface elements together appear as a background of each of the set of animation frames. The pattern area has different optical contrast than the background area, which specifically may be one or a combination of different colors, different brightness and different textures visible to human eyes.

[0069] The embodiments of the present invention further provide a design method of an optical anti-counterfeiting element, which includes: a dynamic characteristic is designed, the dynamic characteristic is a reproduction of a set of animation frames visible at a preset observation angle set Ωv, and each of the set of animation frames includes a pattern area and a background area forming optical contrast with the pattern area; a diffuse reflection region configured for the optical anti-counterfeiting element is designed, and the diffuse reflection region reflects incident light to at least a range of the preset observation angle set Ωv, and the diffuse reflection region includes a plurality of reflection surface elements; based on an observation angle of each of the set of animation frames, the reflection surface elements corresponding to the pattern area of each of the set of animation frames are modified to form the modified reflection surface elements, so that the modified reflection surface elements and the unmodified reflection surface elements have different reflection characteristics, and when the diffuse reflection region is illuminated by incident light, the modified reflection surface elements together appear as a pattern of dynamic characteristic, and the unmodified reflection surface elements together appear as a background of dynamic characteristic.

[0070] The dynamic characteristic in specific design may be represented by a set of pictures generated by computer software, such as mathematical calculation software, pattern processing software, etc. For example, a bitmap in bmp format is configured to reflect design patterns of different colors and the common background of the design patterns through 0-255 gray values. Each picture corresponds to the visual information presented to human eyes at a specific observation angle, which is called a frame of animation of designed dynamic characteristic. The specific working principle and benefits of the design method for optical anti-counterfeiting element of the embodiments of the present invention can be referred to the description of the optical anti-counterfeiting element of the embodiments of the present invention, which will not be repeated here.

[0071] Correspondingly, the embodiments of the present invention further provide an anti-counterfeiting product using the optical anti-counterfeiting element of any embodiment of the present invention. The anti-counterfeiting product, for example, may be in the form of an security thread, an anti-counterfeiting strip, an anti-counterfeiting label and the like The embodiments of the present invention further provide a data carrier having the anti-counterfeiting element of any embodiment of the present invention or the anti-counterfeiting product of any embodiment of the present invention, and the anti-counterfeiting element or anti-counterfeiting product may be disposed in an opaque area of the data carrier, and in or above a transparent window area or through opening in the data carrier. The data carrier may be particularly valuable documents, such as banknotes (especially paper banknotes, polymer notes or film composite notes), stocks, warrants, certificates, tickets, checks, high-value entrance tickets, but also identification cards, such as credit cards, bank cards, cash cards, authorized cards, personal ID cards, or personal information pages of passports.

[0072] The optical anti-counterfeiting element and the manufacturing method thereof provided by the embodiments of the present invention will be further described below in combination with drawing.

[0073] Fig. 1 is a schematic diagram of a diffuse reflection effect of a diffuse reflection region 2 of an optical anti-counterfeiting element on incident light 4. A plane where the optical anti-counterfeiting element 1 is located is defined as xy plane, and the diffuse reflection region 2 is composed of a plurality of reflection surface elements 3. In Fig. 1, the optical anti-counterfeiting element 1 is provided with a substrate 6, and the diffuse reflection region 2 is located on one side of the substrate 6. However, the existence of the substrate 6 is the need of the processing, which may not be part of the optical anti-counterfeiting element 1 itself. The substrate 6 can be used as a part of the anti-counterfeiting product formed by optical anti-counterfeiting element 1. Of course, the substrate 6 may also be removed in anti-counterfeiting products, such as hot stamping products, a structural layer is transferred to other carriers, and the substrate 6 does not become part of the anti-counterfeiting product. The substrate 6 does not become a necessary part of the optical anti-counterfeiting element 1. Incident light 4 is incident on the side, with the diffuse reflection region 2, of the substrate 6, and the incident light 4 is reflected by the diffuse reflection region 2 to form a plurality of reflected light 5 in different directions. By controlling a dimension and an angle (the angle is limited by an azimuth angle and a pitch angle, for example) distribution of the reflection surface element 3 of the diffuse reflection region 2, the basically uniform diffuse reflection visual effect covers the preset observation angle set Ωv of preset dynamic characteristic. In order to simplify description without losing generality, the direction of the incident light 4 is set to z direction, which is a direction perpendicular to the xy plane. The azimuth angle of elements of the preset observation angle set Ωv is preset to 0-360°, and the pitch angle is preset to 0-35°. Accordingly, a transverse dimension of the reflection surface element 3 may be controlled within a range of 10-15 μm, while a longitudinal height is set to 0-5 μm, and its azimuth angle is randomly selected within 0-360°, so that the incident light 4 is reflected to an angle set Ωr by the plurality of reflection surface elements 3, and Ωr covers the preset observation angle set Ωv. Since discrete angle information is usually used in actual design, the coverage of the present invention specifically refers to that any element in the preset observation angle set Ωv may find a corresponding element close enough to it in Ωr, for example, an angle between the two does not exceed 1°. The diffuse reflection region 2 should contain enough reflection surface elements 3 to obtain enough uniform and dense reflected light, in actual design, the dimension of the diffuse reflection region 2 should be more than 50 times the dimension of the reflection surface element 3, preferably more than 100 times, so as to contain at least 10,000 reflection surface elements 3. The reflection surface elements 3 may be designed as an oblique split, and a projection in the xy plane may be designed as a rectangle to cover the diffuse reflection region 2. Fig. 1 only illustrates a diffuse reflection effect of a diffuse reflection region 2 of an optical anti-counterfeiting element 1 on incident light 4, without involving the specific dynamic characteristic and the modification mode of the reflection surface elements 3.

[0074] To further illustrate how the reflection surface elements 3 produce diffuse reflection, Fig. 2 illustrates design data of the pitch angle and the azimuth angle of a reflection surface element 3, the pitch angle is randomly selected within 0-20° and the azimuth angle is randomly selected within 0-360° using a computer program. Pseudo-random numbers are number strings that look random but are computed by a deterministic algorithm, so in a strict sense they are not truly random numbers. However, the pseudo-random numbers are widely used because pseudo-randomly chosen statistical properties (such as equal probability of individual numbers or statistical independence of successive numbers) are generally sufficient for practical purposes, and unlike true random numbers, pseudo-random numbers are easy to generate by computers. In Fig. 2, each of the pitch angle and the azimuth angle has 10×10 data, and a pair of data at the corresponding position determines an orientation of one reflection surface element 3. In Fig. 2, the data in the list of the pitch angle and the azimuth angle are also given in polar coordinates, through the polar coordinate diagram, it can be seen that angles of the reflection surface elements 3 are basically uniform and randomly distributed in a certain area. It is easy to foresee that the reflection surface elements 3 may basically reflect the incident light 4 to a specific area in a diffuse way. In particular, increasing the amount of angle data significantly will obtain a more uniform and random diffuse reflection visual effect.

[0075] Fig. 3 illustrates design data of the pitch angle and the azimuth angle of another reflection surface element, the pitch angle is randomly selected in the set {0, 2, 4, 6, 8, 10, 12, 14, 16, 18}, while the azimuth angle is randomly selected in the set {0, 40, 80, 120, 160, 200, 240, 280, 320, 360}, that is, the preset angle set Ωs of the reflection surface element is:

{(0, 2, 4, 6, 8, 10, 12, 14, 16, 18);

(0, 40, 80, 120, 160, 200, 240, 280, 320, 360)}.

[0076] On the surface, the two sets contain regular angle data, but random angle distributions at different positions may still be formed by random selection (as shown in the pitch angle and the azimuth angle data table in Fig. 3), so that the diffuse reflection region has diffuse reflection properties. In Fig. 3, each of the pitch angle and the azimuth angle has 10×10 data, and a pair of data at the corresponding position determines an orientation of one reflection surface element. In Fig. 3, the data in the list of the pitch angle and the azimuth angle are also given in polar coordinates, through the polar coordinate diagram, it can be seen that angles of the reflection surface elements is basically uniform and randomly distributed in a certain area. When the element data in the preset angle set Ωs is greatly increased, it is easy to foresee that in the polar coordinate distribution diagram in Fig. 3, the data points will become dense in the axial and tangential directions, thus basically covering the designed observation angle set.

[0077] In particular, the observation angle set Ωv is designed as:

{(0, 4, 8, 12, 16, 20, 24, 28, 32, 36);

(0, 40, 80, 120, 160, 200, 240, 280, 320, 360)}.

[0078] When the incident light angle ωi is along the z-axis direction, the elements of the preset observation angle set Ωv and the preset observation angle set Ωs are related to ωi through the geometric reflection law, and the preset observation angle set Ωv is the same as the reflected light angle set Ωr.

[0079] According to each of the set of animation frames that constitutes the dynamic characteristic, the specific reflection surface element in the diffuse reflection region is modified to produce partially different reflection characteristics. Setting the incident light angle ωi is along the z-axis, FIGs.4 and 5 provide two embodiments to illustrate how to determine the reflection surface element to be modified.

[0080] Fig. 4 is an embodiment in which a modified reflection surface element is determined according to an animation frame. 7 is an animation frame describing the change characteristic, which is defined as being observed in the direction of the pitch angle = 0° and the azimuth angle = 0°. 71 is the pattern area of the animation frame, and 72 is the background area of the animation frame. The pattern area 71 has optical contrast visible to human eyes with the background area 72. The size, of the reflection area 21 corresponding to the animation frame 7, of the diffuse reflection region is at least not less than the size of the area where the animation frame 7 is located, so as to completely present the visual information of the animation frame 7. By taking any point Pv (which may also be considered as any pixel point) on the pattern area 71 as an example, the corresponding point of Pv is determined in the reflection area 21. In the reflection area 21, with Pv as a center point, a reflection surface element with pitch angle = 0° or deviation from it less than Δω is searched within a range of ΔP. In the case that the pitch angle is very small, the difference in azimuth angle becomes unimportant, and Therefore, the azimuth angle is not considered here. By properly controlling the magnitudes of ΔP and Δw, the reflection surface elements to be modified may always be found in the reflection area 21. For example, the projection of the reflection surface element in the xy plane is a square with a side length of 15μm, setting ΔP = 30 μm and Δω = 1°, a point (0.4°, 75.2°) may be found at the lower right of the Pv point in the reflection area 21, and the modification for a reflection surface element corresponding to this point may produce the expected visual contrast at the Pv point in the animation frame 7.

[0081] Fig. 5 is another embodiment in which a modified reflection surface element is determined according to an animation frame. In an animation frame 8, 81 is a pattern area of the animation frame, and 82 is a background area of the animation frame. The pattern area 81 has optical contrast visible to human eyes with the background area 82. The pattern area 81 has a position change relative to the pattern area 71 in Fig. 4 above, and the animation frame 8 is defined as being observed in the direction of the pitch angle = 20° and the azimuth angle = 90°. The size, of the reflection area 22 corresponding to the animation frame 8, of the diffuse reflection region is at least not less than the size of the area where the animation frame 8 is located, so as to completely present the visual information of the animation frame 8. By taking any point Pv (which may also be considered as any pixel point) on the pattern area 81 as an example, the corresponding point of Pw is determined in the reflection area 22. In the reflection area 22, with Pw as a center point, a reflection surface element that is the same as the reflection surface element determined by the angles (pitch angle = 10°, azimuth Angle = 90°) or has angle deviation smaller than Δω is searched within a range of ΔP. By properly controlling the magnitudes of ΔP and Δw, the reflection surface elements to be modified may always be found in the reflection area 22, for example, the projection of the reflection surface element in the xy plane is a square with a side length of 15 μm, setting ΔP = 30 μm and Δw = 1°, points (10.1°, 92.2°), (9.8°, 89.7°) may be found near the Pv point in the reflection area 22, and the modification for the reflection surface element corresponding to the two points may produce the expected visual contrast at the Pw point in the animation frame 8.

[0082] The modification for the reflection surface element may adopt a variety of ways. In Fig. 6, the reflection surface element 31 of the diffuse reflection region 2 is partially or wholly modified in a specific way to produce reflection characteristics different from that of the reflection surface element 32. 9 is an example of a modification mode.

[0083] 91 indicates that the modification for the reflection surface element is that the modified area (the modified area is a part or whole of the reflection surface element) is enabled to be concave compared with the periphery (the periphery, for example, may be a reflection surface element), the depth of the depression is selected within 0.5-3 μm, and is related to the width of the modified area. Meanwhile, the modification for the reflection surface element may be to flatten the modified area so that the modified area may only reflect incident light 4 to a specific direction, and at other observation angles, this modified area provides little or no reflected light, resulting in a darker or blacker visual perception than other areas.

[0084] 92 indicates the modification of the reflection surface element may add a secondary structure to the modified area (the modified area is a part or whole of the reflection surface element), and the characteristic dimension of the secondary structure is obviously smaller than that of the reflection surface element, so it may be spread on the surface of the reflection surface element along the direction of the reflection surface element. The transverse characteristic dimension of the secondary structure is 0.2-5 μm, which may produce a diffraction effect or absorption effect on visible light. For the absorption effect, incident light of a specific frequency set is absorbed by a subwavelength scale grating structure through the principle of surface plasmon resonance absorption, so as to change the color of the reflected light, and meanwhile, the original reflection direction is maintained. Usually, when the depth of the subwavelength structure is relatively deep, such as 300-700 nm, it can produce effective absorption in a wider frequency set, thus significantly reducing the brightness of the reflected light in this direction, that is, the subwavelength structure becomes an optical absorption or optical black structure.

[0085] 93 indicates that the modified reflection surface element may be integrated with a secondary structure before modification to produce a uniform distribution of reflected light within a preset observation angle set Ωv, and provide specific color or brightness characteristics. Therefore, the modification on the reflection surface element may smooth the modified area (the modified area is a part or the whole of the reflection surface element), that is, the secondary structure of the area to be modified is removed so that it may produce specular reflection with high reflectivity on the whole band of visible light.

[0086] 94 indicates that in order to produce a pattern of sufficient contrast, the surface on which the reflection surface element is located or the surface opposite to the surface on which the reflection surface element is located may have a plating or a coating. A reflection enhanced coating (especially a metallized layer), a reflection enhanced plating, a reflection ink layer, an absorption ink layer, a high index material coating and high index material plating are also included. The reflection enhanced coating, the reflection enhanced plating or the reflection ink layer preferably have a color shift effect, that is, a hue change in color at different observation angles, such as the use of Fabry-Perot interference structure, for example, Cr(5nm)/MgF_2(500nm)/Al(50nm) structure. Alternatively, a reflection area and a reflection surface element may also be embossed in the reflection ink layer or absorption ink layer.

[0087] The modification for the reflection surface element may be that the thickness of the plating or the coating of the modified area (the modified area is a part or whole of the reflection surface element) is different from that of the unmodified area. For example, the modified area has a reflective plating, reflective coating or reflective ink, and the unmodified area has no reflective plating, reflective coating or reflective ink; or the modified area has no reflective plating, reflective coating or reflective ink, and the unmodified area has a reflective plating, reflective coating or reflective ink.

[0088] 95 indicates that the modification for the reflection surface element may be that the angle of the modified area (the modified area is a part or whole of the reflection surface element) is adjusted, so that incident light is reflected to a direction beyond Ωv. Generally, if the pitch angle of the reflection surface element is increased and exceeds a minimum set determined by the incident light directions ωi and Ωv, the incident light may be reflected to the set determined beyond Ωv. The modified area provides little or no reflected light, resulting in a darker or blacker visual perception than other areas.

[0089] 96 indicates that the modification for the reflection surface element may be a serial combination of the above modification modes. For example, the modified area (the modified area is a part or whole of the reflection surface element) forms a lower depression than the periphery, then a secondary structure is added in the lower depression, and finally, the reflective plating in the secondary structure area is removed (that is, have a different thickness with the unmodified area); or, the modified area forms a lower depression than the periphery, the lower depression is filled with color ink, and its thickness is significantly greater than the thickness of the ink of the unmodified area.

[0090] 97 indicates that the modification for the reflection surface element may be a parallel combination of a plurality of modification modes. For example, a flat depression is formed on a part of the modified area (the modified area is a part or whole of the reflection surface element), and a secondary structure is added on the other part of the modified area along the orientation of the reflection surface element. The modification for the reflection surface element may be a recombination of a serial combination and a parallel combination of the above modification modes.

[0091] The modified area may exist on a part or the whole of the modified reflection surface element. For an ideal planar reflection surface element, the modified area is equal to the reflection surface element, and for a curved reflection surface element, the modified area exists on a part of the reflection surface element. The width of the modified area is 0.5-30 μm, preferably 2-10 μm. The modified area has one or a combination of different reflection colors, different reflection brightness and different reflection textures than the unmodified area.

[0092] In Fig. 6, the reflection surface element 31 and the reflection surface element 32 reflect incident light 4 to a direction 51 and a direction 52, respectively. Reflection light of the modified reflection surface element 31 produce a pattern of animation frames, namely, the modified reflection surface elements together appear as a pattern of animation frames; and reflection light of the unmodified reflection surface element 32 produce a background of animation frames, namely, the unmodified reflection surface elements together appear as a background of the animation frames. The pattern area has different optical contrast than the background area, which specifically may be one or a combination of different colors, different brightness and different textures visible to human eyes.

[0093] Fig. 7 illustrate a schematic diagram of banknote 10, the banknote 10 has the optical anti-counterfeit element of the present invention, and the optical anti-counterfeit element is embedded in the banknote 10 in the form of a window security thread 101. In addition, the optical anti-counterfeiting element may also be used in the way of a label 102, and an opening area 103 may be formed on the substrate of the banknote for easy light transmission observation. It should be understood that the present invention is not limited to security threads and banknotes, but may be used for a variety of anti-counterfeiting products, such as labels on goods and packaging, or for anti-counterfeiting documents, identity cards, passports, credit cards, health cards, etc. In banknotes and similar documents, in addition to security threads and labels, for example, wider anti-counterfeiting strips or transfer elements may be used.

[0094] The embodiments of the present invention provide a storage medium, which stores a computer program thereon;

and the program implements, when being executed by a processor, the design method of the optical anti-counterfeiting element of any embodiment of the present invention.

[0095] The embodiments of the present invention provide a processor, which is configured to run a program, and the program, when running, executes the design method of the optical anti-counterfeiting element of any embodiment of the present invention.

[0096] The embodiments of the present invention provide a device, including a processor, a memory, and a program which is stored on the memory and runs on the processor, when executing the program, the processor implements the design method of the optical anti-counterfeiting element of any embodiment of the present invention.

[0097] The present invention further provides a computer program product which, when executed on a data processing device, is suitable for executing a program initialized with steps of a design method of an optical anti-counterfeiting element of any embodiment of the present invention.

[0098] Those skilled in the art should understand that the embodiments of the present invention may be provided as methods, systems, or computer program products. Therefore, the present invention may adopt the form of a complete hardware embodiment, a complete software embodiment, or an embodiment combining software and hardware. Moreover, the present invention may adopt the form of a computer program product implemented on one or more computer-usable storage media (including but not limited to disk storage, Compact Disc Read-Only Memory (CD-ROM), optical storage, etc.) containing computer-usable program codes.

[0099] The present invention is described with reference to flowcharts and/or block diagrams of the method, the device (system) and the computer program product according to the embodiments of the present invention. It should be understood that each flow and/or block in the flowcharts and/or the block diagrams and a combination of the flows and/or the blocks in the flowcharts and/or the block diagrams can be realized by computer program instructions. These computer program instructions can be provided for a general computer, a dedicated computer, an embedded processor or processors of other programmable data processing devices to generate a machine, so that an apparatus for realizing functions assigned in one or more flows of the flowcharts and/or one or more blocks of the block diagrams is generated via instructions executed by the computers or the processors of the other programmable data processing devices.

[0100] These computer program instructions can also be stored in a computer readable memory capable of guiding the computers or the other programmable data processing devices to work in a specific mode, so that a manufactured product including an instruction apparatus is generated via the instructions stored in the computer readable memory, and the instruction apparatus realizes the functions assigned in one or more flows of the flowcharts and/or one or more blocks of the block diagrams.

[0101] These computer program instructions can also be loaded to the computers or the other programmable data processing devices, so that processing realized by the computers is generated by executing a series of operation steps on the computers or the other programmable devices, and Therefore the instructions executed on the computers or the other programmable devices provide a step of realizing the functions assigned in one or more flows of the flowcharts and/or one or more blocks of the block diagrams.

[0102] In a typical configuration, a computing device includes one or more processors (CPU), input/output interfaces, network interfaces, and a memory.

[0103] A memory may include forms of non-permanent memory in computer readable media, Random Access Memory (RAM) and/or non-volatile memory, such as Read-Only Memory (ROM) or Flash Random Access Memory (flash RAM). Memory is an example of a computer readable medium.

[0104] Computer-readable media, including permanent and non-permanent, removable and non-removable media, may store information by any method or technology. Information may be computer-readable instructions, data structures, modules of programs or other data. Examples of computer storage media include, but not limited to Phase change Random Access Memory (PRAM), Static Random Access Memory (SRAM), Dynamic Random Access Memory (DRAM), other types of Random Access Memory (RAM), Read-Only Memory (ROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), flash memory or other memory technology, Compact Disc Read-Only Memory(CD-ROM), Digital Video Disc (DVD) or other optical storage, magnetic cassette tape, tape disk storage or other magnetic storage device or any other non-transmission medium that may be configured to store information that can be accessed by computing devices. As defined in the specification, computer readable media does not include transitory computer readable media (transitory media), such as modulated data signals and carriers.

[0105] It is to be noted that terms "include" and "contain" or any other variant thereof is intended to cover nonexclusive inclusions herein, so that a process, method, object or device including a series of elements not only includes those elements but also includes other elements which are not clearly listed or further includes elements intrinsic to the process, the method, the object or the device. An element defined by the statement "includes a..." does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element.

[0106] The foregoing is merely the embodiments of the present invention and is not intended to limit the present invention. Various modifications and variations of the present invention may be available for those skilled in the art. Any modifications, equivalent replacements, improvements and the like made within the spirit and principle of the present invention shall fall within the scope of claims of the present invention.

Claims

1. An optical anti-counterfeiting element, wherein the optical anti-counterfeiting element presents dynamic characteristic, the dynamic characteristic is pre-designed to be a reproduction of a set of animation frames visible at a preset observation angle set Ωv, and each of the set of animation frames comprises a pattern area and a background area forming optical contrast with the pattern area;

    the optical anti-counterfeiting element is provided with a diffuse reflection region, and the diffuse reflection region reflects incident light to at least a range of the preset observation angle set Ωv;
    the diffuse reflection region comprises a plurality of reflection surface elements comprising modified reflection surface elements that each of the modified reflection surface elements is wholly or partially modified and unmodified reflection surface elements, the modified reflection surface elements and the unmodified reflection surface elements have different reflection characteristics, wherein the modified reflection surface elements correspond to the pattern area;
    when the diffuse reflection region is illuminated by the incident light, the modified reflection surface elements together appear as a pattern of the dynamic characteristic, and the unmodified reflection surface elements together appear as a background of the dynamic characteristic.

2. The optical anti-counterfeiting element as claimed in claim 1, wherein an angle of each of the plurality of reflection surface elements is randomly selected within a preset angle set Ωs, wherein elements in the preset observation angle set Ωv, elements in the preset angle set Ωs and an angle of the incident light are related through a set reflection law.

3. The optical anti-counterfeiting element as claimed in claim 2, wherein the angle of each of the plurality of reflection surface elements is determined by an inclination angle and an azimuth angle of each of the plurality of reflection surface elements, and the inclination angle is preferably 0-20° and/or the azimuth angle is preferably 0-360°.

4. The optical anti-counterfeiting element as claimed in claim 2, wherein

    the angle of each of the plurality of reflection surface elements is obtained by randomly selecting the elements in the preset angle set Ωs with equal probability; and/or
    the angle of each of the plurality of reflection surface elements is randomly selected from the preset angle set Ωs by using a pseudo-random number generation program.

5. The optical anti-counterfeiting element as claimed in claim 1, wherein a transverse dimension of each of the plurality of reflection surface elements is 3-100 μm, preferably 10-30 μm.

6. The optical anti-counterfeiting element as claimed in claim 1, wherein each of the plurality of reflection surface elements is plane or curved.

7. The optical anti-counterfeiting element as claimed in claim 1, wherein at least part of each of the unmodified reflection surface elements is smooth or has a secondary structure;
    and/or at least part of the diffuse reflection region is provided with a plating or a coating.

8. The optical anti-counterfeiting element as claimed in claim 1, wherein each of the modified reflection surface elements is wholly or partially modified by one or more of following ways:

    adding a secondary structure to each of the modified reflection surface elements;
    enabling each of the modified reflection surface elements to be smooth;
    flattening each of the modified reflection surface elements;
    disposing each of the modified reflection surface elements to be convex or concave compared with the unmodified reflection surface elements;
    adjusting an angle of each of the modified reflection surface elements so that the incident light is reflected beyond the range of the preset observation angle set Ωv; or

adjusting a thickness of a plating or a coating of each of the modified reflection surface elements to be different from that of the unmodified reflection surface elements.

9. The optical anti-counterfeiting element as claimed in claim 8, wherein in a case that each of the modified reflection surface elements is modified by two or more of the ways, the two or more of the ways exist in a parallel combination and/or a serial combination.

10. The optical anti-counterfeiting element as claimed in any of claims 7-9, wherein a transverse characteristic dimension of the secondary structure is 0.2-5 μm.

11. The optical anti-counterfeiting element as claimed in claim 1, wherein a width of a modified area of each of the modified reflection surface elements is 0.5-30 μm, preferably, 2-10 μm.

12. The optical anti-counterfeiting element as claimed in claim 1, wherein the different reflection characteristics refer to one or a combination of different reflection colors, different reflection brightness, or different reflection textures between the modified reflection surface elements and the unmodified reflection surface elements when illuminated by the incident light.

13. A design method of an optical anti-counterfeiting element, comprising:

designing a dynamic characteristic, the dynamic characteristic is a reproduction of a set of animation frames visible at a preset observation angle set Ωv, and each of the set of animation frames comprises a pattern area and a background area forming optical contrast with the pattern area;
designing a diffuse reflection region configured for the optical anti-counterfeiting element, and the diffuse reflection region reflects incident light to at least a range of the preset observation angle set Ωv, wherein the diffuse reflection region comprises a plurality of reflection surface elements;
based on an observation angle of each of the set of animation frames, modifying reflection surface elements corresponding to the pattern area of each of the set of animation frames to form modified reflection surface elements, so that the modified reflection surface elements and unmodified reflection surface elements have different reflection characteristics,
when the diffuse reflection region is illuminated by the incident light, the modified reflection surface elements together appear as a pattern of the dynamic characteristic, and the unmodified reflection surface elements together appear as a background of the dynamic characteristic.

14. The design method as claimed in claim 13, wherein an angle of each of the plurality of reflection surface elements is randomly selected within a preset angle set Ωs, wherein elements in the preset observation angle set Ωv, elements in the preset angle set Ωs and an angle of the incident light are related through a set reflection law.

15. The design method as claimed in claim 14, wherein the angle of each of the plurality of reflection surface elements is determined by an inclination angle and an azimuth angle of the reflection surface element, and the inclination angle is preferably 0-20° and/or the azimuth angle is preferably 0-360°.

16. The design method as claimed in claim 14, wherein that the angle of each of the plurality of reflection surface elements is randomly selected within the preset angle set Ωs comprises:

obtaining the angle of each of the plurality of reflection surface elements by randomly selecting the elements in the preset angle set Ωs with equal probability; and/or
randomly selecting the angle of each of the plurality of reflection surface elements from the preset angle set Ωs by using a pseudo-random number generation program.

17. The design method as claimed in claim 13, wherein a transverse dimension of each of the plurality of reflection surface elements is 3-100 μm, preferably 10-30 μm.

18. The design method as claimed in claim 13, wherein each of the plurality of reflection surface elements is plane or curved.

19. The design method as claimed in claim 13, further comprising:

designing at least part of each of the unmodified reflection surface elements to be smooth or have a secondary structure; and/or
designing at least part of the diffuse reflection region to be provided with a plating or a coating.

20. The design method as claimed in claim 13, wherein that modifying the reflection surface elements corresponding to the pattern area of each of the set of animation frames to form the modified reflection surface elements comprises:

pixelating each of the set of animation frames;
determining a first azimuth angle and a first pitch angle of each of the set of animation frames, and the first azimuth angle and the first pitch angle are determined according to the observation angle of each of the set of animation frames;
determining a second azimuth angle and a second pitch angle of each of the reflection surface elements in the diffuse reflection region;
the following steps are carried out for each of the set of animation frames:

in a position, corresponding to pixels of the pattern area of each of the set of animation frames, of the diffuse reflection region, searching for reflection surface elements corresponding to a second azimuth angle and a second pitch angle matching the first azimuth angle and the first pitch angle of each of the set of animation frames, and thus the reflection surface elements corresponding to the pattern area of each of the set of animation frames are determined in the diffuse reflection region;
modifying the reflection surface elements corresponding to the pattern area of each of the set of animation frames in the diffuse reflection region.

21. The design method as claimed in claim 20, wherein that in the position, corresponding to the pixels of the pattern area of each of the set of animation frames, of the diffuse reflection region, searching for the reflection surface elements corresponding to the second azimuth angle and the second pitch angle matching the first azimuth angle and the first pitch angle of each of the set of animation frames comprises:
within a preset distance range of the position, corresponding to the pixels of the pattern area of each of the set of animation frames, of the diffuse reflection region, searching for the reflection surface elements corresponding to the second azimuth angle having an angle difference with the first azimuth angle within a range of a first preset angle difference and the second pitch angle having an angle difference with half of the first pitch angle within a range of a second preset angle difference.

22. The design method as claimed in claim 21, wherein

the preset distance range refers to that a distance from the position, corresponding to the pixels of the pattern area of each of the set of animation frames is less than 100 μm, preferably less than 50 μm; and/or
the range of the first preset angle difference refers to that an angle difference from the first azimuth angle is less than 3°, preferably less than 0.5°;
and/or the range of the second preset angle difference refers to that an angle difference from the first pitch angle is less than 3°, preferably less than 0.5°.

23. The design method as claimed in claim 13, wherein that modifying the reflection surface elements corresponding to the pattern area of each of the set of animation frames to form the modified reflection surface elements comprises:

adding a secondary structure to each of the modified reflection surface elements;
enabling each of the modified reflection surface elements to be smooth;
flattening each of the modified reflection surface elements;
disposing each of the modified reflection surface elements to be convex or concave compared with the unmodified reflection surface elements;
adjusting an angle of each of the modified reflection surface elements so that the incident light is reflected beyond the range of the preset observation angle set Ωv; or
adjusting a thickness of a plating or a coating of each of the modified reflection surface elements to be different from that of the unmodified reflection surface elements.

24. The design method as claimed in claim 13, wherein

the dynamic characteristic is one or a combination of translation, rotation, zoom, deformation, looming, and

Yin/Yang conversion; and/or
the optical contrast is one or a combination of different colors, different brightness and different textures that are visible to human eyes.

25. The design method as claimed in claim 13, wherein a width of a modified area of each of the modified reflection surface elements is 0.5-30 μm, preferably, 2-10 μm.

26. An anti-counterfeiting product, comprising the optical anti-counterfeiting element as claimed in any of claims 1-12.

27. A data carrier, comprising the optical anti-counterfeiting element as claimed in any of claims 1-12, or the anti-counterfeiting product as claimed in claim 26.

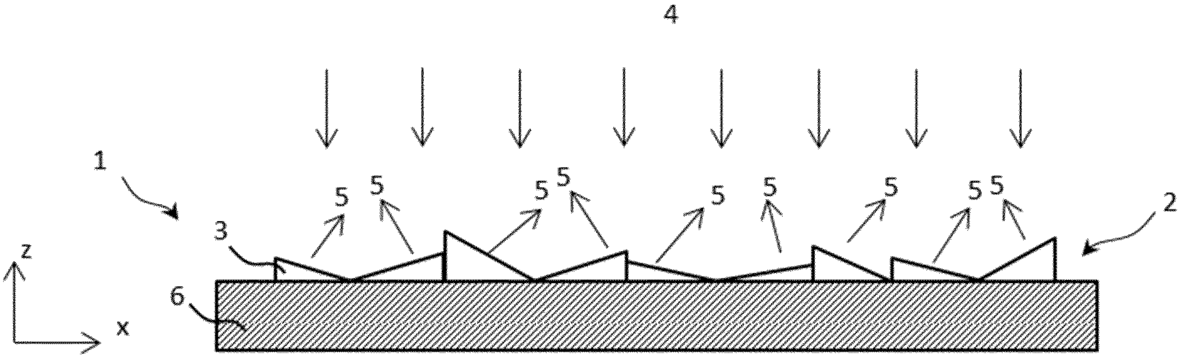

Fig. 1

Azimuth angle

293.3	236.1	157.9	270.5	126.6	58.4	38.4	307.1	280.9	196.9
326.1	12.9	137.4	91.8	299.1	285.9	346.3	223.9	140.3	106.7
45.7	305.7	275.6	182.1	210.7	112.0	1.7	126.3	87.0	268.1
328.8	336.2	286.3	251.7	197.9	190.3	279.0	184.8	145.4	68.0
227.6	244.3	67.3	320.7	330.2	59.6	294.2	144.7	34.7	247.2
35.1	272.8	176.3	345.3	102.9	216.7	312.7	27.3	47.5	66.1
100.3	267.5	160.4	197.0	272.6	94.7	30.4	86.4	339.1	132.7
196.9	141.2	232.7	49.9	271.3	235.5	143.9	44.4	344.2	225.2
344.7	236.0	255.4	53.7	137.0	248.1	93.6	66.2	207.1	280.9
347.4	61.6	271.7	92.7	204.4	269.3	288.0	86.4	21.5	29.2

Pitch angle

8.5	15.6	5.1	3.5	13.0	11.6	8.1	7.0	16.4	10.3
1.9	8.5	4.5	14.4	13.6	10.8	9.0	3.0	8.6	17.7
12.0	1.8	13.4	9.5	12.7	17.4	7.3	11.7	17.8	11.8
9.4	5.3	16.9	3.1	18.9	5.3	15.3	5.2	7.8	3.1
13.9	3.1	6.9	6.8	4.2	6.4	12.6	0.9	15.4	4.0
14.0	5.6	15.6	12.1	14.2	2.4	15.4	15.1	7.9	8.1
12.8	8.8	13.5	3.8	4.7	18.8	18.7	4.9	16.2	15.0
0.7	10.5	0.1	14.8	2.4	12.9	19.5	8.8	15.1	16.5
1.4	9.1	12.0	4.9	12.1	9.6	3.8	13.8	7.5	15.8
6.4	17.5	7.7	18.3	9.0	12.8	2.8	7.2	4.3	6.4

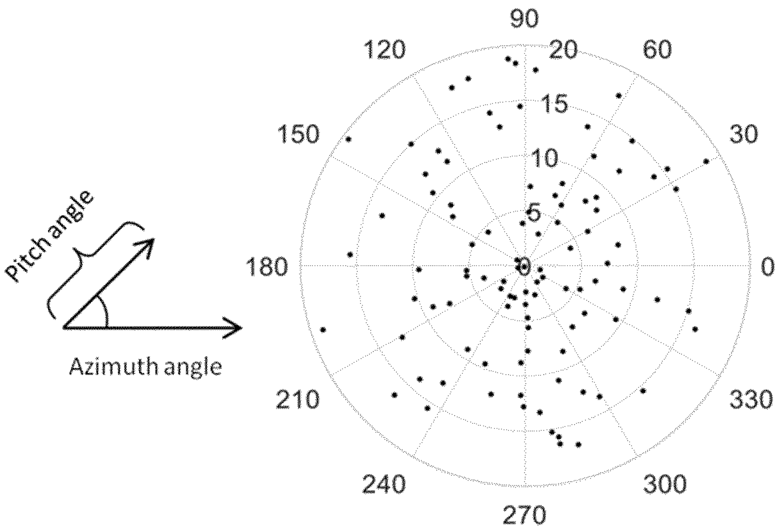

Fig. 2

Azimuth angle

80	40	120	200	240	320	160	120	240	200
80	80	80	160	240	120	240	80	320	160
240	40	120	360	120	200	360	240	120	320
160	160	80	280	320	360	120	240	280	120
240	80	200	160	40	200	320	200	40	160
80	320	320	320	280	120	280	240	320	360
80	40	240	40	240	240	360	0	40	0
280	0	40	160	280	120	0	120	200	360
280	200	160	320	160	280	120	160	120	80
320	280	0	320	280	160	240	80	280	240

Pitch angle

10	8	16	6	6	10	0	16	14	8
12	2	8	0	10	12	10	10	16	12
6	4	0	4	18	6	6	14	6	16
12	4	6	12	12	2	16	10	10	14
14	6	14	12	16	8	18	0	16	8
0	2	14	16	8	6	6	8	16	14
2	6	10	10	8	14	14	12	12	8
18	2	12	2	10	14	16	10	4	18
12	16	16	16	4	12	10	6	12	18
4	2	0	14	14	2	16	16	2	16

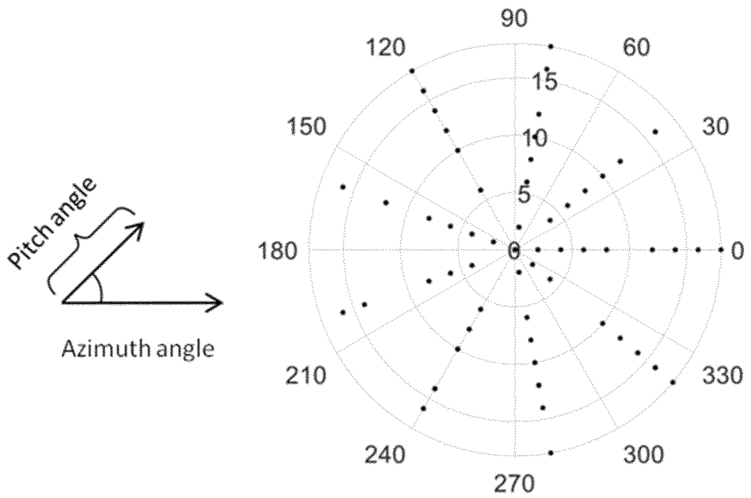

Fig. 3

Pitch angle=0°, Azimuth angle=0°

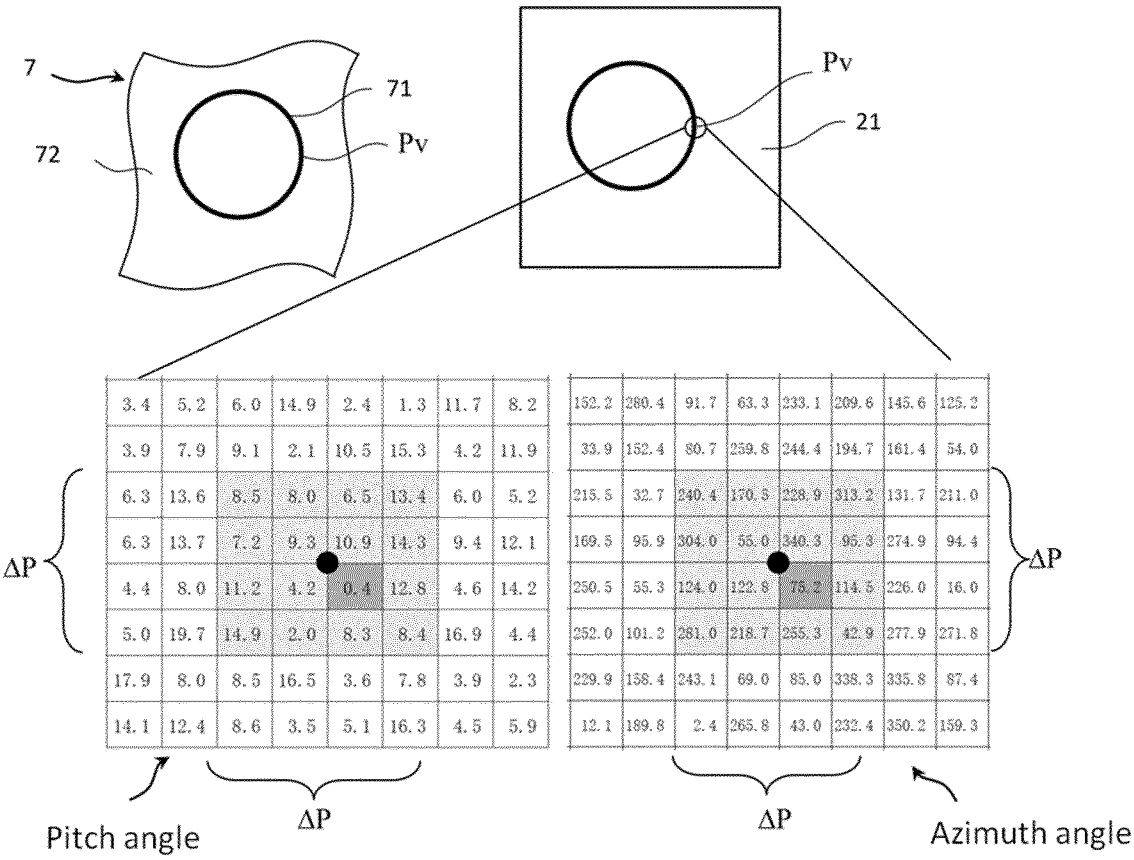

Fig. 4

Pitch angle=0° , Azimuth angle=0°

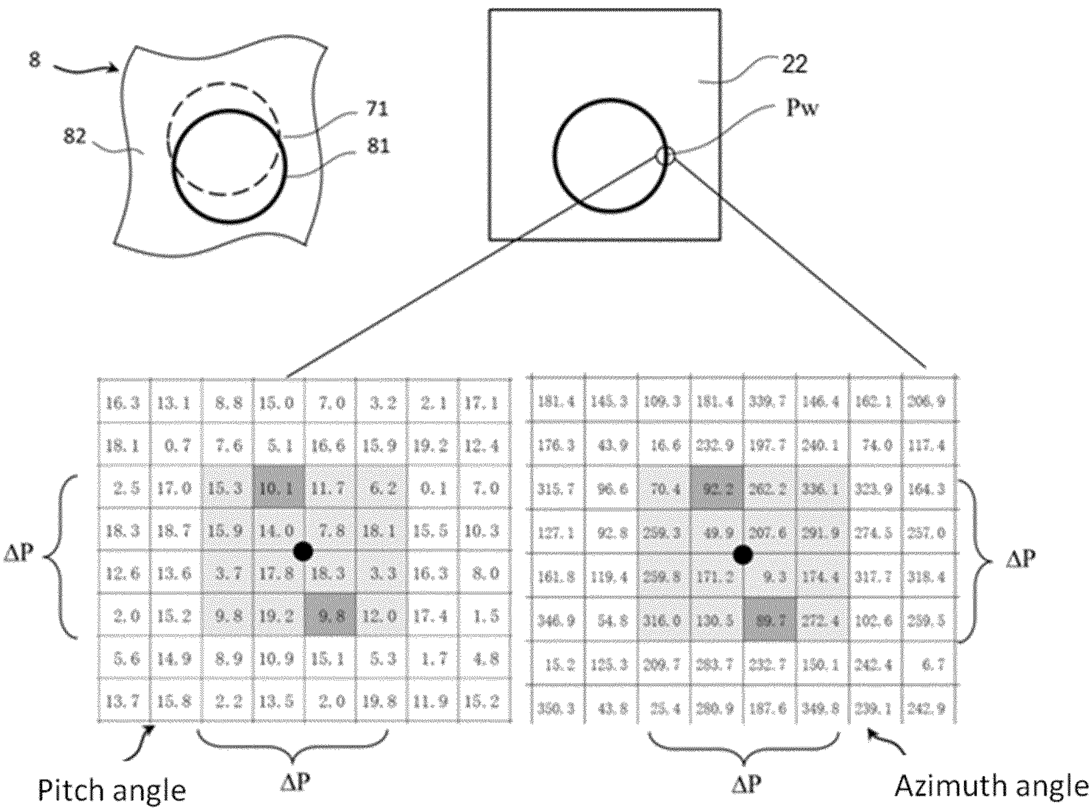

Fig. 5

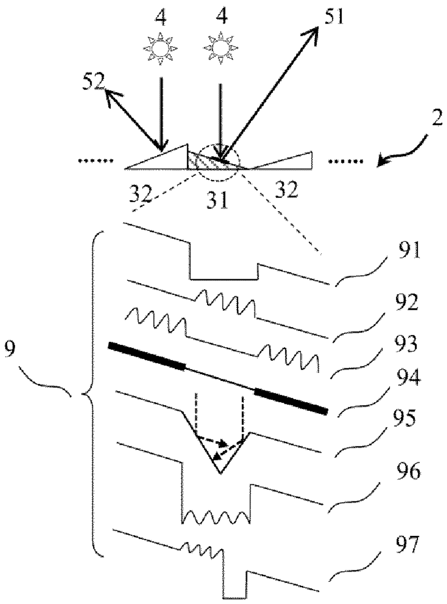

Fig. 6

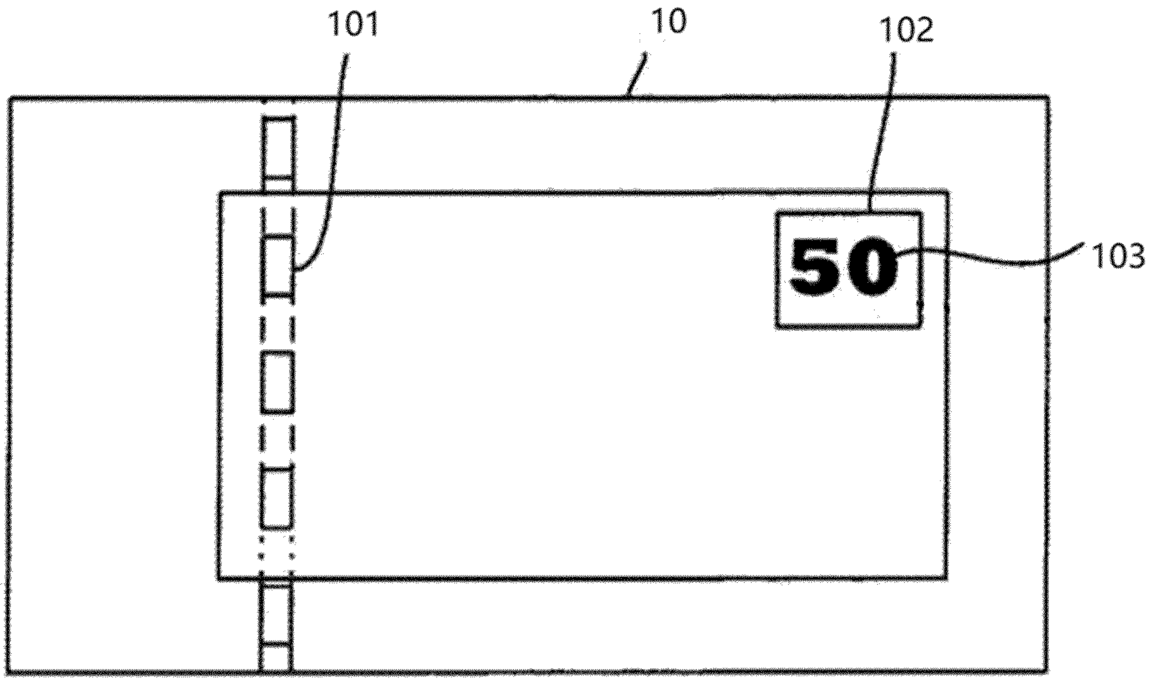

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/073788

A. CLASSIFICATION OF SUBJECT MATTER

B42D 25/324(2014.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B42D 25/-; B42D 15/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT, CNABS, VEN, CNKI: 防伪, 安全, 背景, 图案, 图文, 漫反射, 动态, 动感, 动画, counterfeit+, safe+, securit+, background, pattern, diffus+, reflect+, dynamic+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 110450560 A (ZHONGCHAO SPECIAL SECURITY TECHNOLOGY CO., LTD. et al.) 15 November 2019 (2019-11-15) description, paragraphs 46-97, and figures 1-17	1-27
A	CN 103576216 A (ZHONGCHAO SPECIAL SECURITY TECHNOLOGY CO., LTD. et al.) 12 February 2014 (2014-02-12) entire document	1-27
A	JP 2017007228 A (NATIONAL PRINTING BUREAU) 12 January 2017 (2017-01-12) entire document	1-27
A	JP H10-81056 A (DAI NIPPON PRINTING CO., LTD.) 31 March 1998 (1998-03-31) entire document	1-27
A	US 2013182300 A1 (MUELLER, M. et al.) 18 July 2013 (2013-07-18) entire document	1-27
A	CN 103832114 A (ZHONGCHAO SPECIAL SECURITY TECHNOLOGY CO., LTD. et al.) 04 June 2014 (2014-06-04) entire document	1-27

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 April 2022	**29 April 2022**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China**	
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/073788

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	110450560	A	15 November 2019	None			
CN	103576216	A	12 February 2014	WO	2014019269	A1	06 February 2014
JP	2017007228	A	12 January 2017	None			
JP	H10-81056	A	31 March 1998	None			
US	2013182300	A1	18 July 2013	CA	2810738	A1	19 April 2012
				EP	2441593	A1	18 April 2012
				JP	2013541102	A	07 November 2013
				UA	111069	C2	25 March 2016
				RU	2013121668	A	10 December 2014
				WO	2012048809	A1	19 April 2012
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CN	103832114	A	04 June 2014	WO	2014082319	A1	05 June 2014

Form PCT/ISA/210 (patent family annex) (January 2015)

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- CN 102712207 A **[0004] [0045]**
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- WO 2014108303 A1 **[0006]**