(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 825 139 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.05.2021 Bulletin 2021/21

(51) Int Cl.:
B42D 25/328 *(2014.01)* ***B42D 25/36*** *(2014.01)*

(21) Application number: **20203099.5**

(22) Date of filing: **21.10.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
KH MA MD TN

(30) Priority: **22.11.2019 IT 201900021966**

(71) Applicant: **Centro Grafico DG S.p.A.**
24100 Bergamo (IT)

(72) Inventor: **RADICE, Dino**
20010 Marcallo con Casone (MI) (IT)

(74) Representative: **Gregorj S.r.l.**
Via L. Muratori, 13/b
20135 Milano (IT)

(54) ANTICOUNTERFEIT MULTILAYER DEVICE

(57) The present invention refers to an anticounterfeit multilayer device (1) comprising:
- a shift color layer (2) comprising one or more photonic crystals;
- a holographic layer (3) comprising a holographic structure (4) occupying all the holographic layer (3) or partially occupying the holographic layer (3) so that the holographic layer (3) comprises one or more portions (5) devoid of the holographic structure (4);
- a reflective layer (6);
wherein the shift color layer (2) overlaps the holographic layer (3) and the holographic layer (3) overlaps the reflective layer (6).

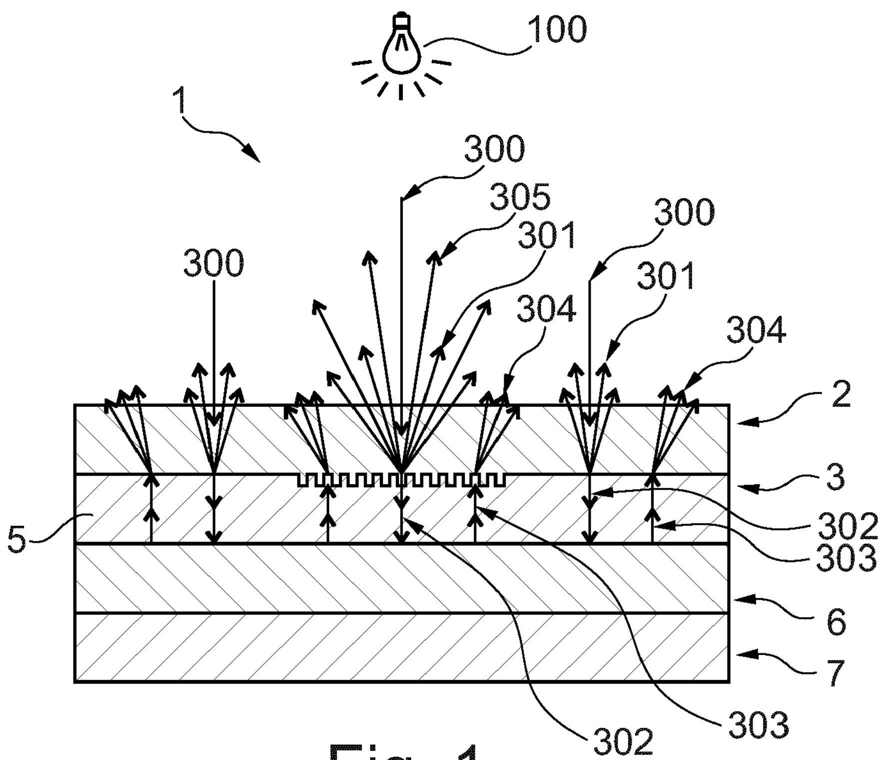


Fig. 1

EP 3 825 139 A1

Description

FIELD OF THE INVENTION

[0001] The present invention refers to an anticounterfeit multilayer device for valuable documents, such as banknotes, certificates, cheques, vouchers, identity cards, passports, seals, safety labels, and similar.

PRIOR ART

[0002] Anticounterfeit multilayer devices to be applied to documents or products in order to verify the authenticity thereof are known.

[0003] Such devices comprise holographic components or non-holographic components which are difficult or expensive to be counterfeited by counterfeiters due to their sophistication and the inherent high costs.

[0004] The layers of the multilayer devices can be arranged in different ways, for example can include: a scratch-resistant layer, a chemical-attack resistant layer, one or more reflecting layers, a layer with printed recorded portions and/or drawings, a layer with printed parts made of normally visible pigments or of particular inks (e.g. UV and/or IR visible inks, thermochromic pigments, photochromic pigments, iridescent pigments or optically variable pigments), a barrier layer. As said, the multilayer devices moreover can include one or more holographic or non-holographic components.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide an anticounterfeit multilayer device which is even more difficult to be counterfeited consequently ensuring an even better safety.

[0006] These and other objects are obtained by an anticounterfeit multilayer device according to claim 1.

[0007] Dependent claims define possible advantageous embodiments of the invention.

BRIEF DESCRIPTION OF THE FIGURES

[0008] The invention is specifically disclosed in the following with reference to exemplifying non-limiting embodiments, and to the attached drawings, wherein:

Figure 1 is a cross-section schematic exploded view of an anticounterfeit device according to a first embodiment;
Figure 2 is a cross-section schematic exploded view of an anticounterfeit device according to a second embodiment;
Figure 3 is a cross-section schematic exploded view of an anticounterfeit device according to a third embodiment;
Figure 4 is a cross-section schematic exploded view of an anticounterfeit device according to a fourth embodiment;
Figure 5 is a cross-section schematic exploded view of an anticounterfeit device according to a fifth embodiment;
Figure 6 is a cross-section schematic exploded view of an anticounterfeit device according to a sixth embodiment;
Figure 7 is a cross-section schematic exploded view of an anticounterfeit device according to a seventh embodiment;
Figure 8 is a cross-section schematic exploded view of an anticounterfeit device according to an eight embodiment;
Figure 9 is a cross-section schematic exploded view of an anticounterfeit device according to a ninth embodiment;
Figure 10 is a cross-section schematic exploded view of an anticounterfeit device according to a tenth embodiment;
Figures from 11 to 18 are front views of anticounterfeit devices according to different embodiments of the invention, showing the effect of illuminating the anticounterfeit devices;
Figure 19 is a cross-section schematic view of a one-dimensional photonic crystal illuminated by a light beam.

DETAILED DESCRIPTION OF THE INVENTION

[0009] For the purpose of the present description and attached claims, except where otherwise stated, all the numbers indicating amounts, measures, percentages, etcetera, must be considered as modified, in any conditions, by the term "about". Moreover, all the ranges comprise any combinations of the disclosed maximum and minimum points and comprise any intermediate range comprised in them, which could be specifically enumerated or not.

[0010] The present disclosure, according to at least one of said aspects, can be implemented according to one or more of the following embodiments, optionally combined with each other.

[0011] For the purpose of the present description and of the attached claims, the terms "a" or "an" should be understood as comprising one or at least one and the singular form comprises also the plural one unless the text clearly means otherwise. This is done only for convenience and to provide a general meaning to the invention.

[0012] In the following description, the same numeral references are used for indicating analogous elements when they are shown in the different figures.

[0013] Referring to the attached figures, an anticounterfeit multilayer device is generally indicated by reference 1. The multilayer device 1 comprises a plurality of overlapped layers, of which a detailed description will be given, and is destined to be positioned on a substrate, e.g. a banknote, a certificate, a cheque, a voucher, a card, a page of a document such as a passport, a seal, or similar.

[0014] The device 1 comprises a color-shift layer 2 made of one or more photonic crystals. In the present description and in the attached claims, the term "color-shift layer" means a structure capable of changing color as the interaction with the light emitted by a light source 100 varies without using colored pigments, particularly as the angle of incidence of a light ray on the shift color structure itself varies.

[0015] In optics and microphotonics, the term "photonic crystal" means a structure whose refraction index has a periodical modulation on scales comparable with the wavelength of the light or, more generally, of an electromagnetic radiation. Based on the type of periodical modulation of the refraction index, the photonic crystals can be divided in:

- one-dimensional photonic crystals having a periodicity of the refraction index in a single direction (also known as Bragg mirrors);
- two-dimensional photonic crystals having a periodicity of the refraction index in two directions;
- three-dimensional photonic crystals having a periodicity of the refraction index in three directions.

[0016] Advantageously, the color-shift layer 2 is made of one or more one-dimensional photonic crystals, preferably having a periodicity of the refraction index in a direction transversal, preferably perpendicular to a plane defined by the color-shift layer 2.

[0017] Referring to Figure 19, the one-dimensional photonic crystals color-shift layer comprises a plurality of layers having corresponding refraction indexes: n1, n2, n3, n4. Given a light ray 101 incident by an incidence angle a, the total reflected light is given by a beam 102 of rays of reflected light. Suitably selecting the periodicity and the refraction indexes of the layers makes possible to obtain mirrors having a very high reflection coefficient in a determined range of wavelengths. Consequently, as the incidence angle α of the incident light ray 101 varies, an observer, considered in a stationary position with respect to the color-shift structure and light source, will see a variation of the structure color. Analogously, the observer will see color variations in the color-shift structure if, by the same incidence angle of the incident light ray, he/she will change his/her position and/or orientation with respect to the color-shift structure and consequently with respect to the reflected light beam 102.

[0018] With references to Figures from 1 to 10, the device 1 comprises a holographic layer 3 comprising a holographic structure 4 shaped in order to only partially occupy the holographic layer 3 itself, in other words so that the holographic layer comprises portions 5 devoid of the holographic structure 4. For example, the holographic layer 4 can comprise a polymeric layer in which holographic etchings forming the holographic structure are made. Alternatively, the holographic layer 4 can be completely holographic, in other words, it is not provided of portions 5 devoid of the holographic structure.

[0019] The color-shift layer 2 overlaps the holographic layer 3. It is observed that, in the present description and attached claims, the term "overlaps" does not want to imply also a direct contact between the cited overlapped elements which can be in direct contact or can have further elements inbetween, by maintaining their overlapped condition. For example, the sentence "the color-shift layer 2 overlaps the holographic layer 3" means the color-shift layer 2 overlaps and directly contacts the holographic layer 3, but also means one or more further layers can be interposed between the shift color layer 2 and holographic layer 3, by maintaining the relative overlapped condition of the color-shift layer 2 and holographic layer 3.

[0020] According to an embodiment, the color-shift layer 2 and holographic layer 3 are directly contacting each other.

[0021] According to an alternative embodiment, the device 1 comprises a transparent intermediate layer 9 placed between the color-shift layer 2 and holographic layer 3. For example, the transparent intermediate layer 9 can comprise a transparent polyester. Preferably, the transparent intermediate layer 9 is resistant to chemical agents and can for example comprise a polymer adapted to this purpose.

[0022] Moreover, the device 1 comprises a reflective layer 6, wherein the holographic layer 3 overlaps the reflective layer 6.

[0023] According to a possible embodiment, the reflective layer 6 has a constant reflection coefficient. For example, the reflective layer 6 can have a reflection coefficient of:

- 100% (obtainable for example by mirror evaporated aluminum or mirror evaporated silver);
- 80% (obtainable for example by transparent materials having a refraction index comprised between 1.9 and 2.6, such as zinc sulphur (ZnS) or titanium bioxide (TiO_2), or by aluminum evaporated on non-mirror satin finish surfaces);
- 50% (obtainable for example by reflecting materials doped by fillers or powders with different percentages);
- 30% (obtainable for example by semi-transparent print colors);
- 10% (obtainable for example by a black/grey print color or other similar ones).

[0024] The optical phenomena underlying this configuration will be particularly described in the following with reference to possible embodiments of the invention.

[0025] According to an embodiment, the reflective layer 6 comprises portions 6', 6", 6'" having different reflective coefficients. Preferably, portions 6', 6" of the reflective layer 6, placed in correspondence of the portions 5 devoid of the holographic structure of the holographic layer 3, have a reflective coefficient different from the one of the portion 6'" of the reflective layer placed in correspondence of the holographic structure of the holographic layer 3.

[0026] Still more preferably, at least two portions 6', 6" disposed at the portions 5 devoid of the holographic structure of the holographic layer 3, have reflection coefficients different from each other. Consequently, the color-shift layer 2 will reflect the light with different color shades in correspondence of the portions 6' and 6" placed at the portions 5 devoid of the holographic structure of the holographic layer 3, maintaining also the color-shift effect.

[0027] According to an embodiment, the reflective layer 6 is transparent. For example, the transparent reflective layer 6 can be made of ZnS or TiO_2.

[0028] According to an embodiment, the device 1 comprises a backing layer 7, wherein the reflective layer 6 overlaps the backing layer 7. The backing layer 7 can be made of a transparent material or non-transparent one. For example, the backing layer 7 can be made of polyester or polycarbonate. When the structure 6 is transparent in order to enable to illuminate the holographic structure 4, advantageously, the backing layer 7 is also transparent. For example, the backing layer 7 can be in this case made of polyester or polycarbonate.

[0029] According to a further possible variant, the backing layer 7 can be made of paper, polyester, or similar silicon material.

[0030] According to a possible variant, the device 1 further comprises an adhesive layer 8 overlapping the backing layer 7, enabling to release this latter and to glue the device 1 to a substrate. Such configuration enables to manufacture safety labels, for example. The adhesive layer 8 can for example comprise adhesive polymers.

[0031] According to an alternative embodiment, the adhesive layer 8 is configured to be hot stamped, for example can include a layer of adhesive polymers to be hot stamped, and a releasing layer. Preferably, according to this variant, the device 1 is not provided of the backing layer 7.

[0032] According to an embodiment, the device 1 comprises one or more protecting transparent layers overlapping the color-shift layer 2. For example, the protecting layers can comprise one or more among:

- a backing layer 10, made of a transparent polyester, for example;
- a releasing layer 11 which the backing layer 10 overlaps. Consequently, in operative conditions of the device 1, it is possible to release the backing layer 10. For example, the releasing layer 11 can comprise a releasing polymer;
- a wear resistant protecting layer 12, for example, comprising a polymeric material. When the releasing layer 11 and backing layer 10 are provided, they overlap the wear resistant protecting layer 12, which will be exposed when the former are removed.

[0033] According to an embodiment, the device 1 comprises a layer 13 provided with fluorescent graphic elements, made of inks and/or pigments visible if are illuminated by a light at predetermined wavelengths, for example if illuminated by UV-A and/or UV-B and/or UV-C lights. The holographic layer 3 overlaps the layer 13 having fluorescent graphic elements, which in turn overlaps the reflective layer 6.

[0034] Alternatively, or in addition to the layer 13 having fluorescent graphic elements, the device 1 comprises a layer 14 having phosphorescent graphic elements made of phosphorescent inks and/or pigments.

[0035] The layer 13 having fluorescent graphic elements and layer 14 having phosphorescent graphic elements further modify the color shade generated by the color-shift layer 2. If both layers are present, the layer 13 having fluorescent graphic elements can overlap the layer 14 having phosphorescent graphic elements, or viceversa.

[0036] With reference to the attached Figures from 1 to 10, possible alternative embodiments of the anticounterfeit device 1 according to the invention will be now described. Moreover, the optical phenomena underlying these layers will be further specifically described. Particularly, such figures are provided with arrows schematically showing the trends of the light rays. Particularly, Figures from 1 to 10 will use the following numeral references for indicating different light beams:

300: the incident light emitted from the light source 100;
301: the incident light portion reflected by the photonic crystal, generating reflecting colors;
302: the incident light portion transmitted by the photonic crystal;
303: the transmitted light reflected by the reflective layer;
304: the transmitted light reflected by the photonic crystal, generating the transmission colors;
305: the reflected light dispersed by the holographic structure at different wavelengths.

First embodiment (Figure 1)

[0037] According to the embodiment illustrated in Figure 1, the anticounterfeit device 1 comprises starting from the outside (in other words from the side facing the light source 100):

- the color-shift layer 2 comprising the photonic crystal;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4;
- the reflective layer 6, with a reflection coefficient for example equal to 100%, in other words having a mirror reflection (made for example of mirror evaporated aluminum or silver);

- the backing layer 7, for example made of transparent or non-transparent polyester or other materials.

[0038] As long as the field of view of the eyes of an observer and the consequent visual angle is not focused, inside the area occupied by the holographic structure 4, on the angle of the incident light portion reflected by the photonic crystal 2, the reflected color generated by it does not reach the observer eyes. Instead, if the visual angle of the observer eyes is focused only on the reflected light generated by the nano-etchings of the holographic structure 4, the holographic structure 4 maintains its holographic diffraction and therefore the observer will only see the hologram with an amplified brightness thanks to the underlying layer 6 which is 100% reflective (as a mirror). Moreover, this latter, due to its reflected light, prevents the reflecting color generated by photonic crystal 2, inside the area occupied by the holographic structure 4, from being seen. The portion 5 devoid of the holographic structure 4, also placed above the mirror reflective layer 6, is also devoid of colors generated by the incident transmitted light reflected by the photonic crystal 2. This phenomenon, in the portions 5 devoid of the holographic structure 4, occurs both when the visual angle of the observer eyes is focused only on the reflected light generated by the nano-etchings of the holographic structure 4, and when the visual angle of the observer eyes is focused inside the area occupied by the holographic structure 4. The factor determining this phenomenon depends on the interaction between the incident light portion reflected by the photonic crystal 2, generating the reflecting color, and the reflection action of the light performed by the underlying mirror reflective layer 6. As a consequence of this interaction, the action generating the reflecting color is strongly counteracted and is so mitigated by the light reflected from the underlying mirror reflective layer that the reflecting color is made almost invisible. Simultaneously, the transmitting color (due to the reflected light generated by the photonic crystal), which is usually less intense than the reflecting color (in turn, obtained by the light portion transmitted from the photonic crystal), is even more mitigated and consequently no more visible because it is also counteracted by the light reflected from the mirror reflective layer 6. The above-described optical phenomena are schematically illustrated in Figure 11.

[0039] By contrast, when the field of view of the observer eyes is focused on the angle of the incident light portion reflected from the photonic crystal 2, the reflecting color, generated by it, becomes visible. However, the field of view of the observer eyes is not focused on the reflected light generated by the nano-etchings of the holographic structure, and consequently the diffraction of the light generated by the holographic element is not perceived by the observer eyes and therefore is not visible. In this condition, the incident light portion reflected from the photonic crystal itself on the area occupied by the holographic structure and generating the reflecting color is not counteracted and is mitigated by the light from the mirror reflective layer due to the holographic structure and consequently the reflecting color remains perfectly visible, while the transmitting color, usually less intense than the reflecting color, generated by the light portion reflected from the photonic crystal placed on the holographic structure, is even more mitigated and then not visible because is counteracted by the reflected light of the mirror reflective layer.

[0040] Outside the area occupied by the holographic structure, which is also covered by the photonic crystal and is placed above the mirror reflective metal layer, the incident light portion reflected from the photonic crystal itself, and generating the reflecting color, is counteracted and mitigated by the light reflected from the mirror reflective layer until it is almost cancelled and until the reflecting color is made almost invisible. Analogously, the transmitting color (in other words the color due to the reflected light portion generated by the photonic crystal, in turn generated by the light portion transmitted from the photonic crystal), usually less intense than the reflecting color, is even more mitigated and consequently is no more visible because it is also counteracted by the light reflected from the mirror reflective layer. This phenomenon enables to distinctly see, with the reflecting color generated by the photonic crystal, the graphic elements, drawings and even the smallest structural elements of the holographic etchings of the holographic structure. The reflecting color generated by the photonic crystal on the part containing the holographic etchings has also a color-shift effect. The color change is shown by modifying the entering angle of the light incident on the photonic crystal. Such phenomenon is schematically illustrated in Figure 12.

Second embodiment (Figure 2)

[0041] According to the embodiment illustrated in Figure 2, the anticounterfeit device 1 comprises, starting from the outside (in other words from the side facing the light source 100):

- the color-shift layer 2 comprising the photonic crystal;
- the transparent intermediate layer 9 made of transparent polyester or other material;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4, for example made of a polymeric material;
- the reflective layer 6 with a reflection coefficient of 100% in other words with a mirror reflection (made of mirror evaporated aluminum or silver, for example);
- the adhesive layer 8, made of an adhesive polymer, for example;
- the backing layer 7 made of paper or polyester or similar siliconized material, for example.

[0042] The optical phenomena are the same occurring in the first embodiment of Figure 1, because the addition of the intermediate layer 9 does not generate substantially different physical/optical phenomena.

Third embodiment (Figure 3)

[0043] According to the embodiment illustrated in Figure 3, the anticounterfeit device 1 comprises, starting from the outside (in other words from the side facing the light source 100):

- the color-shift layer 2 comprising the photonic crystal;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4, or completely comprising the holographic structure 4;
- the non-mirror transparent reflective layer 6, having a reflection coefficient less than 100% (for example ZnS or TiO_2);
- the backing layer 7, made of transparent or non-transparent polyester or other materials, for example.

[0044] The main difference from the first embodiment is that the non-mirror layer 6 is transparent and non-mirror reflective. In this condition, the incident light portion and the transmitted light reflected from the photonic crystal and generating colors are not counteracted and mitigated by the light reflected from the reflective layer (as opposed to a mirror layer reflecting 100%) and consequently the colors generated by the photonic crystal, both by the incident light and by the transmitted one, remain visible.

[0045] As long as the field of view of the observer eyes and the consequent visual angle is not focused, and consequently does not see, inside the area occupied by the photonic crystal, the angle of the incident light portion reflected from the photonic crystal and therefore the reflecting color generated by it does not reach the observer eyes and consequently the color is not visible. On the contrary, if the field of view and the consequent visual angle is not focused, and therefore does not sees inside the area occupied by the photonic crystal the angle of the transmitted light portion reflected from the photonic crystal and consequently the transmitting color generated by it reaches the eyes and therefore the color is visible. Still differently, as long as the field of view of the eyes and the consequent visual angle is not focused, and therefore does not see inside the area occupied by the photonic crystal, the angle of the transmitted light portion reflected from the photonic crystal and consequently the transmitting color generated by it does not arrive to the eyes and therefore is not visible. Otherwise, if the field of view and consequent visual angle is not focused, and therefore sees, inside the area occupied by the photonic crystal, the angle of the incident light portion reflected from the photonic crystal and consequently the reflecting color generated by it reaches the eyes and consequently the color is visible. Still otherwise, if the field of view of the eyes is focused, and therefore it sees also the reflected light generated by the nano-etchings of the holographic structure, this condition makes visible the holographic element. Anyway, they also remain visible, in dependence on the visual angle, or reflecting color or transmitting color generated by the photonic crystal.

[0046] The reflecting color and transmitting color generated by the photonic crystal have a color-shift effect, and their color change occurs and is shown by modifying the angle of the light incident on the photonic crystal. For example, illustratively the reflecting color can change from an intense pink to a gold yellow and the transmitting one can change from a light green to a light blue.

[0047] The above-described optical phenomena are schematically illustrated in Figures 13A and 13B.

Fourth embodiment (Figure 4)

[0048] According to the embodiment illustrated in Figure 4, the anticounterfeit device 1 comprises, starting from the outside (in other words from the side facing the light source 100):

- the color-shift layer 2 comprising the photonic crystal;
- the transparent intermediate layer 9 made of transparent polyester or other material, for example;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4 made of a polymeric material for example;
- the non-mirror transparent reflective layer 6, having a reflection coefficient less than 100% (ZnS or TiO_2, for example);
- the adhesive layer 8 made of an adhesive polymer, for example;
- the backing layer 7 made of paper, polyester or similar siliconized material, for example.

[0049] The physical/optical phenomena are the same as the ones occurring in the third embodiment, because the addition of the intermediate layer 9 does not generate substantially different physical/optical phenomena. Also, the layers 8 and 7, since they are below the reflective layer, do not generate substantially different optical phenomena.

Fifth embodiment (Figure 5)

[0050] According to the embodiment illustrated in Figure 5, the anticounterfeit device 1 comprises, starting from the outside (in other words from the side facing the light source 100):

- the color-shift layer 2 comprising the photonic crystal;
- the holographic layer 3 comprising the holographic

structure 4 and portions 5 devoid of the holographic structure 4, made of a polymeric material, for example;

- the reflective layer 6 comprising the portions 6' and 6" in correspondence of the portions 5 devoid of the holographic structure of the holographic layer 3 and the portion 6"' in correspondence of the holographic structure of the holographic layer 3, wherein the portion 6"' has a reflective coefficient of 100%, as a mirror (made of mirror evaporated aluminum or silver, for example) different from the portions 6' and 6", which in turn have reflection coefficients different from each other, for example respectively of 30% (obtained by print colors mixed with black, or other colors or colored or uncolored pigments, for example) and of 50% (for example obtained by aluminum evaporated on a satin finish layer mixed with pigments capable of reducing the reflection);
- the backing layer 7, made of transparent or non-transparent polyester or other materials, for example.

[0051] The fifth embodiment is similar to the first embodiment, the only difference being the reflective layer 3 made of three portions of layers having three different reflecting percentages. Particularly, the portion 6"' placed in correspondence of the holographic structure 4 is identical to the entire reflective layer of the first embodiment and consequently it reflects 100% of the light, generating the same physical/optical phenomena. The portion 6' reflects 30% and therefore the counteracting action exerted with reference to the transmitted light is mitigated by a percentage of 70% with respect to a mirror layer having a 100% reflection and, consequently, the light transmitted from the photonic crystal generates a color attenuated by an intensity of 30 if compared with a color having an intensity of 100 generated by a zero reflection reflecting structure (no noise). Lastly, the portion 6" reflects 50% and therefore the counteracting action exerted with reference to the transmitted light is mitigated of a percentage of 50% with respect to a 100% reflection mirror layer and consequently the light transmitted from the photonic crystal generates a color toned down by an intensity of 50% if compared with a color with an intensity equal to 100 generated by a zero reflection reflective structure (no noise).

[0052] As long as the field of view of the observer eyes and the consequent visual angle is not focused, and therefore does not see, inside the area occupied by the holographic structure, the angle of the incident light portion reflected from the photonic crystal and consequently the reflection color generated by it does not reach the eyes. Otherwise, if the visual angle of the eyes is focused, and therefore it only sees the reflected light generated by the nano-etchings of the holographic structure, the holographic structure maintains its holographic diffraction and therefore the holographic image is visible on all the three portions of the reflective layer with three different reflecting percentages. The portion of the reflective layer 6"', reflecting 100%, as a mirror, further prevents the reflecting color generated by the photonic crystal, inside the area occupied by the holographic structure, from being visible. Differently, the portion 6', reflecting 30%, further causes the reflecting color generated by the photonic crystal, for the area occupied by this portions 6', inside and outside the area occupied by the holographic structure, to be visible toned down by an intensity of 30 if compared with a color having an intensity of 100. The portion 6", reflecting 50%, further causes the reflecting color generated by the photonic crystal, for the area occupied by this portion, inside and outside the area occupied by the holographic structure, to be visible toned down by an intensity of 50 if compared with a color having an intensity of 100. Differently, the area of the holographic layer 3, placed outside the area occupied by the holographic structure 4 itself but overlapped the 100% mirror reflective portion 6"', is devoid of the colors generated by the incident light and transmitted reflected by the photonic crystal. The cause of this phenomenon depends on the interaction between the incident light portion reflected from the photonic crystal, creating the reflecting color, and the reflecting action of the light performed by the underlying 100% mirror reflective portion 6"'. As a consequence of this interaction, the action generating the reflecting color is strongly counteracted and mitigated by the light reflected from the underlying mirror reflective portion until the reflecting color is made almost invisible. Analogously, the transmitting color, usually less intense than the reflecting color, is still more mitigated and therefore no more visible because it is also counteracted by the light reflected from the mirror reflective portion.

[0053] Such phenomena are schematically illustrated in Figure 14.

[0054] Differently, if the field of view of the eyes and the consequent visual angle, inside the area occupied by the holographic structure, is focused on the angle of the incident light portion reflected from the photonic crystal, the reflecting color becomes visible and, at the same time, the field of view of the observer eyes, inside the area occupied by the holographic structure, is not focused and consequently does not meet the reflected light generated by the nano-etchings of the holographic structure. Therefore, the holographic element is not perceived and therefore is not visible. In this condition, the incident light portion reflected from the photonic crystal on the holographic structure and generating the reflecting color is not counteracted and mitigated by light of the mirror reflective portion due to the holographic structure and therefore the reflecting color remains perfectly visible, while the transmitting color, usually less intense than the reflecting color, generated by the light portion reflected from the photonic crystal placed on the holographic structure, is even more mitigated and consequently not visible because is counteracted by the reflected light of the mirror reflective metal layer. This phenomenon occurs both on the mirror reflective portion 6"', and also on the 30%

reflecting portion 6', and on the 50% reflecting portion 6".

[0055] Differently, outside the area occupied by the holographic structure, also covered by the photonic layer, and overlapped the 100% mirror reflective portion 6"', the incident light portion reflected from the photonic crystal itself and generating the reflecting color, is counteracted and mitigated by the light reflected from the mirror reflective portion 6'" until is almost cancelled and makes the reflecting color almost invisible. Analogously, the transmitting color, usually less intense than the reflecting color, is even more mitigated and consequently is no more visible because it is also counteracted by the light reflected from the mirror reflective portion 6"'. Still differently, outside the area occupied by the holographic structure, also covered by the photonic crystal, and placed above the 30% reflecting portion 6', the incident light portion reflected from the photonic crystal itself and generating the reflecting color, for the area occupied by this portion, is visible toned down by an intensity of 30 if compared with a color with an intensity of 100 due to a smaller contrast from the light reflected from the reflective layer. Still more differently, outside the area occupied by the holographic structure, also covered by the photonic crystal, and placed above the 50% reflecting portion 6", the incident light portion reflected from the photonic crystal itself and generating the reflecting color, for the area occupied by this portion, it is visible toned down by an intensity of 50 if compared with a color with an intensity of 100 due to a smaller contrast of the light reflected from the reflective layer. The reflecting color generated by the photonic crystal has also a color-shift effect. The color change is shown by modifying the entering angle of the light incident on the photonic crystal.

[0056] The above-described physical/optical phenomena are schematically illustrated in Figure 15.

<u>Sixth embodiment (Figure 6)</u>

[0057] According to the embodiment illustrated in Figure 6, the anticounterfeit device 1 comprises, starting from the outside (in other words, the side facing the light source 100):

- the color-shift layer 2 comprising the photonic crystal;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4;
- the reflective layer 6, having a reflection coefficient for example equal to 50% (aluminum evaporated on a satin finish layer with pigments capable of reducing the reflection, for example);
- the backing layer 7 made of transparent or non-transparent polyester or other materials, for example.

[0058] The sixth embodiment is similar to the third embodiment, except for the reflective layer 6 is made uniformly 50% reflective and therefore the counteracting action performed on the transmitted light is mitigated of a percentage of 50% with respect to a 100% reflection mirror reflective layer, which counteracts and mitigates until the color generated by the photonic crystal is cancelled. Therefore, in this case, the light transmitted from the photonic crystal generates a color toned down by an intensity of 50 if compared with a color of an intensity of 100 generated by a zero-reflection structure (no noise).

[0059] As long as the field of view of the observer eyes and the consequent visual angle are not focused, and therefore does not see, inside the area occupied by the holographic structure, the angle of the incident light portion reflected by the photonic crystal and consequently the reflecting color generated by it does not reach the eyes. When, differently, the visual angle of the eyes is focused, and therefore sees only the reflected light generated by the nano-etchings of the holographic element, this condition makes the holographic element to maintain the holographic diffraction thereof and therefore the hologram is seen with a discrete brightness. Simultaneously, the area placed outside the area occupied by the holographic structure, placed also above the 50% reflective layer, is also focused in the field of view and being absent the 100% reflection mirror reflective layer counteracting and cancelling the color generated by the photonic crystal, the incident light portion reflected by the photonic crystal generates the reflecting color and the same is visible with a toned down intensity, in other words by an intensity of 50 if compared with a color with an intensity of 100 generated by a zero reflection (no noise) structure. The hereinbefore described physical/optical phenomena occur, analogously, also for the transmitting generated colors. Usually, the transmitting colors are less intense than the reflecting colors. The reflecting and transmitting colors generated by the photonic crystal have also a color-shift property, and the color change is shown by modifying the entering angle of the light incident on the photonic crystal.

[0060] The above-described physical/optical phenomena are schematically illustrated in Figure 16A.

[0061] Differently, and as long as the field of view of the eyes and consequently the visual angle is focused, and therefore sees, inside the area occupied by the holographic structure, the angle of the incident light portion reflected from the photonic crystal and consequently the reflecting color generated by it reaches the eyes. Differently, when the visual angle of the eyes is not focused, and consequently does not see, the reflected light generated by the nano-etchings of the holographic element, the nano-etchings of the holographic element cancel the noise generated by the 50% reflective layer and consequently the incident light portion reflected from the photonic crystal in the area occupied by the holographic structure generates a color having an intensity toned down by less than 50% with respect to a color of 100% (no noise). Analogously, the area placed outside the area occupied by the holographic layer, placed also above the 50% reflective layer, is focused in the field of view, and, being absent the 100 reflecting mirror reflective layer counteracting and cancelling the color generated by the photonic crystal, the incident light portion reflected by the photonic crystal generates the reflecting color and the same is visible with a toned down intensity, in other words by an intensity equal to 50 if compared with a color with an intensity of 100 generated by a zero reflection (no noise) structure.

[0062] The illustrated physical/optical phenomena occur, analogously, also for the transmitting generated colors. Usually, the transmitting colors are less intense than the reflecting colors. The reflecting and transmitting colors generated by the photonic crystal have also the color-shift property, and the color change is shown by modifying the entering angle of the light incident on the photonic crystal.

[0063] The above-described physical/optical phenomena are schematically illustrated in Figure 16B.

Seventh embodiment (Figure 7)

[0064] According to the embodiment illustrated in Figure 7, the anticounterfeit device 1 comprises, starting from the outside (in other words from the side facing the light source 100):

- the color-shift layer 2 comprising the photonic crystal;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4, made of a polymeric material, for example;
- the reflective layer 6, having a reflection coefficient of 30%, for example (e.g. aluminum evaporated on a satin finish layer with pigments capable of reducing the reflection);
- the backing layer 7, made of transparent or non-transparent polyester or other materials, for example.

[0065] The seventh embodiment is similar to the sixth embodiment, except for the reflection of layer 6 is of 30% and therefore the counteracting action exerted against the transmitted light is mitigated by a percentage of 70% with respect to a 100% reflection mirror reflective layer which counteract and mitigate the light until the color generated by the photonic crystal is cancelled and consequently, in this case, the light transmitted from the photonic crystal generates a color toned down by an intensity of 30 if is compared with a color with an intensity of 100 generated by a zero reflection (no noise) structure.

[0066] The above-described physical/optical phenomena are schematically illustrated in Figures 17A and 17B.

Eighth embodiment (Figure 8)

[0067] According to the embodiment illustrated in Figure 8, the anticounterfeit device 1 comprises, starting from the outside (in other words from the side facing the light source 100):

- the transparent backing layer 10, made of a transparent polyester or other materials, for example;
- the releasing layer 11 made of a releasing polymeric material, for example;
- the wear resistant protecting layer 12 made of a suitable polymer, for example;
- the color-shift layer 2 comprising the photonic crystal;
- the transparent intermediate layer 9 made of a chemical agent resistant polyester, for example;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4, for example made of a polymeric material;
- the reflective layer 6 with a reflection coefficient of 100%, in other words having a mirror reflection (made of mirror evaporated aluminum or silver, for example);
- the hot-stamp adhesive layer 8 made of a suitable hot-stamp polymer, for example.

[0068] The phenomena of the eighth embodiment are the same as the ones of the first embodiment, because the layers 10, 11, 12, 9 do not generate substantially different physical/optical phenomena. Moreover, even the layer 8, being under the reflective layer, does not generate substantially different physical/optical phenomena.

[0069] The physical/optical phenomena are schematically illustrated in Figures 11 and 12.

Ninth embodiment (Figure 9)

[0070] According to the embodiment illustrated in Figure 9, the anticounterfeit device 1 comprises, starting from the outside (in other words from the side facing the light source 100):

- the transparent backing layer 10, made of transparent polyester or other materials, for example;
- the releasing layer 11 made of a releasing polymeric material, for example;
- the wear resistant protecting layer 12 made of a suitable polymer, for example;
- the color-shift layer 2 comprising the photonic crystal;
- the transparent intermediate layer 9 made of a chemical agent resistant polymer, for example;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4, for example made of a polymeric material;
- the transparent reflective layer 6 having a reflection coefficient less than 100%, in other words having a non-mirror reflection (e.g. made of ZnS or TiO_2);

- the hot-stamp adhesive layer 8 made of a suitable hot-stamp polymer, for example.

[0071] The phenomena of the ninth embodiment are the same as the ones of the third embodiment, because the addition of the layers 10, 11, 12, 9 does not generate substantially different physical/optical phenomena. Moreover, even the layer 8, being under the reflective layer 6, does not generate substantially different physical/optical phenomena.

[0072] The physical/optical phenomena are schematically illustrated in Figures 13A and 13B.

Tenth embodiment (Figure 10)

[0073] According to the embodiment illustrated in Figure 10, the anticounterfeit device 1 comprises, starting from the outside (in other words from the side facing the light source 100):

- the transparent backing layer 10, made of transparent polyester or other materials, for example;
- the releasing layer 11 made of a releasing polymeric material, for example;
- the wear resistant protecting layer 12 made of a suitable polymer, for example;
- the color-shift layer 2 comprising the photonic crystal;
- the transparent intermediate layer 9 made of a chemical agent resistant polymer, for example;
- the holographic layer 3 comprising the holographic structure 4 and portions 5 devoid of the holographic structure 4;
- the layer 13 for example made of a polymeric material provided with fluorescent graphic elements made of inks and/or pigments visible under a UV-A and/or UV-B and/or UV-C light, for example;
- the layer 14 made for example of a polymeric material, provided with phosphorescent graphic elements 14 made of phosphorescent inks and/or pigments;
- the transparent reflective layer 6 having a reflection coefficient less than 100%, in other words having a non-mirror reflection (e.g. made of ZnS or TiO_2);
- the hot-stamp adhesive layer 8 made of a suitable hot-stamp polymer, for example.

[0074] The physical/optical phenomena of the tenth embodiment are the same as the ones of the ninth embodiment, except for the physical/optical phenomena generated by the layers 13 (fluorescent pigments) and 14 (phosphorescent pigments), because the addition of a layer modifies the percentage of the transmitted light reflected from the portions of the layers containing said pigments. Modifying the percentage of the transmitted reflected light causes the photonic crystal to generate a different color in the zone of the area where the pigments are present.

[0075] As long as the field of view of the observer eyes and the consequent visual angle is not focused, and therefore does not see, inside the area occupied by the photonic crystal, the angle of the incident light portion reflected from the photonic crystal and consequently the reflecting color generated by it does not reach the eyes, and consequently the color is not visible. Differently, if the field of view and the consequent visual angle is focused, and therefore sees, inside the area occupied by the photonic crystal, the angle of the transmitted light portion reflected from the photonic crystal and consequently the transmitting color generated by it reaches the eyes and so the color is visible. Meanwhile, also the color will be visible with a slightly different intensity, with reference to the areas in which the fluorescent and/or phosphorescent pigments are present because the transmitting color created by the photonic crystal with reference to these areas, is generated by a different transmitting light percentage and therefore the graphic shape of areas containing fluorescent and/or phosphorescent pigments will be well defined and visible. Still differently, as long as the field of view of the eyes and the consequent visual angle is not focused, and therefore does not see, inside the area occupied by the photonic crystal, the angle of the transmitted light portion reflected from the photonic crystal and consequently the transmitting color generated by it does not arrive to the eyes and therefore is not visible. Differently, when the field of view and the consequent visual angle is focused, and therefore sees, inside the area occupied by the photonic crystal, the angle of the incident light portion reflected from the photonic crystal and consequently the reflecting color generated by it, reaches the eyes and therefore the color is visible. Meanwhile, the color will be also visible with a slightly different intensity, with reference to the areas in which the fluorescent and/or phosphorescent pigments are present because the transmitting color generated by the photonic crystal with reference to these areas, is generated by a different percentage of the transmitting light and consequently the graphic shape of areas containing the fluorescent and/or phosphorescent pigments will be well defined and visible. Still differently, if the visual angle of the eyes is focused, and therefore it sees also the reflected light generated by the nano-etchings of the holographic element, this condition causes the holographic element to become visible. However, they will also remain visible, according to the visual angle, or the reflecting color or to the transmitting one generated by the photonic crystal.

[0076] The reflecting color and transmitting color generated by the photonic crystal have also a color-shift effect. The color change occurs and is shown by modifying the angle of the light incident on the photonic crystal. For example, the reflecting color can change from a deep pink to a deep gold yellow and the transmitting one can change from a light green to a light blue.

[0077] Lastly, the fluorescent pigments will be visible with a UV light and the phosphorescent pigments will maintain their phosphorescence.

[0078] The above-described physical/optical phenomena are schematically illustrated in Figures 18A and 18B.

[0079] A person skilled in the art, in order to meet specific contingent needs could introduce many additions, variations or substitutions of elements with other operatively equivalent to the described embodiments of the anticounterfeit device according to the invention, without falling out of the scope of the following claims.

Claims

1. Anticounterfeit multilayer device (1) comprising:

- a color shift layer (2) comprising one or more photonic crystals;
- a holographic layer (3) comprising a holographic structure (4) occupying all the holographic layer (3) or partially occupying the holographic layer (3) so that the holographic layer (3) comprises one or more portions (5) devoid of the holographic structure (4);
- a reflecting layer (6);

wherein the color shift layer (2) overlaps the holographic layer (3) and the holographic layer (3) overlaps the reflecting layer (6).

2. Anticounterfeit multilayer device (1) according to claim 1, wherein the color shift layer (2) is made by one or more one-dimensional photonic crystals having a periodicity of the refraction index in a direction transversal to a plane defined by the color shift layer (2) itself.

3. Anticounterfeit multilayer device (1) according to claim 1 or 2, further comprising an intermediate transparent layer (9) disposed between the color shift layer (2) and holographic layer (3).

4. Anticounterfeit multilayer device (1) according to the preceding claim, wherein said intermediate transparent layer (9) is chemical agent resistant.

5. Anticounterfeit multilayer device (1) according to anyone of claims from 1 to 4, wherein said refraction index of said reflecting layer (6) is constant.

6. Anticounterfeit multilayer device (1) according to anyone of claims from 1 to 4, wherein said reflecting layer (6) comprises portions (6', 6", 6"') having different refraction index.

7. Anticounterfeit multilayer device (1) according to the preceding claim, wherein the refraction index of the portions (6', 6") of the reflecting layer (6) placed in correspondence of the portions (5) devoid of the holographic structure of the holographic layer (3) is different from the one of the portion (6"') of the reflecting layer placed in correspondence of the holographic structure (4) of the holographic layer (3).

8. Anticounterfeit multilayer device (1) according to claim 6 or 7, wherein the refractive indexes respectively of the portions (6', 6") of the reflecting layer (6), placed in correspondence of the portions (5) devoid of the holographic structure of the holographic layer (3) are different from each other.

9. Anticounterfeit multilayer device (1) according to anyone of claims from 1 to 8, wherein said reflecting layer (6) reflects as a mirror, with a refraction index equal to 100%.

10. Anticounterfeit multilayer device (1) according to anyone of claims from 1 to 8, wherein said reflecting layer (6) is transparent with a refraction index less than 100%.

11. Anticounterfeit multilayer device (1) according to anyone of the preceding claims, further comprising a backing layer (7), wherein the reflecting layer (6) overlaps the backing layer (7).

12. Anticounterfeit multilayer device (1) according to the preceding claim, wherein the backing layer (7) is made of a transparent material or non-transparent material.

13. Anticounterfeit multilayer device (1) according to claim 11 or 12, further comprising an adhesive layer (8) overlapping the backing layer (7) for releasing the backing layer (7) and gluing the device (1) to a substrate by the adhesive layer (8).

14. Anticounterfeit multilayer device (1) according to anyone of claims from 1 to 12, further comprising an adhesive layer (8) configured to hot-stamp and glue the device (1) to a substrate by the adhesive layer (8).

15. Anticounterfeit multilayer device (1) according to anyone of the preceding claims, further comprising one or more transparent protecting layers overlapped the color shift layer (2).

16. Anticounterfeit multilayer device (1) according to the preceding claim, wherein said one or more protecting layers comprise one or more among:

- a backing layer (10);
- a releasing layer (11) which the backing layer overlaps;
- a wear resistant protecting layer (12)

17. Anticounterfeit multilayer device (1) according to anyone of the preceding claims, further comprising a layer (13) having fluorescent graphic elements made by inks and/or pigments visible under light having predetermined wave-length ranges, such as UV-A and/or UV-B and/or UV-C lights, wherein the holographic layer (3) overlaps the layer (13) having fluorescent graphic elements.

18. Anticounterfeit multilayer device (1) according to anyone of the preceding claims, further comprising a layer (14) having phosphorescent graphic elements (14) made by phosphorescent inks and/or pigments, wherein the holographic layer (3) overlaps the layer (14) having the phosphorescent graphic elements.

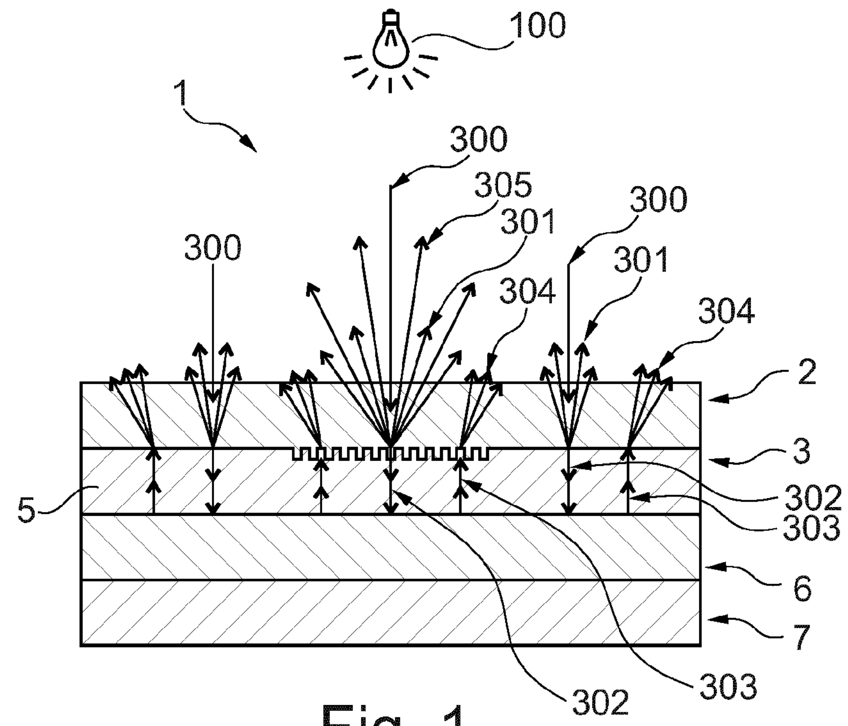

100
1
300
305
301
300
301
300
304
304
2
3
5
302
303
6
7
302
303

Fig. 1

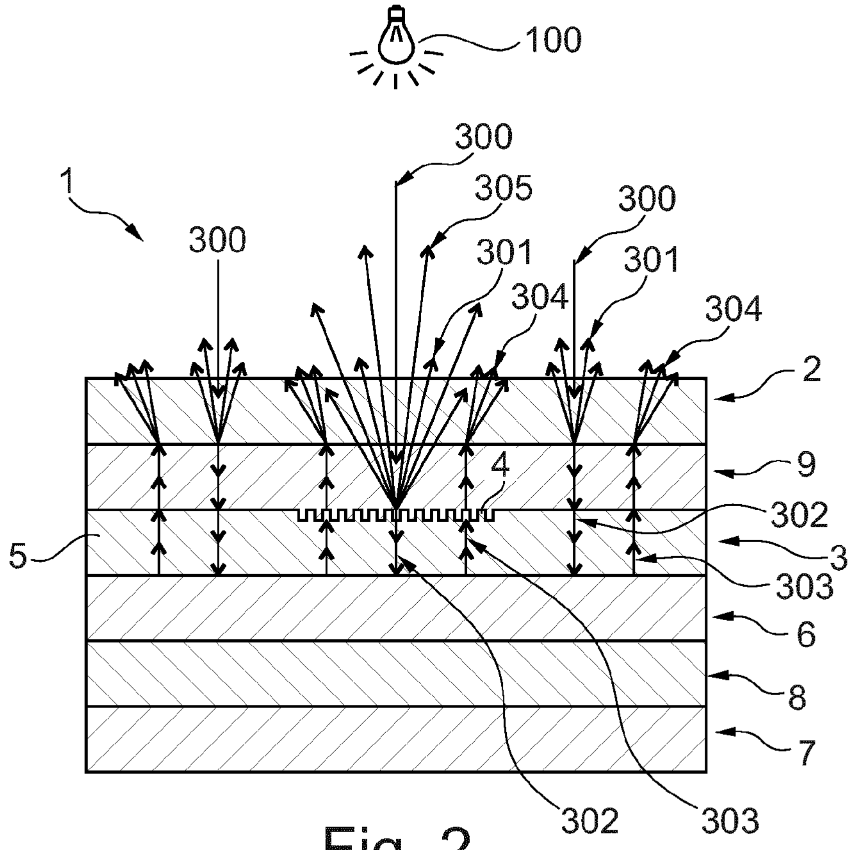

100
1
300
305
300
300
301
301
304
304
2
9
4
302
5
3
303
6
8
7
302
303

Fig. 2

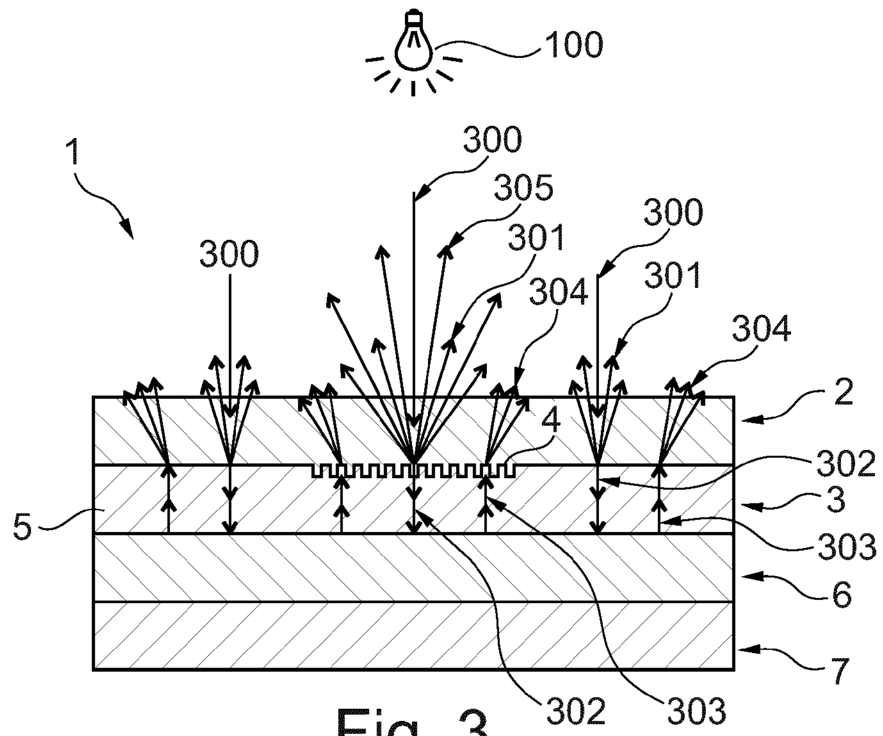

100
1
300
305
301
300
304
301
304
2
4
302
3
303
5
6
7
302
303

Fig. 3

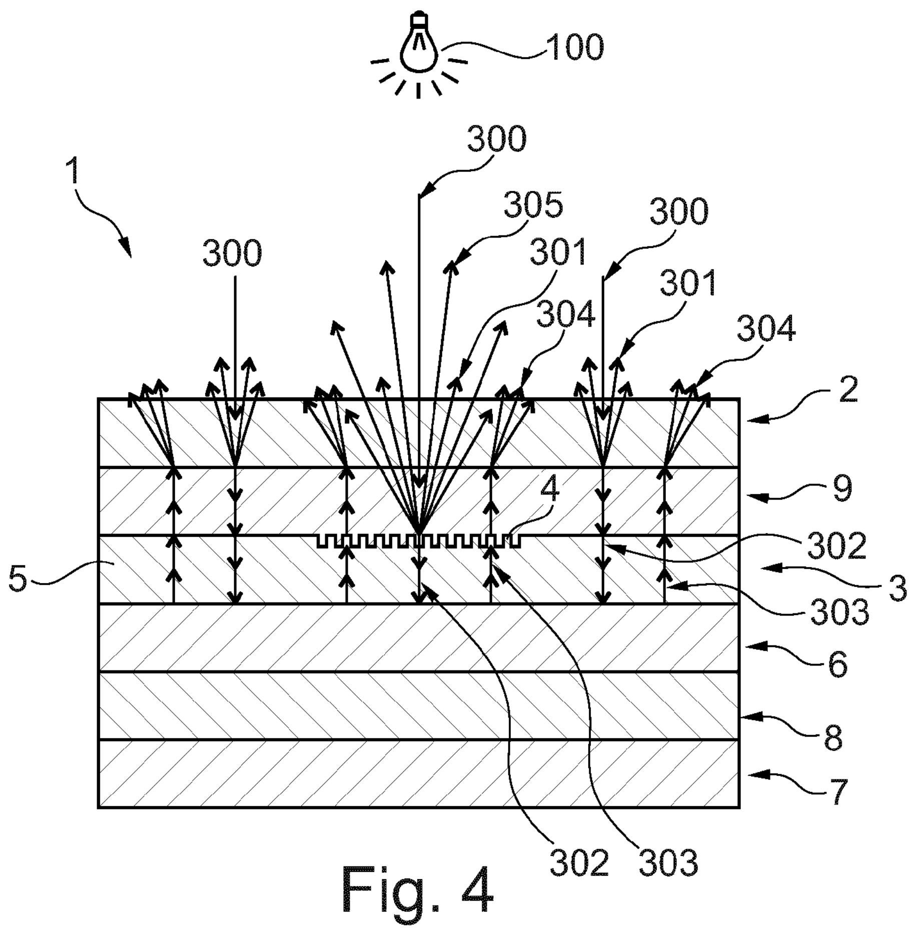

100
1
300
305
301
300
304
301
304
2
9
4
302
3
303
5
6
8
7
302
303

Fig. 4

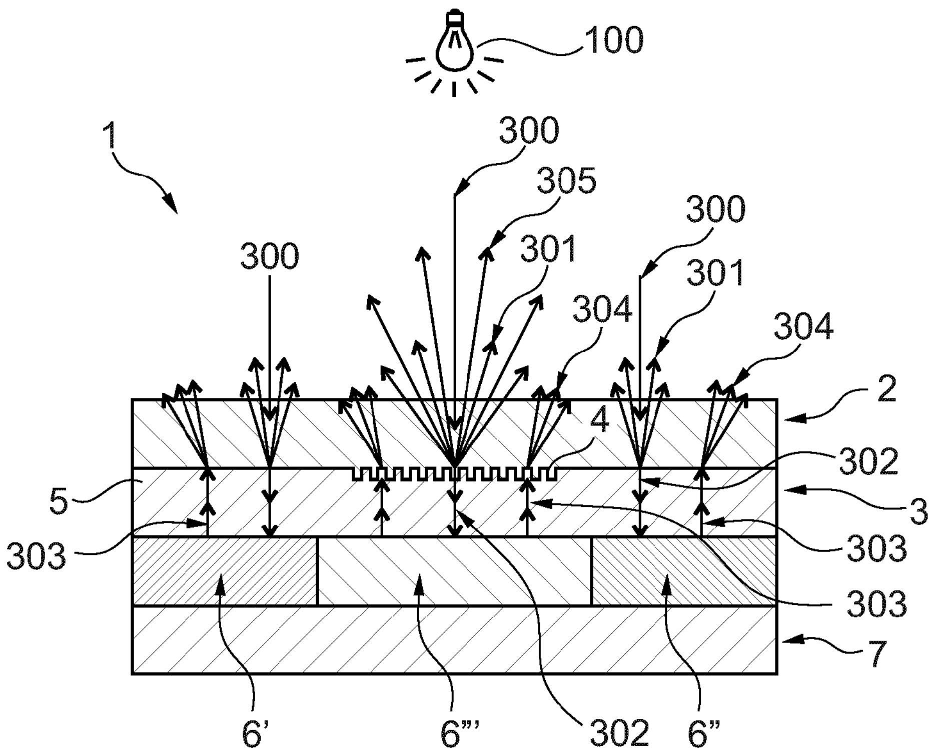

100
1
300
305
300
301
300
301
304
304
2
4
302
5
3
303
303
303
7
6'
6"'
302
6"

Fig. 5

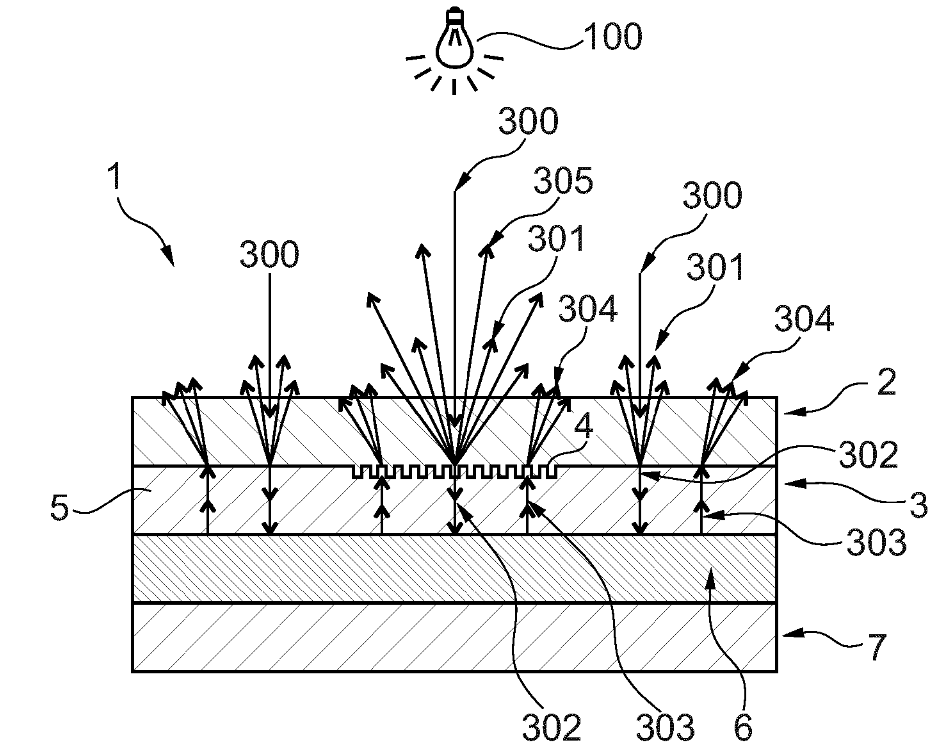
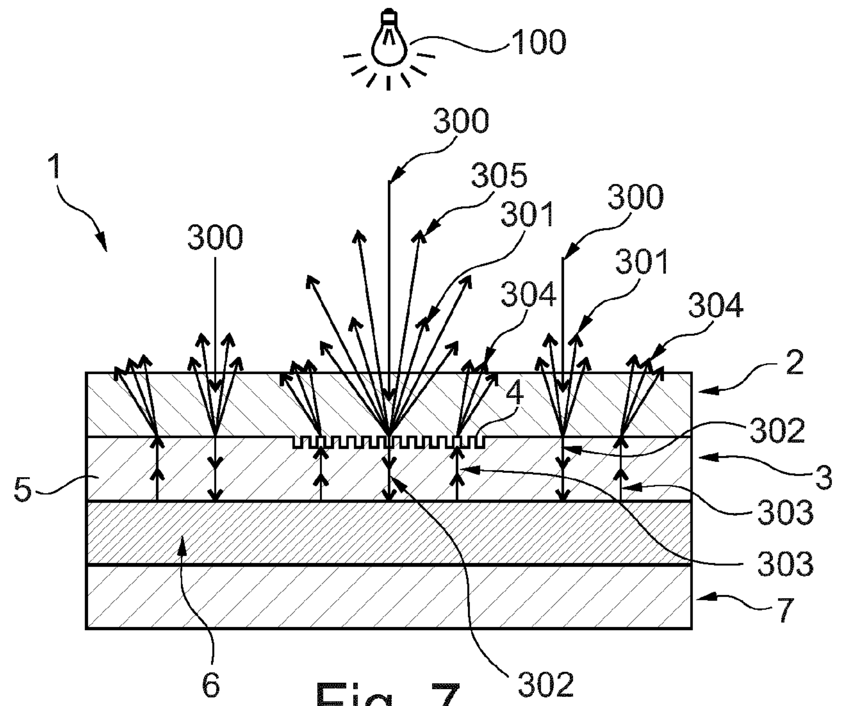
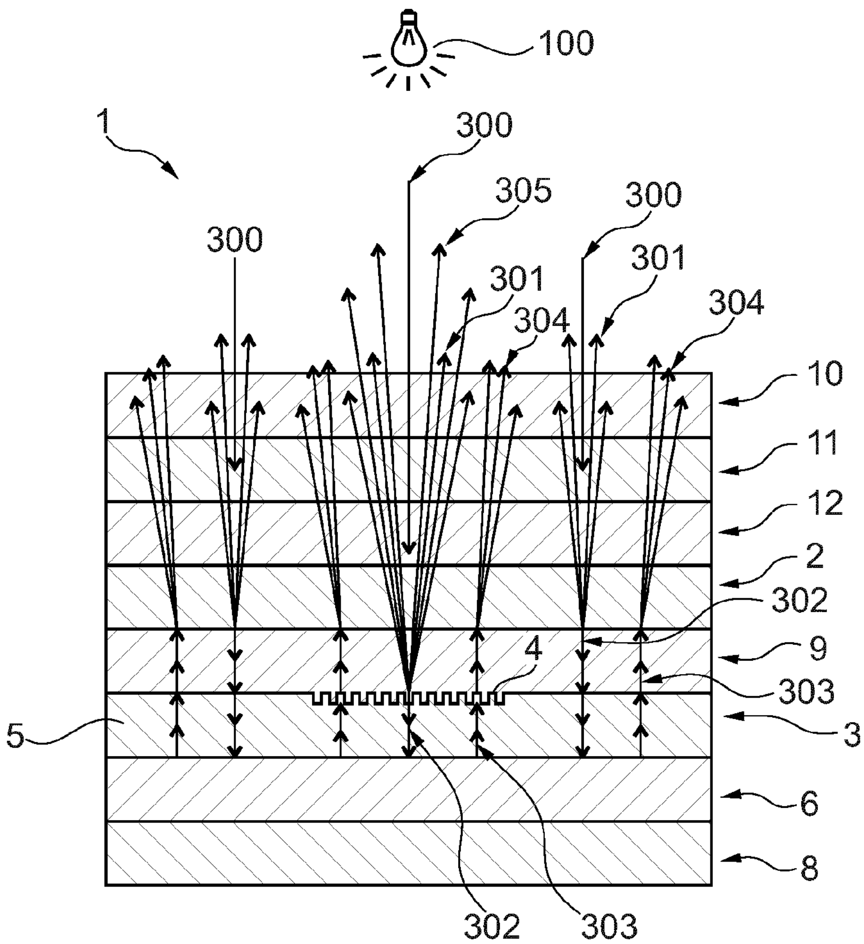

100
300
1
305
300
301
300
301
304
304
2
4
302
5
3
303
7
302
303
6

Fig. 6


100
1
300
305
301
300
301
304
304
2
4
302
3
5
303
303
7
6
302
Fig. 7


100
1
300
305
300
301
301
304
304
10
11
12
2
302
9
4
303
5
3
6
8
302
303
Fig. 8

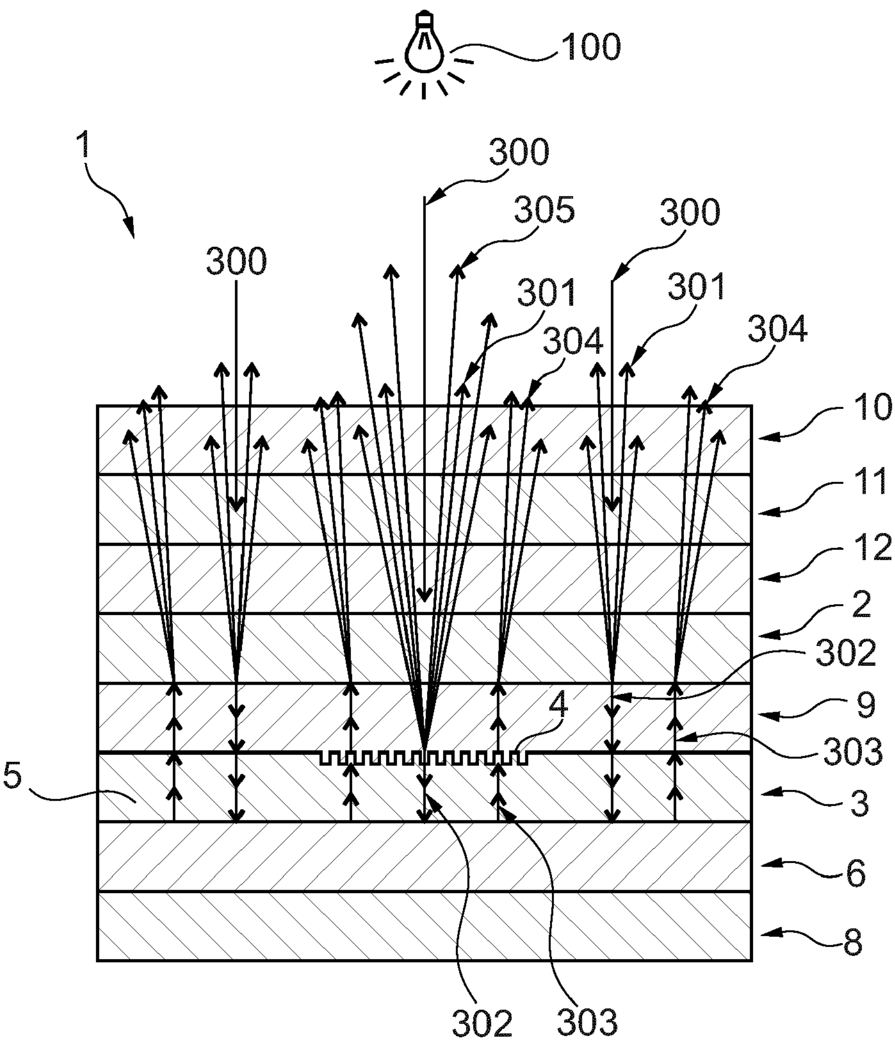

100
1
300
305
300
300
301
301
304
304
10
11
12
2
302
9
4
303
5
3
6
8
302
303

Fig. 9

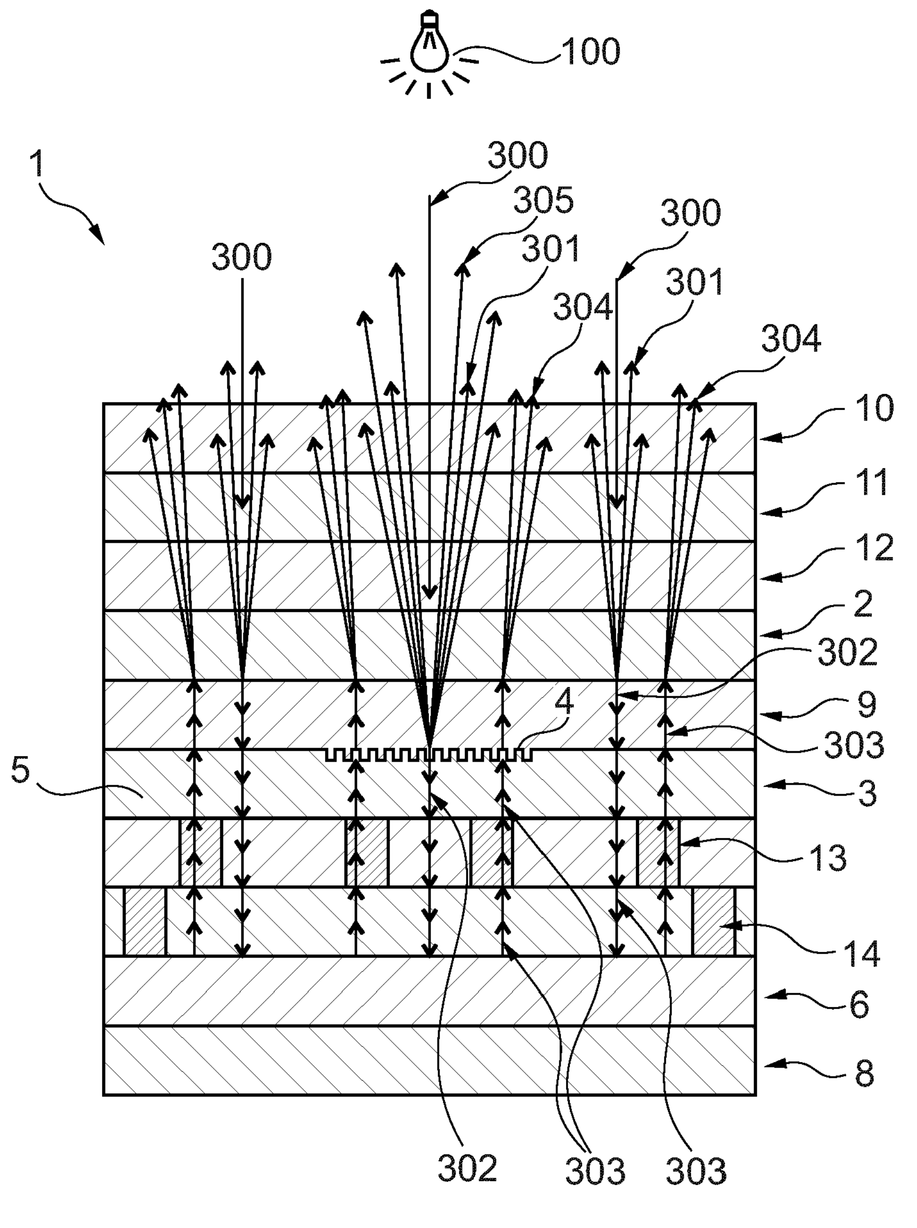

100
1
300
305
301
300
301
304
300
304
10
11
12
2
302
4
9
303
5
3
13
14
6
8
302
303
303

Fig. 10

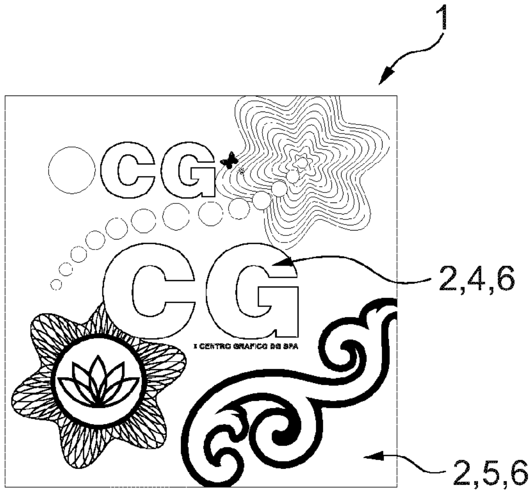


Fig. 11

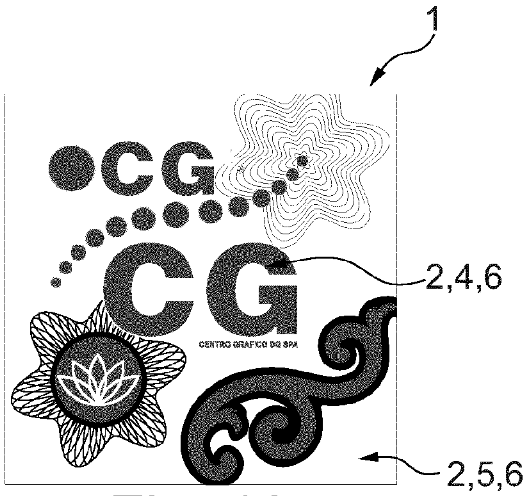


Fig. 12

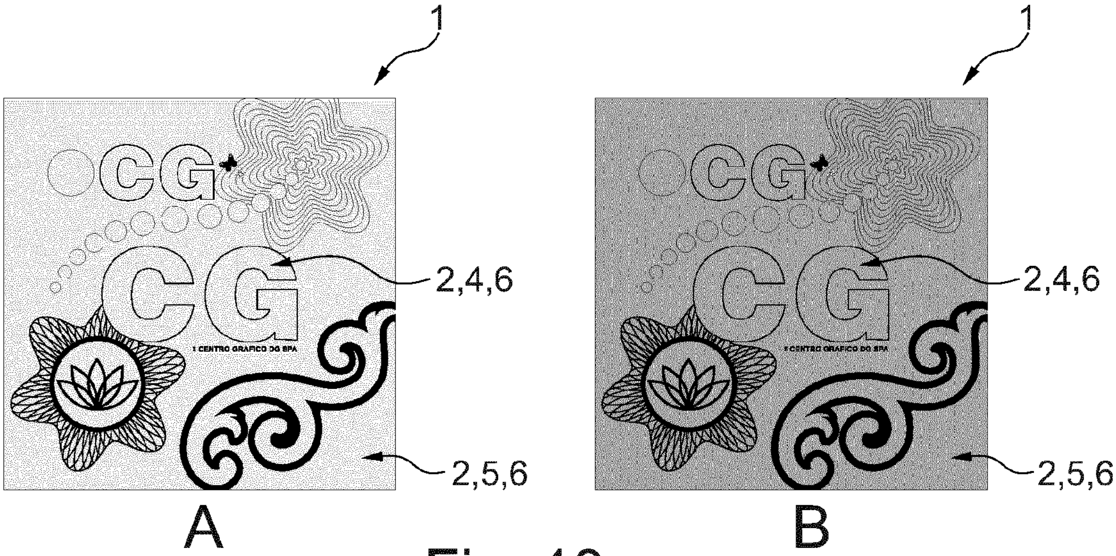


Fig. 13

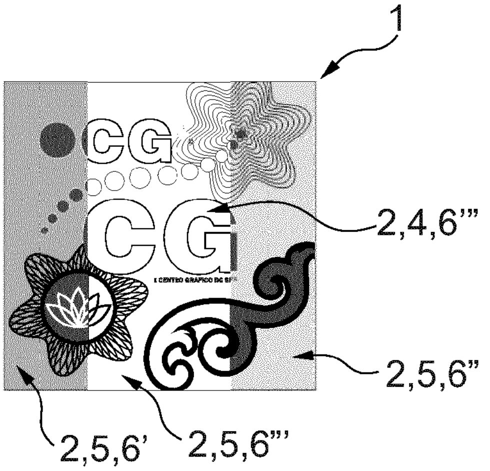


Fig. 14

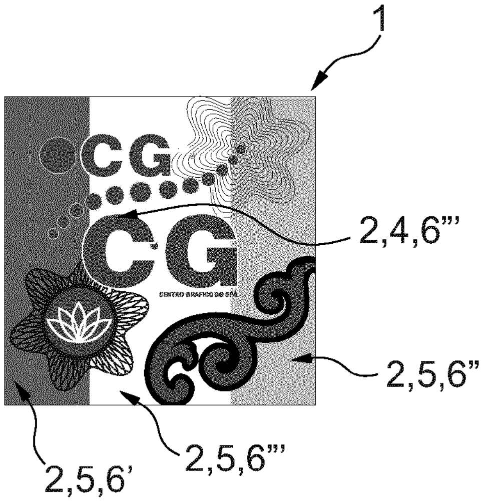


Fig. 15

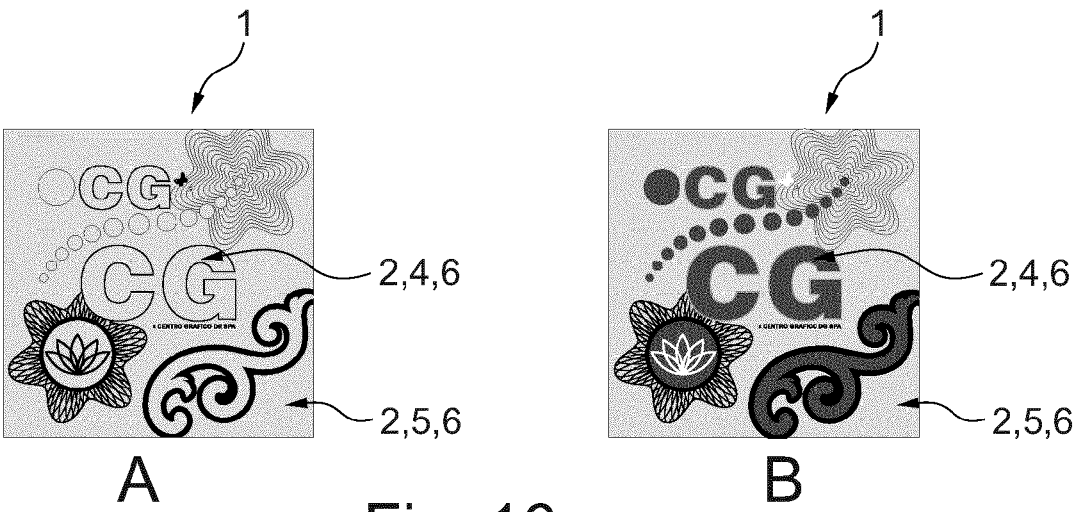


Fig. 16

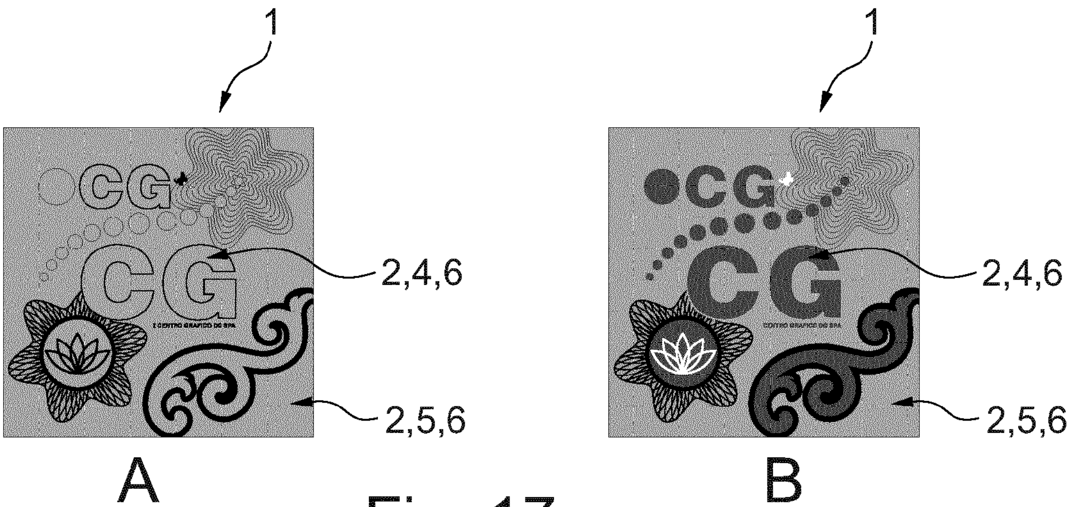


Fig. 17

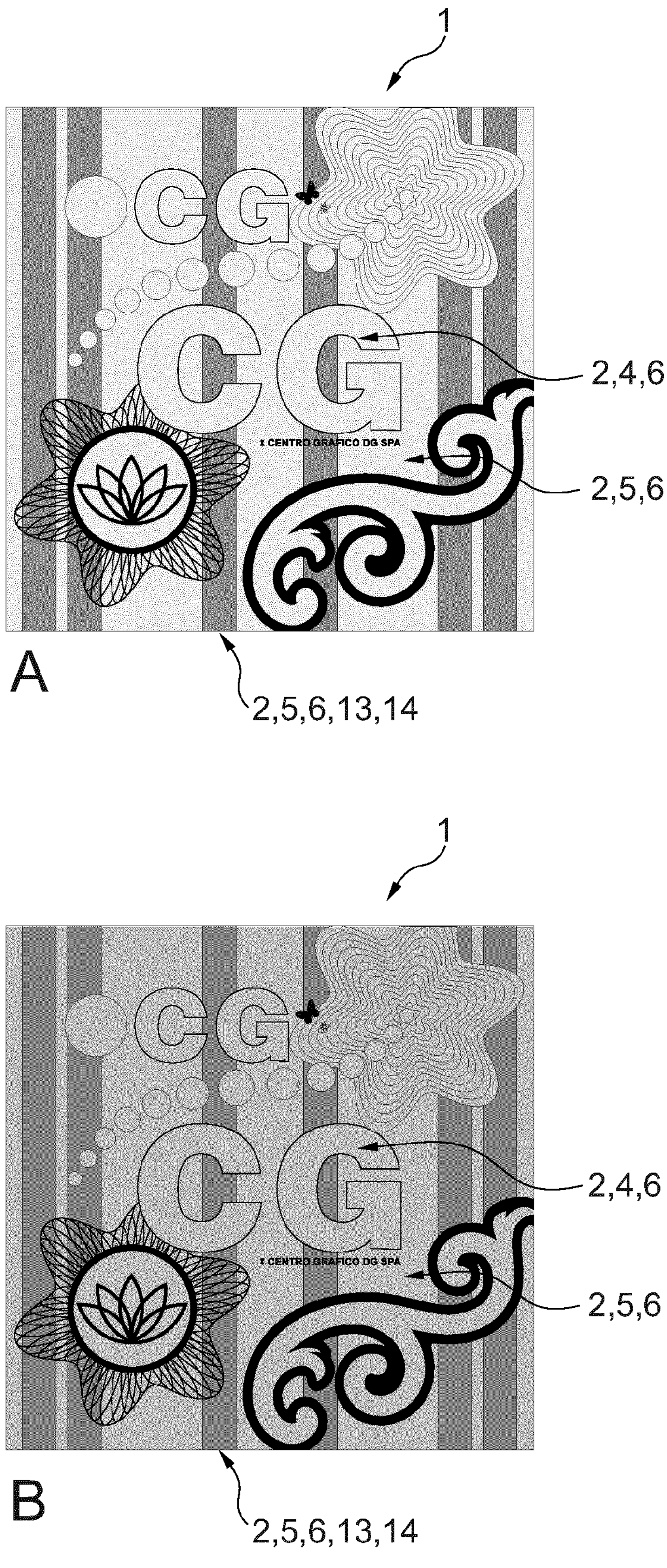

1
CG
CG
I CENTRO GRAFICO DG SPA
2,4,6
2,5,6
2,5,6,13,14
A
1
CG
CG
I CENTRO GRAFICO DG SPA
2,4,6
2,5,6
2,5,6,13,14
B

Fig. 18

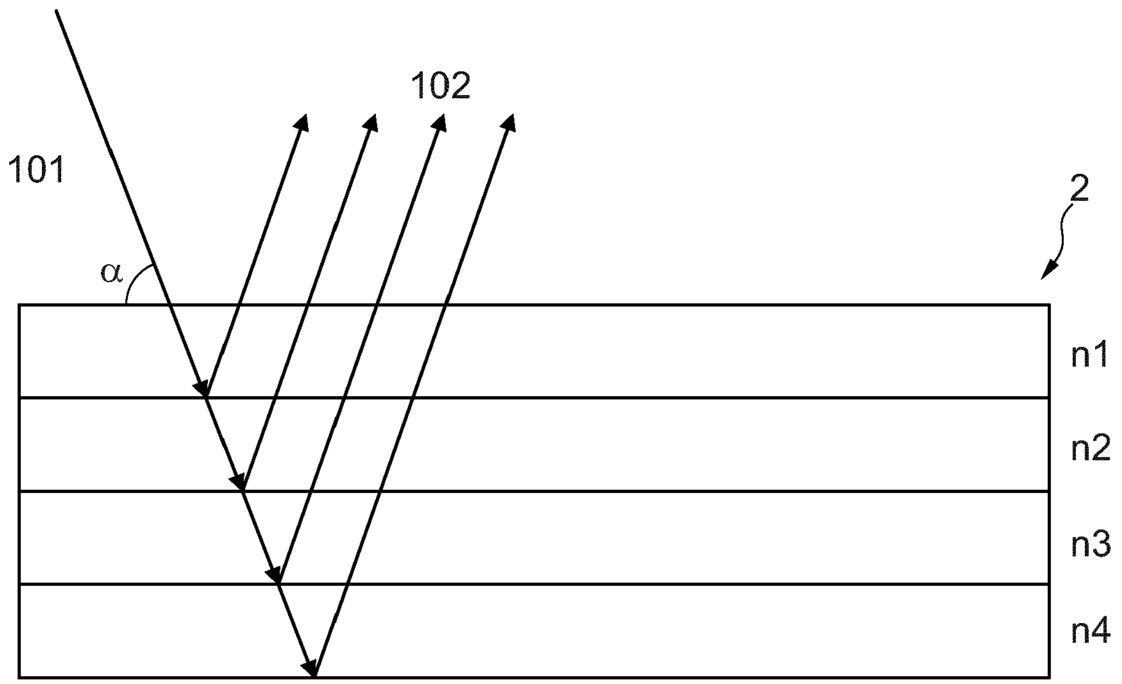


Fig. 19

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 20 3099

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2015/107347 A1 (RUE DE INT LTD [GB]) 23 July 2015 (2015-07-23) * page 37; figure 2b * -----	1,3-5, 9-18	INV. B42D25/328 B42D25/36
A	WO 2014/118569 A1 (RUE DE INT LTD [GB]) 7 August 2014 (2014-08-07) * figure 7 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)
B42D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	5 November 2020	Langbroek, Arjen

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 20 3099

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

05-11-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2015107347 A1	23-07-2015	AU 2015207358 A1	28-07-2016
		CA 2936824 A1	23-07-2015
		CN 106457872 A	22-02-2017
		EP 3096960 A1	30-11-2016
		EP 3372420 A1	12-09-2018
		GB 2523888 A	09-09-2015
		GB 2541823 A	01-03-2017
		JP 6666265 B2	13-03-2020
		JP 2017505926 A	23-02-2017
		RU 2016130968 A	02-03-2018
		US 2016339733 A1	24-11-2016
		WO 2015107347 A1	23-07-2015
WO 2014118569 A1	07-08-2014	AU 2014210899 A1	13-08-2015
		BR 112015017962 A2	11-07-2017
		CA 2899810 A1	07-08-2014
		CN 105228834 A	06-01-2016
		EP 2951030 A1	09-12-2015
		GB 2512453 A	01-10-2014
		JP 2016510431 A	07-04-2016
		RU 2015133720 A	07-03-2017
		US 2015352887 A1	10-12-2015
		WO 2014118569 A1	07-08-2014

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82