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

(11) **EP 4 527 635 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.03.2025 Bulletin 2025/13

(21) Application number: **24020282.0**

(22) Date of filing: **01.09.2024**

(51) International Patent Classification (IPC):
B42D 25/342 *(2014.01)* ***B41M 3/14*** *(2006.01)*
B42D 25/387 *(2014.01)*

(52) Cooperative Patent Classification (CPC):
B42D 25/387; B41M 3/144; B42D 25/342

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **01.09.2023 PL 44598923**

(71) Applicant: **Polska Wytwornia Papierow Wartosciowych S.A.**
00-222 Warszawa (PL)

(72) Inventor: **DYMALA, Piotr**
00-222 Warszawa (PL)

(74) Representative: **Marcinska-Porzuc, Aleksandra**
Kancelaria Patentowa
Ul. J. Slowackiego 5/149
01-592 Warszawa (PL)

(54) **SECURITY ELEMENT AND METHOD OF MANUFACTURING IT**

(57) The invention relates to a security element with a specific layered structure, where at least two printing layers with different properties in VIS and UV light are superimposed to achieve a multi-color gradient transition visible during verification using an ultraviolet (UV) lamp. The invention also relates to a method for making this security element.

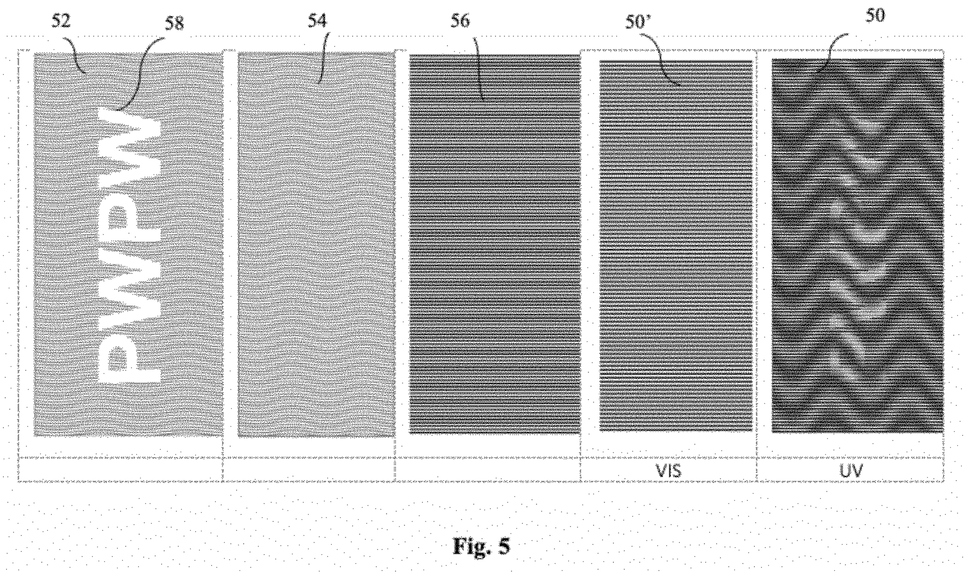

Fig. 5

EP 4 527 635 A1

Description

Technical Field

[0001] The invention relates to a security element with a specific layered structure, wherein at least two printing layers with different properties are superimposed to achieve multi-color visibility during verification using an ultraviolet (UV) lamp. The invention also relates to a method for making the security element.

Background of the Invention

[0002] Valuable goods, particularly valuable documents and/or secured goods, identification tools, and security articles such as banknotes, cheques, vouchers, passports, driving licenses, tickets, identification documents, certificates of authenticity, and licenses, as well as revenue stamps, secure packaging, and other security documents, are often susceptible to copying, counterfeiting, and partial unauthorized modification. Valuable goods, data carriers, and documents of this type are usually equipped with a certain number of visible and invisible security features to verify their authenticity.

[0003] Methods are known for giving security documents optically variable features that cannot be reproduced, for example, in a photocopier or scanner, and what is more important, also features that are invisible to the naked eye, but are identified using UV light during verification.

[0004] Security features applied to data carriers using UV-active inks are one of the most recognizable and popular features of document security. They are applied in the form of microprinting, embossed backgrounds, ornaments, or other graphic elements. Fluorescent inks are used for printing in offset, letterset, flexographic, gravure, screen and letterpress printing, etc.

[0005] UV activity means that when exposed to UV light of a specific wavelength, typically ranging from 200 nm to 400 nm, for example, 254, 313, 365, and 400 nm, the ink emits light of a specific color.

[0006] Fluorescent inks are becoming increasingly available on the commercial market, and therefore are also available to potential counterfeiters, necessitating further development of these types of solutions.

[0007] Another group of security elements with optically variable features are security elements with an angular effect, made by printing lines at a specific angle to each other using, for example, the Moiré effect. The Moiré effect is an optical effect resulting from the interaction of two superimposed structures. In commercial printing, they are considered a printing error - poorly selected raster point structures superimposed on each other, while in secure printing - they are often used to security documents and banknotes.

State of the Art

[0008] A solution is known from the state of the art that involves printing an element composed of an image and a masking layer. The image itself consists of three regions, each printed with an ink of the same color in visible light, but two of them have a different color in the ultraviolet spectrum and one does not have any activity for this light wavelength. The main drawback of this solution is its difficulty in printing; any change in the amount or intensity of any of the inks causes the hidden image to appear. Additionally, it requires the use of four printing units, which significantly limits the color palette of the final product.

[0009] EP1567358 discloses printing an element consisting of two regions printed with two inks. Both have the same color in visible light, but different in the UV spectrum. The downside of this solution is the need for perfect alignment of the regions and their color; otherwise, the division will be very visible.

[0010] EP2562726 discloses a solution consisting of two layers: parallel lines printed by offset and a gravure embossing, also composed of lines with similar characteristics, but rotated by a specified degree relative to the offset lines. This causes the Moiré effect to appear when looking at the print at an angle.

[0011] EP1554700 discloses a solution where given structures are created, and their verification occurs by applying a special semi-transparent filter. The superimposed structures, thanks to the Moiré effect, reveal a hidden image.

[0012] The main inconvenience of these types of solutions currently available on the market is that to make a security element, it is necessary to create rasters of different colors on the substrate, and perform appropriate embossing in the appropriate direction, or divide the security element into many parts with different engraving profiles to obtain sufficient contrast between the areas and thus expose the hidden image. Creating such a security feature requires a great deal of specialized knowledge, as well as machines, but it is also labor-intensive and expensive to implement technologically.

[0013] However, the main drawback of solutions with embossing is the need for embossing itself - the gravure process, which due to its cost is not cost-effective for low-cost products.

[0014] Additionally, there is still a need to improve features wherein identification is performed using special devices containing an ultraviolet (UV) lamp.

Summary of the Invention

[0015] The problem underlying this invention is thus to create a security element with a multi-color optical effect characterized by a gradient color transition thanks to the Moiré effect, which would be visually recognizable using special devices containing an ultraviolet (UV) lamp, while being difficult to produce and counterfeit.

[0016] The object of this solution is to ensure that the security element located on the data carrier constitutes a first and second-order security feature, thereby hindering both the modification of the original data carrier and the creation of a completely fake one.

[0017] Therefore, the aim of this invention is to create a security element with a multi-color optical effect characterized by a gradient color transition thanks to the Moiré effect, which would be visually recognizable using special devices containing an ultraviolet (UV) lamp, which would enhance the security of data carriers against scanning, photocopying, and counterfeiting.

[0018] The object of this invention is also to develop a security element that glows in UV light and is invisible in VIS light with an optical effect based on combining the features of an angular effect using at least two inks creating sequences of lines parallel to each other, visible in UV light or in VIS light, which could be used to protect documents and banknotes against counterfeiting, being inexpensive to produce, and at the same time very difficult to copy.

[0019] These aims are achieved by the security element, data carrier, and method for making a security element according to the invention - since the security element is sensitive to changes in the shapes and parameters of the lines, its counterfeiting would be very difficult.

[0020] Therefore, the subject matter of the invention is a security element consisting of at least two layers printed on top of each other, wherein at least one layer is a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, and at least the second layer is a sequence of lines parallel to each other in the second color with second properties in VIS and UV light, wherein the overlay of the second layer on at least one first layer creates a gradient color transition visible in UV light.

[0021] The layer consisting of a sequence of lines parallel to each other may be a sequence of sinusoidal lines parallel to each other, or a sequence of straight lines parallel to each other. The layers consisting of a sequence of lines parallel to each other may have any length and width, as well as take any shape - for example, an image, geometric figure, text and/or alphanumeric characters, special characters, they can also be inscribed within any area of an image, sign, etc.

[0022] It is possible for a first layer consisting of a sequence of sinusoidal lines parallel to each other in a first color with first properties in VIS and UV light to be overlaid with at least one further layer consisting of a sequence of sinusoidal lines parallel to each other in another color with first properties in VIS and UV light.

[0023] Preferably, the lines in the layer of a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, and the lines in each subsequent layer of a sequence of sinusoidal lines parallel to each other, each in a different color with first properties in VIS and UV light, have the same line shape and the same parameters. Advantageously, they have the same amplitude A, frequency T, phase shift C, deflection angle a of the tangent to the peaks in the sinusoidal line, and the thickness of a single line g.

[0024] First properties in VIS and UV light mean that the layer is invisible in VIS light and is visible in UV light.

[0025] Second properties in VIS and UV light mean that the layer is visible in VIS light and is invisible in UV light.

[0026] However, according to the invention, it is also possible for the security element to consist only of layers of a sequence of lines parallel to each other with first properties in VIS and UV light. This occurs when the first layer of a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light is applied to the substrate, followed by the second layer of a sequence of straight lines parallel to each other, in the second color with first properties in VIS and UV light. Thus, the second properties in VIS and UV light can be the same as the first properties in VIS and UV light.

[0027] The layer with first properties in VIS and UV light may be a fluorescent layer. Preferably each layer with first properties in VIS and UV light has a different color. It is also advantageous for at least two layers with first properties in VIS and UV light combine additively by selecting two colors out of three: red, green, blue.

[0028] In yet another variant, the security element may consist of three layers with first properties in VIS and UV light arranged alternately in different colors, preferably red, green, blue, and a fourth interference layer applied on top. It is therefore possible for the three printed layers to form sequences of lines parallel to each other in three different colors, which repeat on the substrate in the same order. Preferably the lines of the three layers with first properties in VIS and UV light are arranged alternately, meaning - a line in the first color, a line in the second color, a line in the third color, a line in the first color, a line in the second color, a line in the third color, etc. Preferably these layers are printed on the substrate of the data carrier so that the lines of the first layer do not overlap the lines of the second and third layers. In turn, the second layer is printed so that the lines of the second layer do not overlap the lines of the first layer and the lines of the third layer. The third layer is printed so that the lines of the third layer do not overlap the lines of the first layer and the lines of the second layer. Also, preferably the layers printed alternately are layers of a sequence of sinusoidal lines parallel to each other.

[0029] It is also possible for the sequence of lines parallel to each other and/or the sequence of sinusoidal lines parallel to each other, to be lines constituting one of: dashed lines, micro-image lines, micro-text lines, lines of graphic elements.

[0030] The sinusoidal lines in the sequence of sinusoidal lines parallel to each other, are calculated by connecting the calculated points (x,y) on the sinusoidal line from the formula:

$$y = A * \sin (T * x + C),$$

where:

A - denotes the amplitude

T - denotes the frequency

C - denotes the phase shift

x,*y* - denotes points on the sinusoidal line.

[0031] The frequency *T* is calculated using the formula:

$$T = \mathrm{ctg}\,(a) \text{ x } A,$$

where:

a - denotes the deflection angle of the tangent to the sinusoid
A - denotes the amplitude.

[0032] The amplitude *A* is the thickness of a single sinusoidal line *g*, or a multiple thereof. In the case of the amplitude of a sequence of straight lines parallel to each other, it is the same as the amplitude *A* of a sequence of sinusoidal lines parallel to each other, but modified by a factor *d* of optical magnification of the sinusoids. Advantageously, the factor (*d*) of optical magnification of the sinusoids is from 80% to 120%, preferably from 92% to 108%.

[0033] Different optical effects are obtained by changing the parameter of the line in the sequence of lines parallel to each other of at least one of: amplitude *A*, frequency *T*, phase shift *C*, deflection angle *a* of the tangent to the sinusoid, factor *d* of optical magnification of the sinusoids, thickness of a single line *g*. Wherein, by changing the parameter of the phase shift *C*, the deviation/deflection of the sequence of sinusoidal lines parallel to each other, varies.

[0034] According to the invention, preferably at least one layer with first properties in VIS and UV light has an extraction constituting hidden information (hidden image) invisible in VIS light and visible in UV light. It is also possible for at least one layer with second properties in VIS and UV light to have an extraction constituting hidden information visible in VIS and UV light.

[0035] Preferably the layer with second properties in VIS and UV light has a dark color, for example, black, dark grey, dark blue, dark green, dark brown, graphite, and other colors in its dark shade.

[0036] According to the invention, preferably the layers constituting a sequence of sinusoidal lines parallel to each other, and/or the layers constituting a sequence of lines parallel to each other, are printed by offset printing.

[0037] The security element may be one multi-color sequence or several multi-color sequences parallel to each other selected from: sinusoids, circles, squares, ellipses, rectangles, alphanumeric and/or graphic characters.

[0038] The subject matter of the invention is also a method for making a security element on a data carrier, comprising the following steps:

a) printing on the substrate of the data carrier at least one layer constituting a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light,

d) printing the second layer constituting a sequence of lines parallel to each other in the second color with second properties in VIS and UV light,

so that printing the second layer in the second color with second properties in VIS and UV light on at least one layer in the first color with first properties in VIS and UV light creates a gradient color transition visible in UV light.

[0039] This method may also include the following steps:

b) printing on the layer constituting a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, at least one additional layer constituting a sequence of sinusoidal lines parallel to each other, in another color with first properties in VIS and UV light.

c) drawing (carrying out/ extracting)by means of a laser beam in at least one layer constituting a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, the first extraction and/or in the same place in the additional layer constituting a sequence of sinusoidal lines parallel to each other, in another color with first properties in VIS and UV light, the same extraction constituting hidden information invisible in VIS light and visible in UV light.

e) drawing (carrying out/ extracting) by means of a laser beam in the second layer constituting a sequence of lines parallel to each other in the second color with second properties in VIS and UV light, the extraction constituting hidden information visible in VIS and UV light.

[0040] Preferably, the two layers constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light combine additively by selecting two colors from three: red, green, blue.

[0041] In the method according to the invention, one layer is printed on the substrate of the data carrier, constituting a sequence of sinusoidal lines parallel to each other, in red with first properties in VIS and UV light, the second layer constituting a sequence of sinusoidal lines parallel to each other, in green with first properties in VIS and UV light, and the third layer constituting a sequence of sinusoidal lines parallel to each other, in blue with first properties in VIS and UV light, so that the lines of each of these layers do not overlap, but form a sequence of sinusoidal lines parallel to each other, with alternating lines: red line, green line, blue line, red line, green line, blue line, etc.

[0042] The layer constituting a sequence of lines parallel to each other is a sequence of sinusoidal lines parallel to each other, or a sequence of straight lines parallel to each other.

[0043] First properties in VIS and UV light mean that the layer is invisible in VIS light and is visible in UV light.

[0044] Second properties in VIS and UV light mean that the layer is visible in VIS light and is invisible in UV light.

[0045] The lines in the sequence of sinusoidal lines parallel to each other, are generated by connecting the calculated points (x,y) from the formula:

$$y = A * \sin(T * x + C),$$

where:

A - denotes the amplitude

T - denotes the frequency (1/f)

C - denotes the phase shift

x,*y* - denotes points on the sinusoidal line.

The frequency *T* is calculated from the formula:

$$T = \mathrm{ctg}\,(a) \text{ x } A,$$

where:

a - denotes the deflection angle of the tangent to the peaks of the sinusoidal lines
A - denotes the amplitude.

[0046] The amplitude *A* is the thickness of a single sinusoidal line g, or a multiple thereof.

[0047] Advantageously, the amplitude *A* of a sequence of straight lines parallel to each other, is the same as the amplitude *A* of a sequence of sinusoidal lines parallel to each other, but modified by a factor *d* of optical magnification of the sinusoids. Advantageously, the factor *d* of optical magnification of the sinusoids is from 80% to 120%, preferably from 92% to 108%. Also, preferably by changing the parameter of the phase shift C, the deviation/deflection of the sequence of sinusoidal lines parallel to each other, varies.

[0048] In the method according to the invention, the layers are made by offset printing or letterset printing, flexographic printing, gravure printing, screen printing, letterpress printing.

[0049] The data carrier according to the invention contains a security element made by the method described above. The data carrier is made using one of: paper, polymer, a combination of materials, and/or glued paper, paper-like, and/or polymer materials.

Definitions

[0050] The expression "data carrier" according to the invention, includes in its meaning all documents, such as banknotes, personal documents, driving licenses, cheques, security papers, tickets, passports, as well as other valuable and security documents, being carriers of secure information recording.

[0051] The substrate (data carrier) may be, for example, a paper, paper-like, and/or paper-like material substrate such as teslin, fabric, nonwoven fabric, multi-layer composite substrate, polymer, including polypropylene (PP) and/or polyamide (PA), as well as a hybrid background based on a combination of paper and polymer. The substrate may be transparent or colored.

[0052] The terms "first", "second", "third", "fourth" used in the description and in the patent claims are used to distinguish similar elements, but not to describe the sequential or chronological order. It should be understood that the terms used in this way are interchangeable in the appropriate circumstances, and that the embodiments of the invention described herein are capable of operating in sequences other than those described or illustrated herein. According to the invention, it is possible for the security element to contain only the first layer and the second layer. It is also possible for the security element to contain the first layer and the second layer, as well as the third layer placed between the first layer and the second layer. It is also possible for the security element to contain more than three or four layers.

[0053] Also, references to colors - first, second, third, other color are intended to distinguish the colors of the elements. At the same time, all described embodiments relating to one color combination are suitable for any color combination. If the description indicates a solution for one color combination, it also means that it is suitable for any color combination. If the description does not refer to colors, it means that the given solution applies to any color combination. For example, this applies to the colors of the layers - each layer is in a different color, wherein the first layer may be in the first color, as well as in the second color and in a color different from the first color and the second color. Each other layer may be in the first color, as well as in the second color and in a color different from the first color and the second color, as long as it has not been chosen for another layer. Dark color means black, dark grey, dark blue, dark green, dark brown, i.e. all shades of colors in their dark shade.

[0054] The layers according to the invention, observed in the range of VIS visible light, have the same color perceived by an observer without additional devices in normal daylight conditions, but differ in color in the range of UV light.

[0055] Layer with second properties in VIS and UV light (otherwise interchangeably: visible layer, visible in VIS visible light, visible in VIS light), means a layer which, when observed in the range of VIS visible light, has the same color perceived by an observer without additional devices in normal daylight conditions. It does not differ in color in the range of UV light. It does not glow in the range of UV light.

[0056] Layer with first properties in VIS and UV light (otherwise interchangeably: UV-visible layer, UV-visible layer, UV-glowing layer, transparent UV-glowing layer), means a layer which, when observed in the range of VIS visible light, is invisible to an observer without additional devices in normal daylight conditions. It is visually recognizable using special devices containing an ultraviolet (UV) lamp. It is a layer printed with a transparent ink that glows in any color in the range of UV light. For example, it is a fluorescent layer.

[0057] Layer constituting a sequence of sinusoidal lines parallel to each other means that the given layer consists of a sequence of printed sinusoidal lines parallel to each other. For the purposes of this application, the term "sinusoidal line" is used instead of "sinusoid" in this case. The distance between sinusoidal lines in a sequence is determined from the axis of symmetry of the first sinusoidal line to the axis of symmetry of the next sinusoidal line. Preferably, the distance between the axes of symmetry of all sinusoidal lines in the sequence of sinusoidal lines parallel to each other, is the same. However, it is also possible that the distance between the axes of symmetry of all sinusoidal lines may be different throughout the sequence or the same in part and different in part.

[0058] Each layer of a sequence of sinusoidal lines parallel to each other, has the same line parameters in the sequence: thickness g of the line, amplitude A, frequency T, phase shift C, deflection angle a of the tangent to the peak of the sinusoidal lines.

[0059] Layer constituting a sequence of straight lines parallel to each other, means that the given layer consists of printed straight lines, wherein the distance between the straight lines is determined from the axis of symmetry of the first straight line to the axis of symmetry of the next straight line following the first line, etc. Preferably, the distance between the axes of symmetry of all straight lines in the sequence of straight lines parallel to each other, is the same. Preferably, the thickness g of the straight lines forming a sequence of straight lines parallel to each other, as well as the factor d of optical magnification of the sinusoid, is the same.

[0060] Layer of lines parallel to each other means either a layer constituting a sequence of sinusoidal lines parallel to each other, or a layer constituting a sequence of straight lines parallel to each other.

[0061] *A* sequence of parallel, bi- or multi-colored sinusoids creates one variant of a security element. It originates from the superimposing of at least two layers - one layer with first properties in VIS and UV light and the second layer with second properties in VIS and UV light. They create a multi-color optical effect in the form of a sequence of parallel, bi- or multi-colored sinusoids with a gradient color transition thanks to the Moiré effect visible in UV light. When the term "sinusoid" is used in the description and claims, it means a sinusoid in a security element. For the purposes of this invention, a single wave of the sinusoid is referred to as a "stripe".

[0062] Peaks indicate the number of periods on a single sinusoidal line. Peaks on a given segment on a sinusoidal line can be "condensed", then the sinusoidal line on that segment has many peaks, i.e. it has many periods. The sinusoidal line can also be stretched upwards and downwards, then the peaks are longer - pointed.

[0063] For better understanding, the embodiments described in the examples below they are reduced to essential basic information, and the illustrations presented in the figures are very schematic and do not reflect real conditions. Above all, the proportions shown in the drawings do not correspond to real conditions and are for illustrative purposes only. It should be emphasized that the drawings also do not reflect the actual colors of the secure element placed on the data carrier. The colors in the drawings are only used to distinguish the individual elements shown in these drawings. In practical implementation, much more complex patterns and images can be used in bi- or multi-color. The information provided in the examples below may be replaced by complex and intricate graphic and textual information.

[0064] The examples present preferred embodiments, but the invention should not be limited to them in any way. In particular, different embodiments are not limited to being used in the described form. To improve the effects, their mutual combination is possible.

Brief description of the drawings

[0065] This invention will be better understood and appreciated from the following detailed description in conjunction with the drawing, in which:

Fig. 1	presents a data carrier with a security element applied;
Fig. 2	presents a security element, magnified, according to the first embodiment, with the appearance of the security element shown visible in VIS and UV light;
Fig. 3	presents a security element, magnified, according to the second embodiment, with the appearance of the security element shown visible in VIS and UV light;
Fig. 4	presents a security element, magnified, according to the third embodiment, with the appearance of the security element shown visible in VIS and UV light;
Fig. 5	presents a security element, magnified, according to the fourth embodiment, with the appearance of the security element shown visible in VIS and UV light;
Fig. 6	presents a security element, magnified, according to the fifth embodiment, with the appearance of the security element shown visible in VIS and UV light;
Fig. 7	presents a security element, magnified, according to the sixth embodiment, with the appearance of the security element shown visible in VIS and UV light;
Fig. 8	presents a security element, magnified, according to the first embodiment, visible in UV light;
Fig. 9	presents a security element, magnified, according to the second embodiment, visible in UV light;
Fig. 10	presents schematically the relationship between the amplitude *A* and frequency *T* in the sinusoidal line and the thickness of a single sinusoidal line g;
Fig. 11	presents schematically a sequence of two sinusoidal lines parallel to each other, with a distance between them of twice the amplitude 2 *A;
Fig. 12	presents schematically the deflection angle *a* of the tangent to the peak in the sinusoidal line;
Fig. 13	presents schematically a sequence of three straight lines parallel to each other, with a distance be-

tween them of twice the amplitude *2*A* modified by a factor *d* of optical magnification of the sinusoid and the thickness of a single straight line *g*;

Fig. 14 presents a table showing the appearance of the security element according to the first embodiment visible in UV light, with different parameters - deflection angle *a* of the tangent to the peak of the sinusoidal line and the factor *d* of optical magnification of the sinusoid;

Fig.15a-15c present the appearance of the security element according to the second embodiment visible in UV light, while varying the phase shift parameter C;

Fig. 16a-16b present the appearance of the security element according to the seventh embodiment visible in UV light, when the straight line is micro-text;

Fig. 17 presents the appearance of the security element according to the eighth embodiment visible in UV light, wherein three fluorescent layers were used, constituting a sequence of sinusoidal lines parallel to each other, arranged alternately in red, green, and blue with a phase shift;

Fig. 18 presents a security element, magnified, according to the ninth embodiment.

[0066] In the drawings, a graphic simplification was used to illustrate the differentiation of the individual layers contained in the security element, wherein in reality all layers glowing in the range of UV light are invisible in VIS light and are indistinguishable because they are transparent. The inks occurring in the layers glowing in UV light may have any color in UV light. Advantageously, these are layers printed with fluorescent ink. Transparent inks are invisible in visible light VIS, but are characterized by an effect in UV light. The colored inks used are visible in visible light (VIS), but are invisible in UV light.

[0067] The layers shown in the drawings in the security element have been schematically hatched or shaded in different ways to show that they have different characteristics in terms of visual effects in UV light, i.e. in UV light, the individual layers ensure the occurrence of different optical effects - different colors, which for an observer using authenticity verification of the data carrier in UV light is observed as a multi-colored (multi-color) image - at least two-color, depending on which layers are contained in a given security element, which constitutes different variants of the invention.

[0068] Herein, examples of the implementation of the security element, data carrier, and method of making a security element consisting of at least two printed layers with different parameters described in this invention are presented below, which allows different effects to be obtained when securing a data carrier. However, it should be strongly emphasized that the examples described below are not intended to limit the scope of protection, but only to illustrate one of many possible applications of this invention. This invention finds application wherever a security element with a multi-color gradient color transition visible in UV light is required.

Detailed description of the invention

[0069] Fig. 1 shows a data carrier, 1, according to the invention, which has various security features. Security elements are elements that enhance security against counterfeiting of the data carrier. For example, the data carrier, 1, may have personalization applied to/in the form of a photograph of the document owner and/or in the form of personalized data, which is preferably made by printing or laser engraving in the layer of the data carrier, 1, active laser-wise or sensitive to the action of a laser. The data carrier, 1, may also contain electronic components such as an RFID transponder, chip modules, antennas for dual-interface modules, or a hologram element. However, these security features are not shown in the drawing because they are not the essence of this invention. The data carrier, 1, contains a security element, 10, 20, 20’, 30, 30’, 40, 50, 50’, 60, 60’, 70, 70’, 80, 90, 100, 110, 120, 130, 140, 150, 160, consisting of superimposed layers, which together create an angular and optically variable effect that has a different appearance depending on whether it is viewed in VIS visible light or in the range of UV light. For example, the security element, 10, 20, 20’, 30, 30’, 40, 50, 50’, 60, 60’, 70, 70’, 80, 90, 100, 110, 120, 130, 140, 150, 160, visible in UV light, may be, for example, two- and multi-colored sinusoids, circles, squares, rectangles, ellipses, alphanumeric characters and/or graphic signs repetitious in the same sequence.

[0070] A security element, 10, 20, 20’, 30, 30’, 40, 50, 50’, 60, 60’, 70, 70’, 80, 90, 100, 110, 120, 130, 140, 150, 160, is applied to the data carrier, 1, containing the substrate, 12, using printing techniques. On the surface of the substrate 12 opaque in visible light, for example, in the form of paper, there is at least one security element, 10, 20, 20’, 30, 30’, 40, 50, 50’, 60, 60’, 70, 70’, 80, 90, 100, 110, 120, 130, 140, 150, 160, of any shape, transparent in visible light and visible in UV light. The security element, 10, 20, 20’, 30, 30’, 40, 50, 50’, 60, 60’, 70, 70’, 80, 90, 100, 110, 120, 130, 140, 150, 160, has a different appearance in VIS visible light and in UV light.

[0071] The security element, 10, 20, 20’, 30, 30’, 40, 50, 50’, 60, 60’, 70, 70’, 80, 90, 100, 110, 120, 130, 140, 150, 160, consists of at least two layers printed on top of each other, where at least one first layer with first properties in VIS and UV light is a sequence of sinusoidal lines parallel to each other, in the first color, while the second layer with second properties in VIS and UV light is a sequence of lines parallel to each other in the second color, wherein the superimposing of the second layer on at least one first layer creates a gradient color transition visible in UV light.

[0072] The security element, 20, shown in Fig. 2 consists of two layers printed on top of each other. The first layer, 22, with first properties in VIS and UV light is a sequence of sinusoidal lines parallel to each other, in the first color, while the second layer, 26, with second properties in VIS and UV light is a sequence of straight lines parallel to each other, in the second color. The first layer, 22, in the form of a sequence of sinusoidal lines parallel to each other, is printed with a transparent ink that glows in UV light - for example, in red. The second layer, 26, constituting a sequence of straight lines parallel to each other, is printed with an ink visible in visible light, but an ink that does not glow in UV light - for example, it may be black ink. By applying the second layer, 26, on the first layer, 22, a security element is created which has a different appearance, 20, in UV light and a different appearance, 20', in visible light VIS. The security element, 20', viewed in VIS visible light, shows only the second layer, 26, constituting a sequence of straight lines parallel to each other, in black. The security element, 20, viewed in UV light shows a gradient color transition. With a white substrate, 12, and the first layer, 22, constituting a sequence of sinusoidal lines parallel to each other, in red and the second layer, 26, constituting a sequence of straight lines parallel to each other, in black, the security element, 20, takes the form of elongated, pointed peaks in a grey-red color. In this case, for the security element, 20, the optical effect visible in UV light will be determined by the parameters of the first layer, 22, and the second layer, 26, applied on top of it, i.e. it will be a resultant combination of the effects provided by the first layer, 22, glowing in UV light, and the second layer, 26, invisible in UV light.

[0073] Fig. 3 shows a security element, 30, 30', according to the second embodiment. In this case, one more layer was applied to the data carrier, 1, which constitutes a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light. The first layer, 32, is a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light, in the first color - for example, red, the second layer, 34, is a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light, in the second color - for example, green, while the third layer, 36, is a sequence of straight lines parallel to each other, with second properties in VIS and UV light, in the third color - for example, black. The first layer, 32, is printed with a transparent ink that glows in UV light, the second layer, 34, is also printed with a transparent ink that glows in UV light, while the third layer, 36, constituting a sequence of straight lines parallel to each other, is printed with an ink visible in visible light, but an ink that does not glow in UV light. By applying the second layer, 34, on the first layer, 32, and then the third layer, 36, a security element is created which has a different appearance, 30, in UV light and a different appearance, 30', in visible light VIS. The security element, 30', viewed in VIS visible light, only shows the third layer, 36, constituting a sequence of straight lines parallel to each other, in black. The security element, 30, viewed in UV light shows a gradient color transition. Advantageously, each line in the layer of the sequence of sinusoidal lines parallel to each other, has the same thickness g of the line, amplitude *A*, frequency *T,* phase shift *C*, and deflection angle *a* of the tangent to the peak of the sinusoidal line. However, depending on the parameters selection of the layers, 32, 34, of the sequence of sinusoidal lines parallel to each other, and the parameters selection of the layer, 36, of the sequence of straight lines parallel to each other, a security element, 30, with a different appearance visible in UV light can be created. In this embodiment, with a white substrate, 12, the first layer, 32, constituting a sequence of sinusoidal lines parallel to each other, in red with a high frequency *T* of the sinusoidal line, the second layer, 34, constituting a sequence of sinusoidal lines parallel to each other, also with a high frequency *T* of the sinusoidal line in green (pointed, elongated peaks) and the third layer, 36, constituting a sequence of straight lines parallel to each other, in black, the security element, 30, takes the form of elongated, pointed sinusoid stripes in a red-green color.

[0074] The security element, 40, shown in Fig. 4 presents the third embodiment of this invention. Two layers are applied to the substrate, 12, of the data carrier, 1 - the first layer, 42, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light, in the first color, and the second layer, 44, constituting a sequence of straight lines parallel to each other, with first properties in VIS and UV light, in the second color. In this embodiment, both layers are transparent and glow in UV light, with the first layer, 42, being for example in red, and the second layer, 44, being for example in green. By applying the second layer, 44, on the first layer, 42, a security element, 40, is created which has an optical effect visible only in UV light, thus invisible in visible light VIS. In this case, for the security element, 40, the optical effect, visible in UV light, will be determined by the parameters of the first layer, 42, in the form of a sequence of sinusoidal lines parallel to each other, and the second layer, 44, applied on top of it, constituting a sequence of straight lines parallel to each other. Therefore, the optical effect of the security element, 40, will be a resultant combination of the effects provided by the transparent first layer, 42, visible in UV light, in red, with a high frequency *T* of the sinusoidal line, and the transparent second layer, 44, visible in UV light, in green, with a high frequency *T* of the sinusoidal line. Fig. 4 shows that the optical effect in UV light generated by these two layers are elongated, pointed sinusoids in red-green, with these colors being brighter than in a case when a layer with second properties in VIS and UV light is added in black, visible in visible light.

[0075] Fig. 5 shows the fourth embodiment, based on the second embodiment shown in Fig. 3. Here again, three layers are proposed, with the first layer, 52, being a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light, glowing red in UV light, the second layer, 54, being a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light, glowing green in UV light, and the third layer, 56, being a sequence of straight lines parallel to each other, with second properties in VIS and UV light, in a dark color that does not glow in UV light, for example, black, navy blue, graphite, dark green, dark brown, or another dark color of the chosen hue. The first layer, 52, and the second layer, 54, are transparent, i.e. they are invisible in VIS light. In this embodiment, an extraction, 58, which may be any hidden information or otherwise a hidden image, here the inscription PWPW, is placed/contained in the first layer, 52, with first properties in VIS and UV light. This hidden image, 58, may be any single character in textual, alphanumeric, special character, or graphic element form, or any mutual combination thereof. The extraction, 58, is made on the substrate, 12, of the data carrier, 1, whereby it assumes the color of the substrate, 12, - in the drawing it is shown as white. The security element, 50, visible in UV light, will be determined by the parameters of the first layer, 52, in the form of a sequence of sinusoidal lines parallel to each other, the parameters of the second layer, 54, in the form of a sequence of sinusoidal lines parallel to each other, and the third layer, 56, applied on top of it, constituting a sequence of straight lines parallel to each other. Therefore, the optical effect of the security element, 50, will be a resultant combination of the effects provided by the transparent first layer, 52, with a white extraction, 58, visible in UV light, in red, and the transparent second layer, 54, visible in UV light, in green, and the visible third layer, 56, in a dark color. The security element, 50’, viewed in VIS visible light, shows only the visible third layer, 56, constituting a sequence of straight lines parallel to each other, in a dark color. The security element, 50, viewed in UV light shows a red-green gradient color transition with a low frequency. The extraction, 58, is visible in UV light in the color of the substrate with straight lines parallel to each other applied to it, of the visible third layer, 56, in dark and sinusoidal lines parallel to each other, of the second layer, 54, in green.

[0076] The fifth embodiment is presented in Fig. 6. It is similar to the fourth embodiment, but the extraction is made here in both layers with first properties in VIS and UV light, i.e. glowing in UV light. In this example, three layers are also proposed, with the first layer, 62, being a sequence of sinusoidal lines parallel to each other, glowing red in UV light, the second layer, 64, being a sequence of sinusoidal lines parallel to each other, glowing green in UV light, and the third layer, 66, being a sequence of straight lines parallel to each other, in a dark color, for example, black, navy blue, graphite, not glowing in UV light. The first layer, 62, and the second layer, 64, are transparent, i.e. they are invisible in VIS light. The first extraction, 68, in the form of the inscription PWPW is placed/contained in the first layer, 62, with first properties in VIS and UV light, and the second extraction, 68’, in the form of the inscription PWPW is placed/contained in the second layer, 64, with first properties in VIS and UV light. According to the invention, the extraction, 68, 68’, may be any hidden information, otherwise a hidden image. This hidden image, 68, 68’, may be any single character in textual, alphanumeric, special character, or graphic element form, or any mutual combination thereof. It is possible that the second extraction, 68’, of the second layer, 64, is the same as the first extraction, 68, of the first layer, 62, i.e. it contains the same hidden image. Preferably the second extraction, 68’, overlaps locally with the first extraction, 68. According to this embodiment, the first extraction, 68, is made on the substrate, 12, of the data carrier, 1, whereby it assumes the color of the substrate, 12, - in the drawing it is shown as white. If the second extraction, 68’, is the same as the first extraction, 68, and is placed in the same place in the second layer, 64, as in the first layer, 62, then the substrate, 12, of the data carrier, 1, will also be visible through the second extraction, 68’. The security element, 60, visible in UV light, will be determined by the parameters of the first layer, 62, in the form of a sequence of sinusoidal lines parallel to each other, with the first extraction, 68, the parameters of the second layer, 64, in the form of a sequence of sinusoidal lines parallel to each other, with the second extraction, 68’, and the third layer, 66, applied on top of it, constituting a sequence of straight lines parallel to each other, in a dark color that does not glow in UV light. Therefore, the optical effect of the security element, 60, will be a resultant combination of the effects provided by the transparent first layer, 62, with the white first extraction, 68, visible in UV light, in red, and the transparent second layer, 64, with the white second extraction, 68’, visible in UV light, in green, and the visible third layer, 66, in black. Therefore, the security element, 60, viewed in UV light, shows a red-green gradient color transition in the form of sinusoids with a low frequency *T*. The extractions, 68, 68’, in the security element, 60, are visible in UV light in the color of the substrate, 12, with dark lines parallel to each other applied to it, of the visible third layer, 66. There is no gradient color transition on the extractions, 68, 68’. The security element, 60’, viewed in VIS visible light, shows only the visible third layer, 66, constituting a sequence of straight lines parallel to each other, in black.

[0077] Another possibility according to this embodiment, not shown in the drawings, is that part of the characters of the hidden image is placed in the first extraction, 68, of the first layer, 62, and part of the characters of the same hidden image is placed in the second extraction, 68’, of the second layer, 64. The first extraction, 68, may complement the second extraction, 68’, and/or each of these extractions, 68, 68’, may be a separate hidden image. Then the optical effect generated by the extractions, 68, 68’, will be different than described above - it will combine the optical effect described in the fourth and fifth embodiments.

[0078] Fig. 7 presents another, sixth, embodiment of this invention. The security element, as before, consists of three layers, with the first layer, 72, with first properties in VIS and UV light, being a transparent sequence of sinusoidal lines parallel to each other, glowing red in UV light, the second layer, 74, with first properties in VIS and UV light, being a transparent sequence of sinusoidal lines parallel to each other, glowing green in UV light, and the third layer, 76, being a sequence of straight lines parallel to each other, with second properties in VIS and UV light, in a dark color, for example, black, navy blue, graphite, brown, dark green, etc., not glowing in UV light. In this embodiment, the third extraction, 78", is made in the third layer, 76, in the form of the inscription PWPW. The third extraction, 78", constitutes a hidden image contained in the security element, 70, 70', according to the sixth embodiment. The security element, 70, visible in UV light, will be determined by the parameters of the first layer, 72, constituting a sequence of sinusoidal lines parallel to each other, the parameters of the second layer, 74, constituting a sequence of sinusoidal lines parallel to each other, and the third layer, 76, applied on top of it, constituting a sequence of straight lines parallel to each other, in a dark color, with the third extraction, 78", in the form of the inscription PWPW. Therefore, the optical effect of the security element, 70, will be a resultant combination of the effects provided by the transparent first layer, 72, visible in UV light, in red, and the transparent second layer, 74, visible in UV light, in green, and the visible third layer, 76, in black with the extraction, 78". The security element, 70, viewed in UV light, shows a red-green gradient color transition with smooth sinusoids and a hidden image in the form of the third extraction, 78". The third extraction, 78", visible in UV light, is a combination of the features and parameters of the applied second layer, 74, on the first layer, 72, without black straight lines parallel to each other, of the third layer, 76. According to this embodiment, the security element, 70', viewed in VIS visible light, shows the visible third layer, 76, constituting a sequence of straight lines parallel to each other, in black, and the hidden image contained in it in the form of the third extraction, 78", in the color of the substrate, 12, - the inscription PWPW.

[0079] Fig. 8 shows a security element, 80, made according to the first embodiment from Fig. 2, but with sinusoidal lines with different parameters than those shown in Fig. 2 - here smooth sinusoids. The security element, 80, may have one fluorescent layer of any color visible in UV light, for example, in green, blue, and red. According to the second embodiment, the security element, 90, may have two fluorescent layers of different colors visible in UV light. Fig. 9 shows the second embodiment, but with different parameters of the sinusoidal lines, in which the security element, 90, has an optical effect created by optically combining colors (so-called additive) - two colors out of three: red, green, blue. Therefore, for example, preferably the first layer glows red in UV light and the second layer glows green, or the first layer glows green and the second layer glows blue, or the first layer glows blue and the second layer glows red. And vice versa. Examples of interference with different colors may be arbitrary, as well as the selection of the color glowing in UV light for the first or second and/or further layers. Then the security element, 90, consists of sinusoids in alternating colors: red-green, green-blue, blue-red.

[0080] According to the invention, sinusoidal lines are generated by calculating points (x,y) which are then connected. These points are calculated from the formula:

$$y = A * \sin(T * x + C), \text{ where}$$

A - denotes the amplitude

T - denotes the frequency (1/f)

C - denotes the phase shift

x,*y* - denotes points on the sinusoidal line.

[0081] The above-described method of developing sinusoidal line shapes also applies to calculating the shapes of sinusoidal lines in a sequence of sinusoidal lines parallel to each other.

[0082] Fig. 10 shows a single sinusoidal line, 111, with a line thickness, *g*, and an amplitude *A* equal to the thickness, *g*, of the sinusoidal line and frequency *T*. The frequency *T* is responsible for the density of peaks (number of periods) on a single sinusoidal line, 111, and thus in the entire sequence of sinusoidal lines parallel to each other. If the frequency *T* is too high, the gradient transition between colors is not clearly visible. If a frequency *T* is too high, it means that the peaks in a single sinusoidal line, 111, are more condensed - a greater number of periods exists on a given segment of the sinusoidal line, 111. In turn, a low frequency *T* means a smooth sinusoid - a smooth course of the sinusoidal line, 111 - a small number of periods on a given segment, that may be visible on a single sinusoidal line, 111, in Fig. 10. In addition to the fact that peaks on a sinusoidal line can be "condensed", the sinusoidal line can also be stretched upwards and downwards. The maximum value reached by the sinusoidal line determines the amplitude *A*. The calculation of the frequency *T* is possible by giving the ratio between *A* and *T*.

[0083] Advantageously, the amplitude *A* is equal to the single thickness g of the sinusoidal line, 111. However, it is also possible to use other values, for example, their multiples g = 3 * *A* or *g* = 2 * *A*, etc. Fig. 11 shows an example of a sequence of sinusoidal lines parallel to each other, consisting of two sinusoidal lines - the first sinusoidal line, 111, and the second sinusoidal line, 111a. The thickness g of the sinusoidal line in the sequence of sinusoidal lines parallel to each other, is the same. The distance between the axis of symmetry of the first sinusoidal line, 111, and the axis of symmetry of the second sinusoidal line, 111a, may be *A*, a multiple of *A* - as in Fig. 11, this distance is 2**A*.

[0084] According to this invention, it has been found that it is advantageous to calculate the frequency *T* taking into account the maximum deflection of the tangents to the peaks on the sinusoidal line, 111. It occurs at point y = 0. This is shown in Fig. 12. Thus, the frequency *T* can be calculated from the formula:

$$T = \mathrm{ctg}\,(a) \times A, \text{ where}$$

a - denotes the deflection angle of the tangent to the peak on the sinusoidal line

A - denotes the amplitude

x,y - denotes points on the sinusoidal line.

[0085] The deflection angle *a* of the tangent to the peak on the sinusoidal line, in order to obtain the desired effect, should be +/- 10°, preferably +/- (1 - 2)°. This desired effect is a two- or multi-colored gradient color transition in the security element.

[0086] Examples of the relationship between the parameters: amplitude *A,* frequency *T*, and deflection angle *a* of the tangent to the peak on the sinusoidal line are presented in table 1:

Ratio A : T	1 : 114.5	1 : 57.3	1 : 28.6	1 : 14.3	1 : 9.5	1 : 7.1
A (px)	20	20	20	20	20	20
T (px)	2291	1145	572	286	190	142
Max. deflection angle *a*	+/- 0.5°	+/- 1°	+/-2°	+/- 4°	+/-6°	+/- 8°

[0087] According to the invention, lines in a sequence of straight lines parallel to each other, are developed differently than lines in a sequence of sinusoidal lines parallel to each other. In order to develop lines in a sequence of straight lines parallel to each other, the thickness g of the straight line and the amplitude *A* are determined. The thickness g of the straight line may be the same as the thickness g of the sinusoidal line, as well as it may be many times smaller or larger, depending on the desired optical effect. Preferably, the amplitude *A* is the same as the amplitude *A* of the occurrence of sinusoidal lines, but modified by a factor *d.* This factor should be 80 - 140%, most preferably 92 - 108%. The factor *d* is responsible for the effect of optical magnification of sinusoids. An example of the distribution of straight lines in a sequence of straight lines parallel to each other, is shown in Fig. 13. The distribution of straight lines shown in the drawing is suitable for the example of a sequence of sinusoidal lines parallel to each other, consisting of two sinusoidal lines from Fig. 11. Fig. 13 shows the first straight line, 113, the second straight line, 113a, and the third straight line, 113b, constituting a sequence of straight lines parallel to each other. All straight lines, 113, 113a, 113b, in the sequence of straight lines parallel to each other, have the same line thickness g. The distance between the axis of symmetry of the first straight line, 113, and the second straight line, 113a, as well as between the second straight line, 113a, and the third straight line, 113b, is the same and is for example *2*A*d.* The optical effect arises from superimposing the sequence of straight lines parallel to each other, from Fig. 13 on the sequence of sinusoidal lines parallel to each other, consisting of two sinusoidal lines from Fig. 11. Preferably, the distance between the axes of symmetry of all straight lines in the sequence of straight lines parallel to each other, as well as the thickness g of the lines, is the same.

[0088] Fig. 14 shows a table with examples of making a security element, 100, consisting of two printing layers with different parameters. In these embodiments, the first layer, 112, with first properties in VIS and UV light, is a transparent sequence of sinusoidal lines parallel to each other, glowing red in UV light, on which the second layer, 116, with second properties in VIS and UV light is applied, constituting a sequence of straight lines parallel to each other, in black, visible in VIS light and invisible in UV light. The examples of the security element, 100, present changes in its optical effect glowing in UV light and its angular variability thanks to the Moiré effect. Fig. 14 shows the changes taking place in the security element, 100, depending on the deflection angle *a* of the tangent to the peak on the sinusoidal line and the factor *d* responsible for the effect of optical magnification of the sinusoids. The security element, 100, in Fig. 14 shows the effect obtained by superimposing different sequences of lines parallel to each other, sinusoidal and straight. The columns contain exemplary sequences with a variable parameter of the angle, *a*, of the tangent. The rows contain exemplary sequences with a variable factor, *d,* of sinusoid magnification. It follows from Fig. 14 that the higher the parameter *a*, the greater the number of visible individual stripes in the same zone, and the frequency of visible sinusoids increases. Increasing the parameter *d* causes a decrease in the thickness of the obtained optical sinusoids, thus the number of these sinusoids increases.

[0089] Fig. 15a - Fig. 15c show the influence of the phase shift parameter C on the appearance of the security element. Figs. 15a-c show the security element, 110, 120, 130, consisting of two layers of a sequence of sinusoidal lines parallel to each other, glowing in UV light - the first layer is visible in red and the second layer applied on top of it is visible in green. On both layers, a third layer is applied, constituting a sequence of straight lines parallel to each other, in black, visible in visible light, but invisible in UV light. Each of the security elements shown, 110, 120, 130, is characterized by a deflection angle *a* of the tangent to the peak on the sinusoidal line that is equal to 4° and an amplitude *A* of 0.2 mm. What distinguishes the security elements 110, 120, 130, shown, is the phase shift parameter *C*, which is responsible for the tilt of the sinusoidal line - interchangeably called the tilt of the peaks. In Fig. 15a the sinusoids in the security element, 110, do not tilt either to the left or to the right. Here, the phase shift parameter *C* is 0. In Fig. 15b the sinusoids in the security element, 120, are slightly tilted to the right. Here, the phase shift parameter *C* results from the formula *C* = T*5%, where the factor 5% is responsible for tilting the stripes by 5%. In Fig. 15c it can be seen that the sinusoids in the security element, 130, are tilted to the right. Here, the phase shift parameter *C* results from the formula *C* = *T**10%, where the factor 10% is responsible for tilting the stripes by 10%. The higher the % factor, the greater the tilt of the stripes - the stripes are tilted at a greater angle from the initial value.

[0090] According to the seventh embodiment, it is possible for the layer constituting a sequence of straight lines parallel to each other, in black, visible in visible light, but invisible in UV light, to be not straight lines, but dashed lines, micro-image lines, micro-text lines, or other graphic elements that will function as straight lines. An example of such a security element, 140, is shown in Fig. 16a. Then, in VIS light, only a sequence of micro-images, micro-text, etc. is visible on the data carrier 1. It can be seen from section a, which is Fig. 16b, that the second layer, 143, constituting a sequence of lines parallel to each other in the form of a string of text characters - the repeating word MICROTEXT in black - is printed on the first layer, 141, constituting a sequence of sinusoidal lines parallel to each other, glowing green in UV light. The first layer, 141, is transparent, i.e. invisible in visible light, while the second layer, 143, is visible in VIS visible light, but invisible in UV light. It is also possible for dashed lines, micro-image lines, micro-text lines, or other graphic elements to constitute sinusoidal lines in the layer of a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light.

[0091] According to the invention, it is also possible to obtain a full multi-colored - rainbow color transition - this constitutes the eighth embodiment of the invention. To this end, three layers with first properties in VIS and UV light are applied to the substrate, 12, of the data carrier, 1, but so that they do not overlap as described above, but so that each layer is arranged alternately on the substrate. Advantageously, three fluorescent layers can be used alternately: red, green, blue, and a fourth layer of interference ink. Fig. 17a shows a security element, 150, visible in UV light with a multi-colored gradient transition with a phase shift *C* of *C*=*T**10%. Fig. 17b shows the fluorescent layers printed alternately in red, green, and blue, with the fluorescent layer visible in green in UV light being formed by a sequence of sinusoidal lines parallel to each other, 152, in green, the fluorescent layer visible in blue in UV light being formed by a sequence of sinusoidal lines parallel to each other, 154, in blue, and the fluorescent layer visible in red in UV light being formed by a sequence of sinusoidal lines parallel to each other, 159, in red. A sequence of straight lines parallel to each other (not shown in the drawing), in black, visible in VIS visible light, but invisible in UV light, is printed on these layers.

[0092] A surprising optical effect according to the invention can be achieved when two layers are printed on the substrate, 12, of the data carrier, 1, each constituting a sequence of sinusoidal lines parallel to each other, but with an opposite phase shift C. This is the ninth embodiment of this invention. Therefore, if the second layer, 166, constituting a sequence of sinusoidal lines parallel to each other, with second properties in VIS and UV light with a phase shift to the left, is applied to the first layer, 162, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light with a phase shift to the right, a security element, 160, is created whose image shows circles instead of "stripes". In order to obtain this effect of circles, one of the selected layers mentioned above has a phase shift *C* of 50% of the frequency *T*. The security element, 160, as it appears in UV light, is shown in Fig. 18. In VIS light, the sinusoidal lines of the second layer, 166, will be visible.

[0093] According to the invention, a security element is created by superficially arranging the position of individual, at least two further, printing layers on the surface of the data carrier. The following arrangements of layers forming a security element are therefore possible - in the case of using two layers - in the first embodiment, the first layer, visible in UV light and invisible in VIS light, is printed first, followed by the second layer, visible in VIS light and invisible in UV light. According to the third embodiment, the following arrangement of layers is possible - the second layer, visible in UV light and invisible in VIS light, is applied to the first layer, visible in UV light and invisible in VIS light. In the case of three layers, the order of these layers is strictly defined - the first layer, visible in UV light and invisible in VIS light, is applied first to the substrate, the second layer, visible in UV light and invisible in VIS light, is applied second, and the third layer, visible in VIS light and invisible in UV light, is applied third. In order to obtain the selected optical effect according to the invention, the security element contains two or three layers from those listed above, which occur in this strictly defined order on the substrate.

[0094] The security element in the individual combinations may be arbitrary - examples are shown in Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 14, Fig. 17, Fig. 18. The security element does not have to be only in the form of filling a square or rectangle. The security element can take any shape, as well as it can be a filling of a geometric shape, alphanumeric characters, text characters, or special characters. The graphic layout of the security element in the form of various sinusoids or circles is presented in Fig. 14, Fig. 17, and Fig. 18. The security element may also have an extraction in one or more layers - additional hidden information - a hidden image - revealed during observation in UV light or only in VIS light. The order and graphic arrangement of the layers forming the security element shown in the drawings is only a schematic representation of the visual effects achieved and is not intended to limit the invention.

[0095] The table below presents, in a simplified manner, the order of layers in the individual embodiments of the security element, wherein each element in terms of the layers present and the parameters that these layers are characterized by, causes that each security element, when verifying the data carrier, 1, using a UV lamp, provides a different visual effect. As a result, from the combination of at least two layers with a sequence of sinusoidal lines parallel to each other, and/or with a sequence of straight lines parallel to each other, a complex visual effect is created, i.e. a complex multi-colored gradient image forming an UV-visible image of the security element. The table below lists the individual layers in the order in which they are arranged on the substrate, 12, of the data carrier, 1. Subsequent columns in the table (concerning the type of layers) from left to right show the order of layers on the data carrier, 1. For example, the security element, 20, has such an order of layers that the first fluorescent layer with a sequence of sinusoidal lines parallel to each other, is applied to the substrate, 12, and then the second layer with a sequence of straight lines parallel to each other, is applied on top of it. Similarly, the order of layers for the nine embodiments of this invention can be read from the table.

Table 2:

Security element	Layer: sequence of sinusoidal lines / first properties in VIS and UV light	Layer: sequence of sinusoidal lines / first properties in VIS and UV light	Layer: sequence of sinusoidal lines / first properties in VIS and UV light	Layer: sequence of sinusoidal lines / first properties in VIS and UV light	Layer: sequence of sinusoidal lines / second properties in VIS and UV light	Layer: sequence of sinusoidal lines / second properties in VIS and UV light
20, 20’	+	-	-	-	+	-
30, 30’	+	+	-	-	+	-
40	+	-	-	+	-	-
50, 50’	+	+	-	-	+	-
60, 60’	+	+	-	-	+	-
70, 70’	+	+	-	-	+	-
140	+	-	-	-	+	-
150	+	+	+	-	+	-
160	+	-	-	-	-	+
Note: The "+" sign indicates the presence of a given layer in the listed security element, and the "-" sign indicates its absence.						

[0096] These elements are characterized by different coloration under the influence of UV light. Each security element has a different configuration of UV light activity properties and/or transparent and/or visible properties in VIS light, as well as parameters of these layers.

[0097] In reality, a color image is obtained - each layer visible in UV light is visible in a different color. These different colors are shown as different hatching or shading of the layers. In these layers, there may be two layers of fluorescent inks with a different, but complementary, coloration of glow under the influence of UV light, or only one layer of fluorescent ink. By complementary colors, two colors selected from the group of red, blue, and green should be understood. Due to different configurations of the layers mentioned above, multi-color is obtained, visible in UV light.

[0098] Advantageously, each of the layers of the security element can be printed independently by offset, letterset, flexographic, gravure, screen printing, or letterpress printing methods.

[0099] In the case of printing using the offset method, it is possible to use the Moiré effect in a "self-verifying" form, which means that no additional filters or other printing techniques are required, which would increase the costs of using the given solution.

[0100] Fluorescent layers contain known inks with optical activity in UV light. The fluorescent ink contains in its composition particles/pigments (a substance or a mixture of substances) that absorb radiation from the ultraviolet range, for example, with a wavelength of 365/313/254 nm, and emit radiation in the visible range with a specific color, which is used for visual verification of the authenticity of the data carrier. The fluorescent inks used in the layers visible in UV light preferably have an additive color, i.e. they are two inks selected from the group: red, green, blue.

[0101] The security element, 10, 20, 20’, 30, 30’, 40, 50, 50’, 60, 60’, 70, 70’, 80, 90, 100, 110, 120, 130, 140, 150, 160, according to the invention is produced in known ways by printing additional (further) layers: at least one first layer constituting a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, and the second layer with second properties in VIS and UV light, constituting a sequence of lines parallel to each other in the second color, so that printing the second layer on at least the first layer creates a gradient color transition visible in UV light. Advantageously, at least one additional layer constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light, in another color, is printed between the first layer and the second layer.

[0102] Printing the aforementioned layers is carried out sequentially, on one side of the substrate, 12, of the data carrier, 1. Therefore, the security element, 10, 20, 20', 30, 30', 40, 50, 50', 60, 60', 70, 70', 80, 90, 100, 110, 120, 130, 140, 150, 160, according to the invention is produced by a method in which multiple, for example, two-fold, three-fold, four-fold, printing is used. In the case of producing a security element consisting of three layers, then in each cycle sequentially the first layer with first properties in VIS and UV light - transparent, visible in UV light and invisible in VIS light - is applied first, the further (additional) layer with first properties in VIS and UV light - transparent, visible in UV light and invisible in VIS light - is applied second, and the second layer with second properties in VIS and UV light - visible in VIS light and invisible in UV light - is applied third. Additionally, due to different properties of the layers used in a given security element - a sequence of sinusoidal lines parallel to each other, or a sequence of straight lines parallel to each other - of which in each individual security element, 10, 20, 20', 30, 30', 40, 50, 50', 60, 60', 70, 70', 80, 90, 100, 110, 120, 130, 140, 150, 160, of the layers, it may have different parameters: different amplitude of sinusoidal lines, different frequency, different phase shift, deflection angle of tangent to the peaks of sinusoidal lines, factor *d* of optical magnification of sinusoids, a different optical effect of this secure element is obtained.

[0103] According to the invention, a sequence of sinusoidal lines parallel to each other is generated by connecting the calculated points (x,y) from the formula:

$$y = A * \sin(T * x + C),$$

where:

- *A* - denotes the amplitude
- *T* - denotes the frequency
- *C* - denotes the phase shift
- *x*,*y* - denotes points on the sinusoidal line

[0104] The frequency *T* is calculated from the formula:

$$T = \mathrm{ctg}(a) \mathrm{~x~} A,$$

where:

- *a* - denotes the deflection angle of the tangent to the peaks of the sinusoidal lines
- *A* - denotes the amplitude.

[0105] Advantageously, the amplitude *A* is equal to the single thickness g of the sinusoidal line or a multiple thereof, for example, g = 3 * *A* or *g* = 2 * *A*. In the case of a sequence of straight lines parallel to each other, the amplitude *A* is the same as the amplitude *A* of the sequence of sinusoidal lines parallel to each other, but modified by a factor *d* of optical magnification of the sinusoid. This factor should be 80 - 120%, most preferably 92 - 108%. The factor *d* is responsible for the effect of optical magnification of sinusoids.

[0106] According to the invention, a single sinusoidal line has a line thickness, *g*, and an amplitude *A* equal to the thickness, g, of the sinusoidal line and frequency *T*. All sinusoidal lines, in the sequence of sinusoidal lines parallel to each other, have the same parameters. The frequency *T* is responsible for the density of peaks (number of periods) on a single sinusoidal line, and thus in the entire sequence of sinusoidal lines parallel to each other. The maximum value reached by the sinusoidal line determines the amplitude *A*. Advantageously, the thickness g of the sinusoidal line, in the sequence of sinusoidal lines parallel to each other, is the same. The distance between the axis of symmetry of the first sinusoidal line and the axis of symmetry of the second sinusoidal line, as well as subsequent sinusoidal lines, may be *A,* a multiple of *A,* i.e. *2*A, 3*A, 4*A,* wherein this distance is the same throughout the layer, as well as in further layers belonging to the same security element. Preferably, the straight lines, in the sequence of straight lines parallel to each other, have the same line thickness g and the distance between the axes of symmetry of all straight lines, in the sequence of straight lines parallel to each other, is the same. The distance between the axis of symmetry of the first straight line and the second straight line, as well as further straight lines, is the same and is for example *2*A*d.* Advantageously, printing layers - sequences of lines parallel to each other, sinusoidal and straight, is carried out by offset printing.

[0107] Printing using the method according to the invention is carried out in layers. For example, the security element, 20, 20', according to the first embodiment, is printed on the surface of the substrate, 12, by applying the first layer, 22, fluorescent, transparent, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light - visible in UV light, in red, after which the second layer, 26, constituting a sequence of straight lines parallel to each other, with second properties in VIS and UV light, in black, not glowing in UV light and visible in VIS light, is printed on top of it, so that a security element, 20, 20', according to the first embodiment is created, which exhibits multi-color in UV light and is invisible in VIS light.

[0108] The security element, 30, 30', according to the second embodiment, is printed on the surface of the substrate, 12, by applying the first layer, 32, fluorescent, transparent, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light - visible in UV light, in red, with the first parameters of the sinusoidal lines, after which another layer, 34, constituting a fluorescent, transparent layer, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light - visible in UV light, in green, with the first parameters of the sinusoidal lines, is printed on top of it. Then, the second layer, 36, constituting a sequence of straight lines parallel to each other, with second properties in VIS and UV light, in black, not glowing in UV light and visible in VIS light, is printed, so that a security element, 30, 30', according to the second embodiment is created, which exhibits multi-color in UV light and is invisible in VIS light.

[0109] According to this invention, it is possible that after applying the first layer, 52, 62, fluorescent, transparent, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light - visible in UV light, in red, with the first parameters of the sinusoidal lines, a first extraction, 58, 68, constituting the text element PWPW, which is hidden information invisible in VIS light and visible in UV light, is extracted from the first layer, 52, 62, using a laser beam. It is also possible, according to the fifth embodiment, that a second extraction, 68', constituting the text element PWPW, which is hidden information, is extracted from the second layer, 64, with first properties in VIS and UV light, using a laser beam. In this embodiment, the first extraction, 68, and the second extraction, 68', are the same and are superimposed, so that one hidden image (otherwise also one piece of hidden information) of the color of the substrate, 12, is created. According to the invention, the extraction, 68, 68', may be any character or graphic. In both embodiments, the hidden image in the form of extractions, 58, 68, 68', is invisible in VIS light and visible in UV light.

[0110] In turn, according to the sixth embodiment, the first layer, 72, and the second layer, 74, with first properties in VIS and UV light are printed, and then the third layer, 76, with second properties in VIS and UV light is printed. Then, an extraction, 78", constituting hidden information - the inscription PWPW, which is visible in both VIS and UV light - is extracted using a laser beam in the third layer, 76, constituting a sequence of straight lines parallel to each other, in the second color with second properties in VIS and UV light.

[0111] According to the third embodiment, the security element, 40, is created by printing the first layer, 42, fluorescent, transparent, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light - visible in UV light in red, with the first parameters of the sinusoidal lines, on the surface of the substrate, 12, after which another layer, 44, constituting a fluorescent, transparent layer, constituting a sequence of straight lines parallel to each other, with first properties in VIS and UV light - visible in UV light in green, is printed on top of it, so that a secure element, 40, according to the third embodiment is created, which exhibits multi-color in UV light and is invisible in VIS light.

[0112] In the case of the ninth embodiment, if the secure element, 160, is to contain circles, for example, then the first fluorescent, transparent layer, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light - visible in UV light in red, green, blue, or other - with the first parameters of the sinusoidal lines - with a phase shift directed to the left, is printed on the surface of the substrate, 12, of the data carrier, 1, after which the second layer, constituting a sequence of sinusoidal lines parallel to each other, with second properties in VIS and UV light - visible in VIS light in a dark color - with the second parameters of the sinusoidal lines - with a phase shift directed to the right, is printed on top of it. In order to obtain the effect of circles, it is chosen which of these two layers has sinusoidal lines with a phase shift C of 50% of the frequency *T*. According to the invention, one of these layers must have a phase shift C of 50% of the frequency *T* in order to obtain a secure element, 160, with an optical effect in the form of circles.

[0113] In turn, the security element shown in Fig. 15 with oblique sinusoid stripes is printed on the surface of the substrate, 12, of the data carrier, 1, in such a way that the second fluorescent, transparent layer, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light, in green, with the first parameters of the sinusoidal lines, is printed on the first fluorescent, transparent layer, constituting a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light - visible in UV light in red, with the first parameters of the sinusoidal lines, and then the third layer, constituting a sequence of straight lines parallel to each other, with second properties in VIS and UV light - visible in VIS light in a dark color, is printed. However, in order to obtain the optical effect of oblique sinusoid stripes in the secure element, 110, 120, 130, the phase shift parameter C of the sinusoidal lines of the first and second layers should be changed. By changing the phase shift parameter C, the tilt of the sequence of sinusoidal lines parallel to each other, varies to the left or to the right. Thus, in the security element, 110, the first and second layers are printed with a deflection angle *a* of the tangent to the peak on the sinusoidal line of 4°, with an amplitude *A* of 0.2 mm and a phase shift C of 0, because the sinusoid stripes in the security element, 110, do not tilt either to the left or to the right. In the security element, 120, the first and second layers are printed with the deflection angle *a* of the tangent to the peak on the sinusoidal line of 4°

and with an amplitude *A* of 0.2 mm and a phase shift C calculated from the formula C = T*5%, where the factor 5% is responsible for tilting the stripes by 5%. The sinusoid stripes in the security element, 120, are slightly tilted to the right. In the security element, 130, the first and second layers are printed with the deflection angle *a* of the tangent to the peak on the sinusoidal line of 4° and with an amplitude *A* of 0.2 mm and a phase shift C calculated from the formula C = *T**10%, where the factor 10% is responsible for tilting the stripes by 10%. The sinusoid stripes in the security element, 130, are tilted to the right. The higher the % factor, the greater the tilt of the stripes - the stripes are tilted at a greater angle from the initial value.

[0114] Fig. 14 shows a table with examples of making a security element, 100. It shows changes in the appearance of the security element, 100, visible in UV light, which are dependent on the deflection angle *a* of the tangent to the peak on the sinusoidal line and the factor *d* responsible for the effect of optical magnification of the sinusoids in the security element, 100. By superimposing different sequences of sinusoidal lines parallel to each other, with a variable parameter of the angle, *a*, of the tangent to the peak on the sinusoidal line, and sequences of straight lines parallel to each other, with a variable factor, *d*, of sinusoid magnification, a different optical effect of gradient color transition in the secure element is obtained. The higher the parameter a, the greater the number of visible individual stripes in the same zone - 0.5°, 1°, 2°, 4°, 6°, 8° - and the frequency of visible sinusoids increases. Increasing the parameter *d* causes, in the same zone - 100%, 101%, 103%, 106%, 110%, 120%, 130%, 140% - a decrease in the thickness of the obtained optical sinusoids, thus the number of these sinusoids increases. Advantageously, the factor *d* of optical magnification of the sinusoid is from 80% to 120%, and most preferably from 92% to 108%.

[0115] If the security element, 140, constituting the seventh embodiment, contains an optical effect generated by dashed lines, micro-image lines, micro-text lines, or other graphic elements that will function as straight lines, then the first layer, 141, constituting a sequence of sinusoidal lines parallel to each other, glowing in UV light, invisible in VIS light, for example, in green, red, blue, or other, is printed, followed by the second layer, 143, in a dark color, for example, dark grey, graphite, black, visible in visible light, but invisible in UV light. However, the second layer, 143, is a sequence of parallel, dashed lines, micro-image lines, micro-text lines, or other graphic elements that will function as straight lines - for example, as shown in Fig. 16, the lines are the repeating word MICROTEXT (a string of words MICROTEXT). It is also possible for dashed lines, micro-image lines, micro-text lines, or other graphic elements to be printed as the first layer, 141, in the form of a sequence of sinusoidal lines parallel to each other, with first properties in VIS and UV light, while the second layer, 143, would be straight lines with second properties in VIS and UV light.

[0116] The security element, 150, constituting the eighth embodiment, is in turn made in such a way that one layer, 159, constituting a sequence of sinusoidal lines parallel to each other, in red with first properties in VIS and UV light, the second layer, 152, constituting a sequence of sinusoidal lines parallel to each other, in green with first properties in VIS and UV light, and the third layer, 154, constituting a sequence of sinusoidal lines parallel to each other, in blue with first properties in VIS and UV light are printed on the substrate of the data carrier, 1, so that the lines of each of these layers do not overlap, but form a sequence of sinusoidal lines parallel to each other, with alternating lines: red line, 159, green line, 152, blue line, 154, and again: red line, 159, green line, 152, blue line, 154, etc., on the substrate, 12. A fourth layer in the form of a sequence of straight lines parallel to each other, with second properties in VIS and UV light, in a dark color, is printed on these layers.

[0117] The data carrier according to the invention may have a non-transparent substrate, and fluorescence during the use of UV light is visible in reflected light only and solely from one side of the data carrier.

[0118] Visual effects in UV light are visible only from the print side, i.e. the side where the security features are applied.

Claims

1. A security element (10, 20, 20', 30, 30', 40, 50, 50', 60, 60', 70, 70', 80, 90, 100, 110, 120, 130, 140, 150, 160) comprising at least two layers printed on top of each other, in which at least one layer is a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, and at least the second layer is a sequence of lines parallel to each other in the second color with second properties in VIS and UV light, wherein the superimposing of the second layer on at least one first layer creates a gradient color transition visible in UV light.

2. The security element according to claim 1, wherein the layer constituting a sequence of lines parallel to each other is a sequence of sinusoidal lines parallel to each other, or a sequence of straight lines parallel to each other.

3. The secure element according to claim 1, which has at least one additional layer constituting a sequence of sinusoidal lines parallel to each other, in another color with first properties in VIS and UV light applied on the first layer constituting a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light.

4. The security element according to claim 1, wherein the first properties in VIS and UV light mean that the layer is invisible in VIS light and is visible in UV light, and the second properties in VIS and UV light mean that the layer is visible in VIS light and is invisible in UV light.

5. The security element according to claim 1, wherein the security element (40) comprises a first layer constituting a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, and at least a second layer constituting a sequence of straight lines parallel to each other, in the second color with second properties in VIS and UV light, wherein the second properties in VIS and UV light are the same as the first properties in VIS and UV light.

6. The security element according to claim 1, wherein the layer with first properties in VIS and UV light is a fluorescent layer.

7. The security element according to claim 1, wherein the sinusoidal lines in the sequence of sinusoidal lines parallel to each other, are calculated by connecting the calculated points (x,y) on the sinusoidal line from the formula:

$$y = A * \sin (T * x + C),$$

where:

A - denotes the amplitude
T - denotes the frequency
C - denotes the phase shift
x,*y* - denotes points on the sinusoidal line.

8. The security element according to claim 7, wherein the frequency *T* is calculated from the formula:

$$T = \mathrm{ctg}\ (a) \times A,$$

where:

a - denotes the deflection angle of the tangent to the peaks of the sinusoidal line
A - denotes the amplitude.

9. The security element according to any one of the preceding claims, wherein the amplitude (A) of the sequence of straight lines parallel to each other, is the same as the amplitude (*A*) of the sequence of sinusoidal lines parallel to each other, but modified by a factor (*d*) of optical magnification of the sinusoid.

10. The security element according to any one of the preceding claims, wherein the amplitude (*A*) is the thickness of a single sinusoidal line (*g*), or a multiple thereof.

11. The security element according to claim 9, wherein the factor (*d*) of optical magnification of the sinusoid is from 80% to 120%, preferably from 92% to 108%.

12. The security element according to any one of the preceding claims, wherein different optical effects are obtained by changing the parameter of the line in the sequence of lines parallel to each other of at least one of: amplitude (*A*), frequency (*T*), phase shift (*C*), deflection angle (*a*) of tangent to the sinusoid, factor (*d*) of optical magnification of the sinusoid, thickness (*g*) of a single line.

13. The security element according to any one of the preceding claims, wherein by changing the parameter of the phase shift (*C*), the deviation/tilt of the sequence of sinusoidal lines parallel to each other, varies.

14. The security element according to claim 1, wherein at least one layer with first properties in VIS and UV light has an extraction constituting hidden information invisible in VIS light and visible in UV light, or at least one layer with second properties in VIS and UV light has an extraction constituting hidden information visible in VIS and UV light.

15. A method for making a security element (10, 20, 20', 30, 30', 40, 50, 50', 60, 60', 70, 70', 80, 90, 100, 110, 120, 130, 140, 150, 160) on a data carrier (1), comprising the following steps:

a) printing on the substrate (12) of the data carrier (1) at least one layer constituting a sequence of sinusoidal lines

parallel to each other, in the first color with first properties in VIS and UV light,
d) printing the second layer constituting a sequence of lines parallel to each other in the second color with second properties in VIS and UV light,

so that printing the second layer in the second color with second properties in VIS and UV light on at least one layer in the first color with first properties in VIS and UV light creates a gradient color transition visible in UV light.

16. The method according to claim 15, comprising the following step:
b) printing on the layer, constituting a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, at least one further layer constituting a sequence of sinusoidal lines parallel to each other, in another color with first properties in VIS and UV light.

17. The method according to any one of the preceding claims, further comprising at least one of the following steps:

c) carrying out by means of a laser beam in at least one layer, constituting a sequence of sinusoidal lines parallel to each other, in the first color with first properties in VIS and UV light, the first extraction and/or in the same place in the further layer, constituting a sequence of sinusoidal lines parallel to each other, in another color with first properties in VIS and UV light, the same extraction constituting hidden information invisible in VIS light and visible in UV light,
e) carrying out by means of a laser beam in the second layer, constituting a sequence of lines parallel to each other in the second color with second properties in VIS and UV light, the extraction constituting hidden information visible in VIS and UV light.

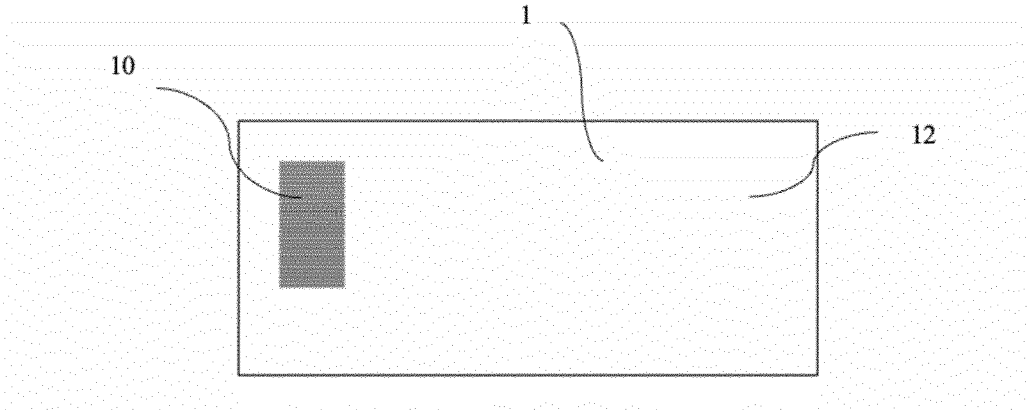

Fig. 1

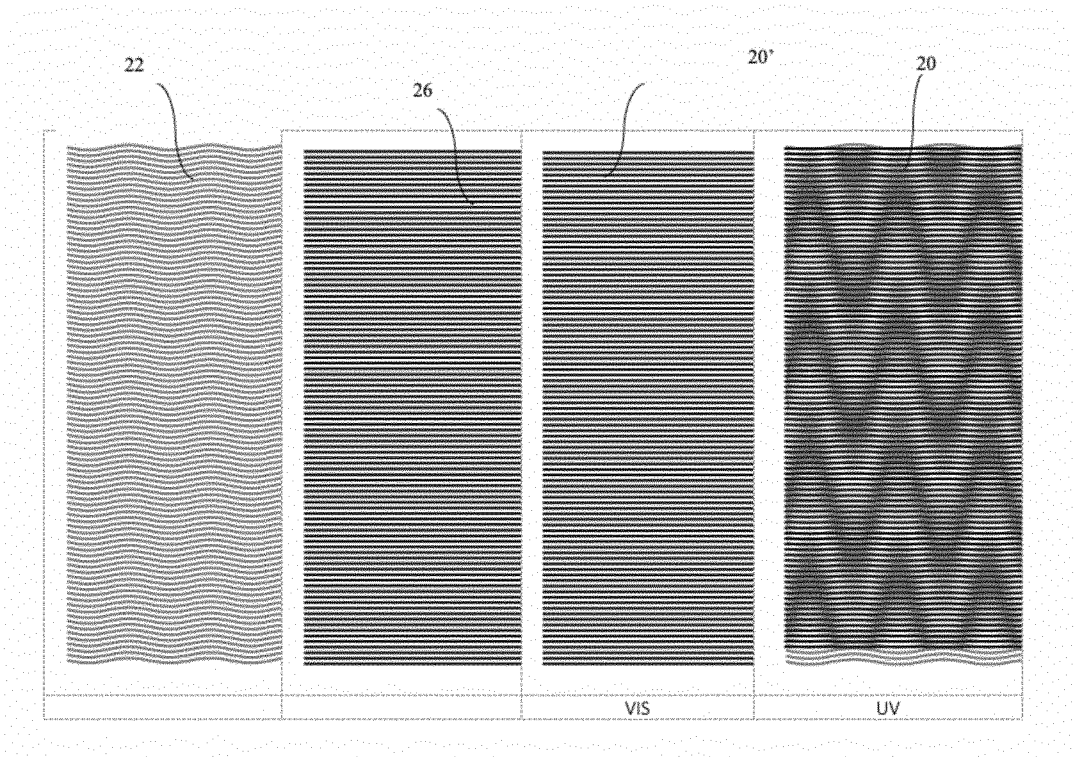

Fig. 2

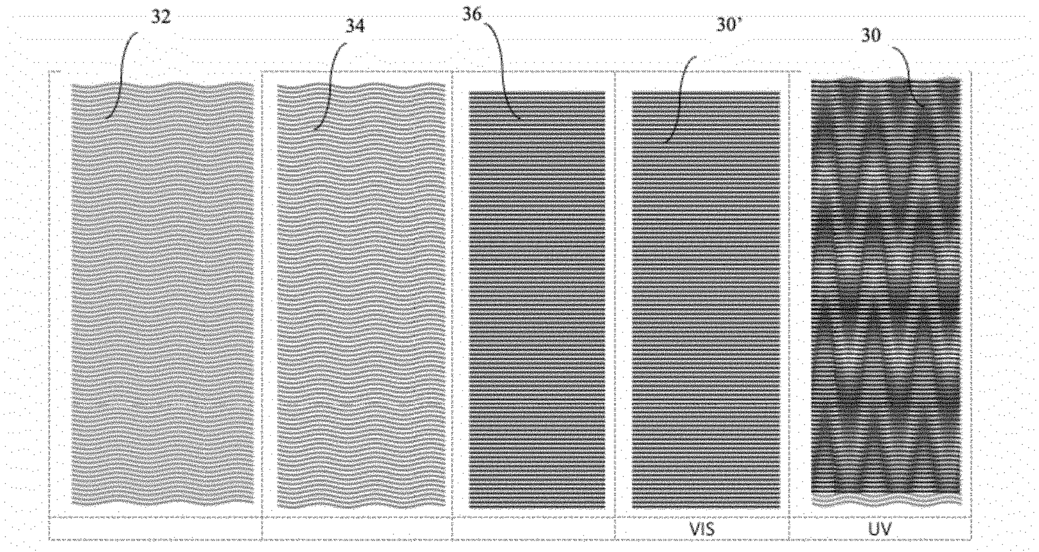

Fig. 3

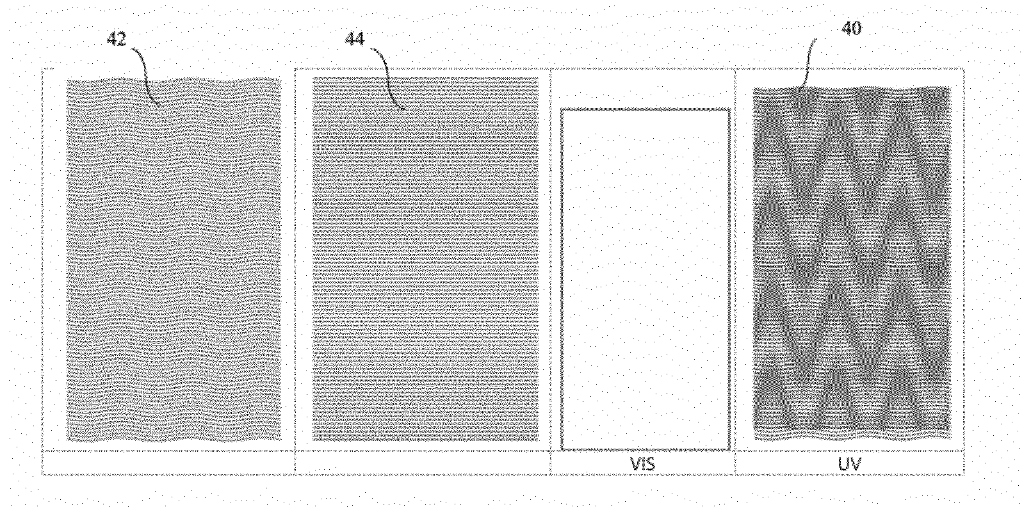

Fig. 4

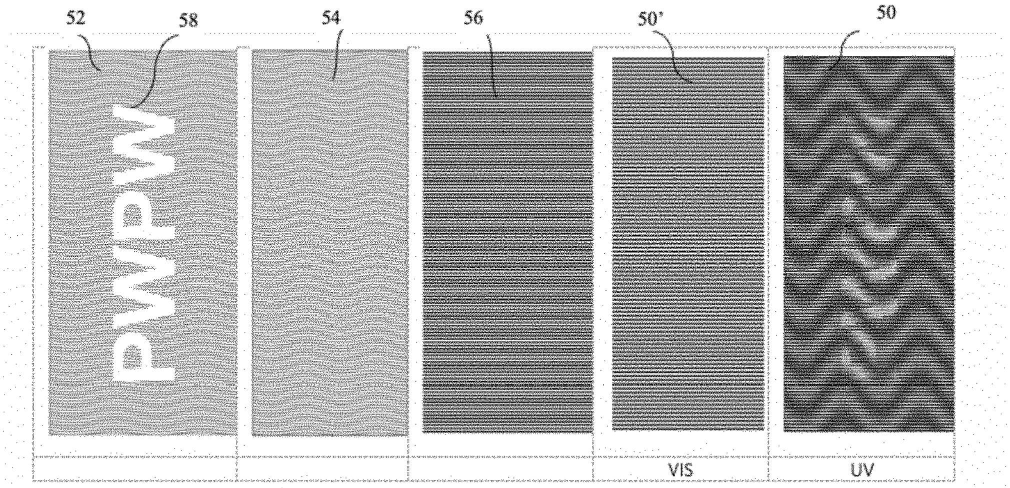

Fig. 5

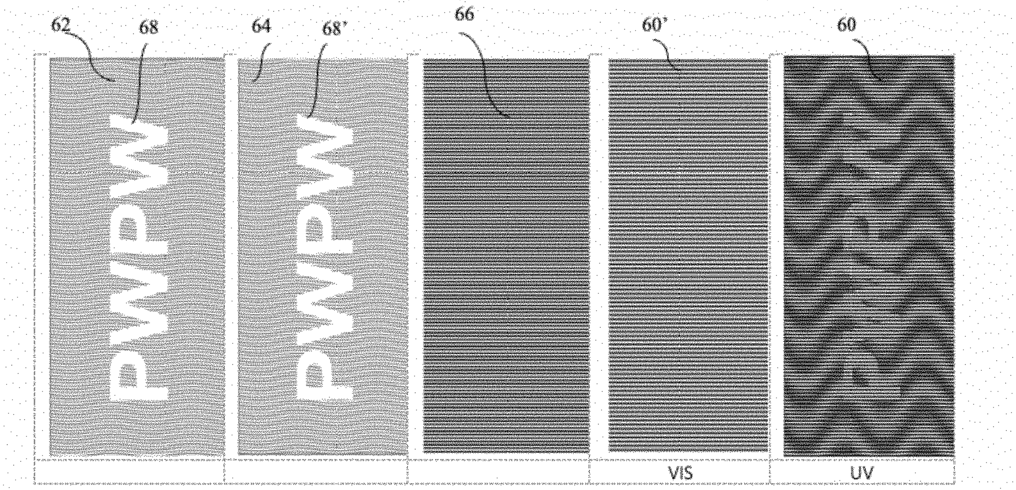

Fig. 6

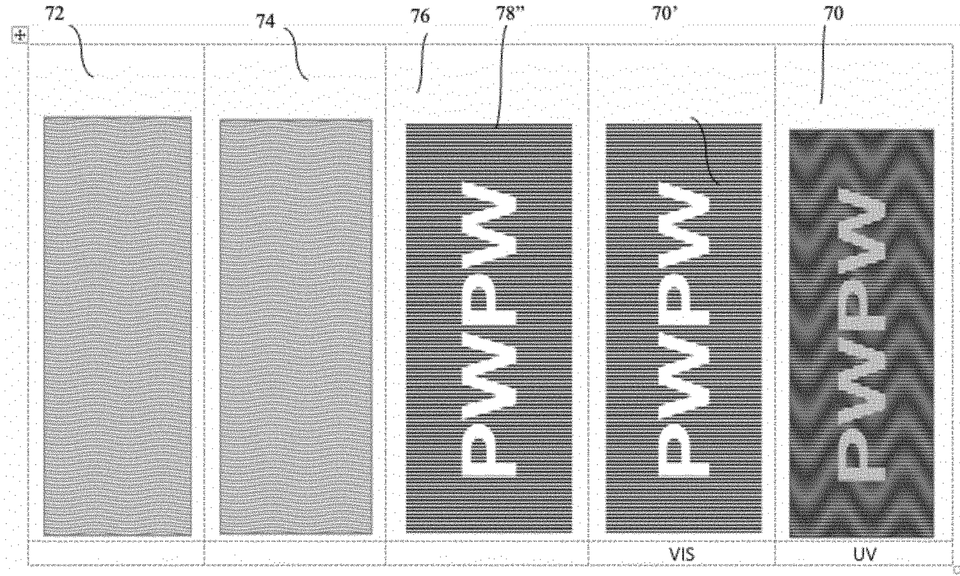

Fig. 7

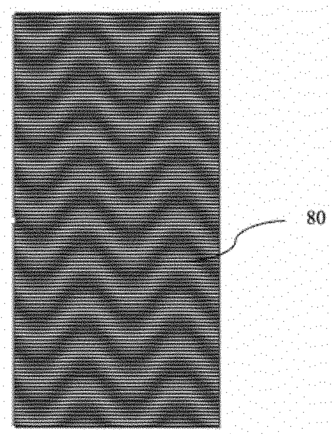

Fig. 8

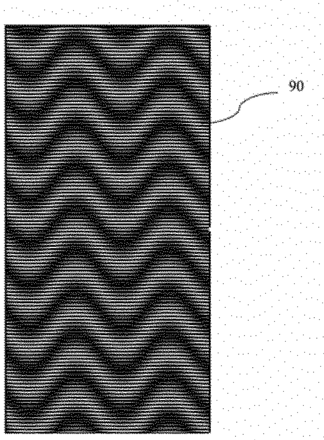

Fig. 9

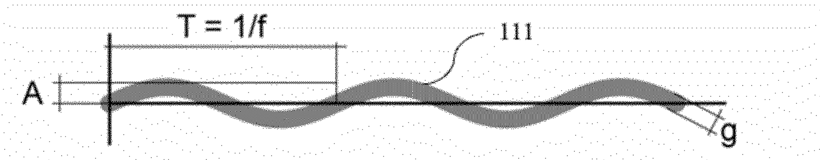

Fig. 10

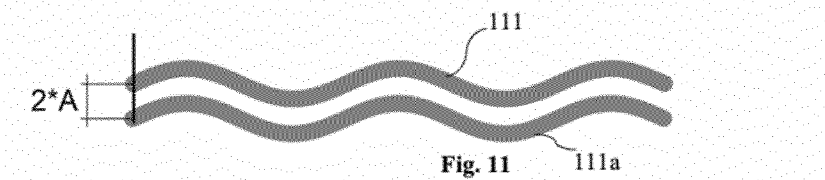

Fig. 11

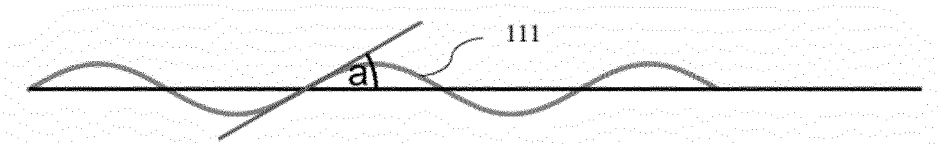

Fig. 12

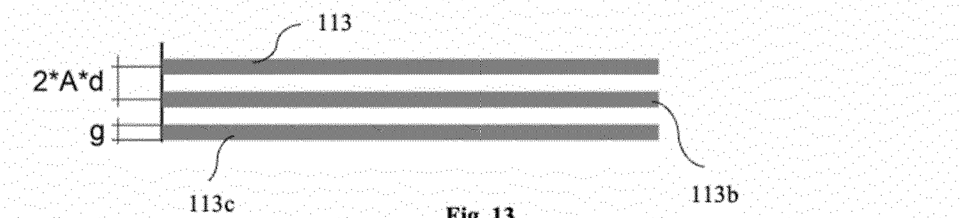

Fig. 13

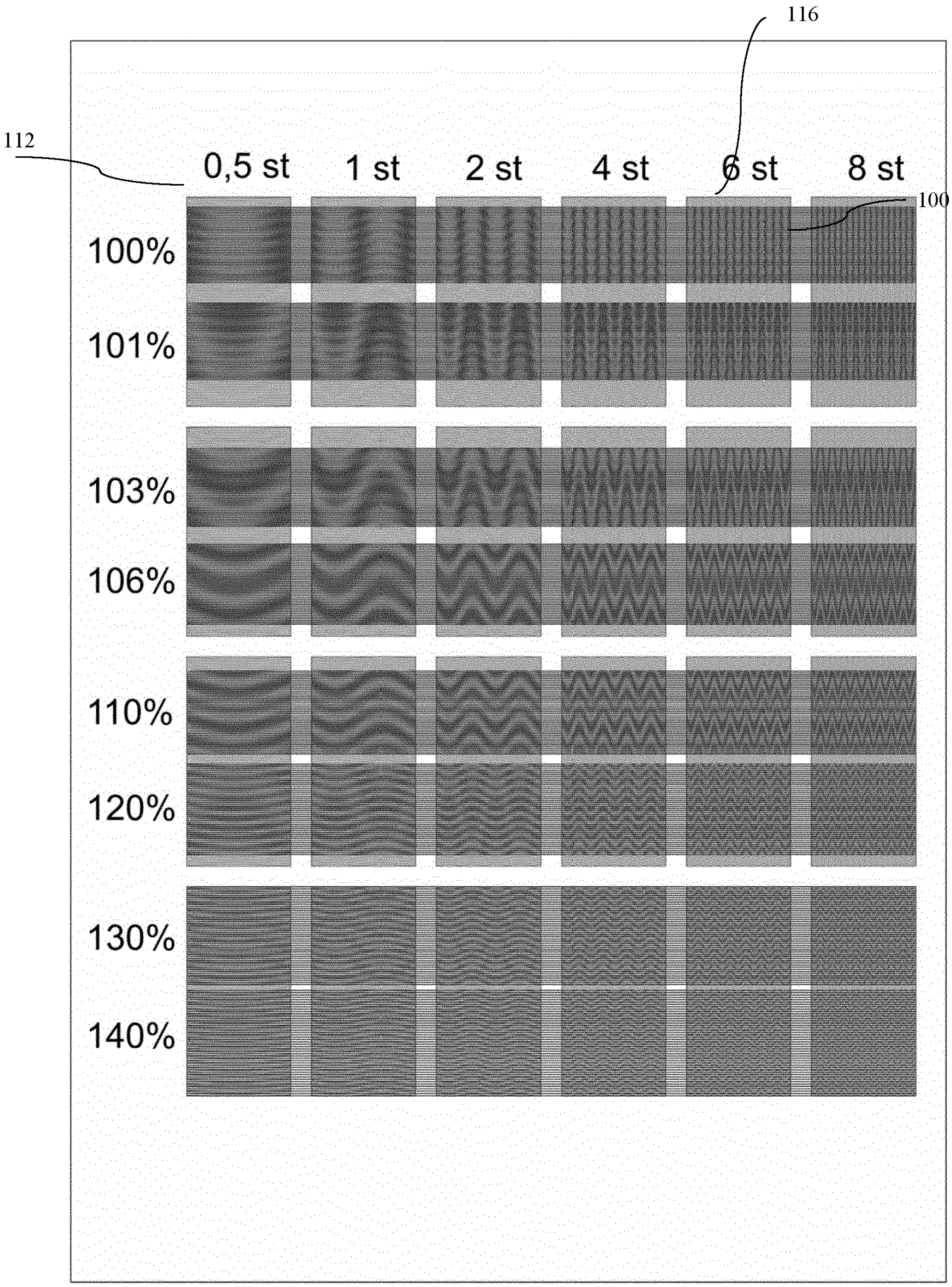
116
112
0,5 st
1 st
2 st
4 st
6 st
8 st
100
100%
101%
103%
106%
110%
120%
130%
140%

Fig. 14

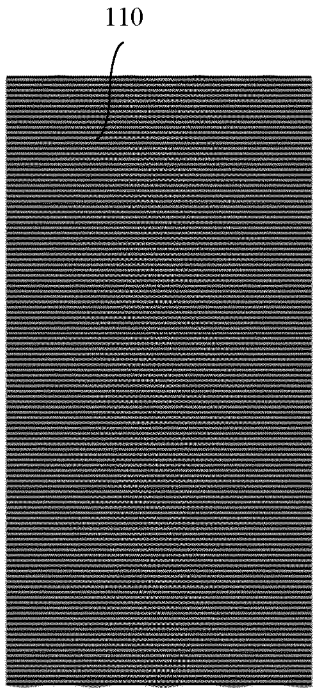

Fig. 15a

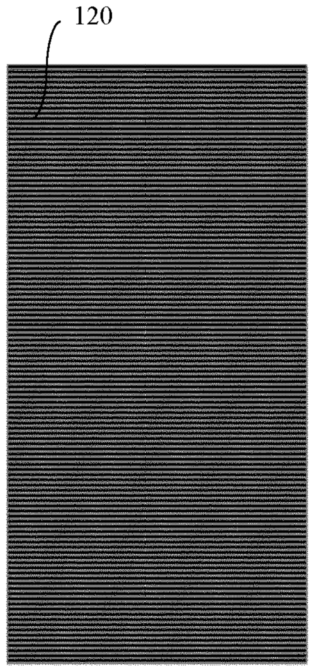

Fig. 15b

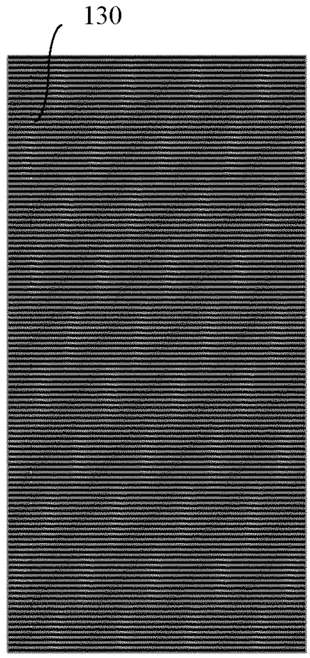

Fig. 15c

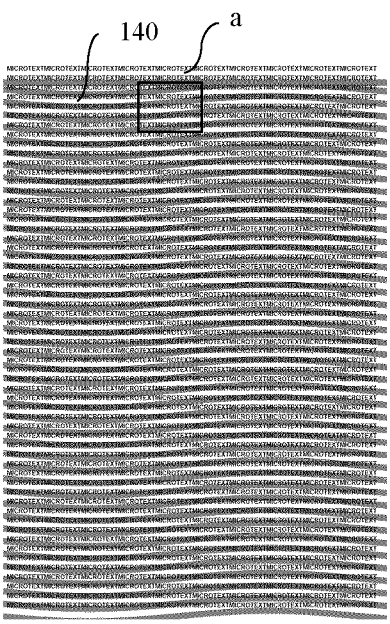

Fig. 16a

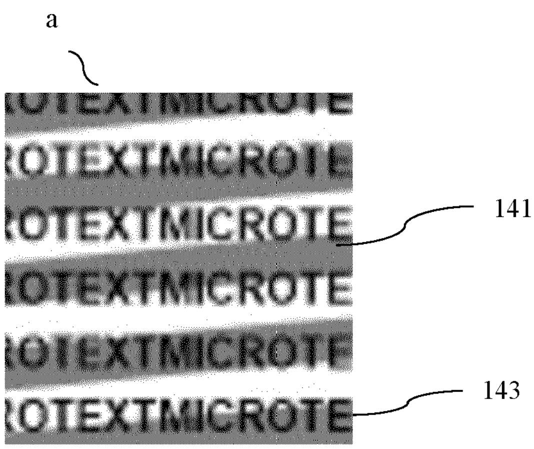

Fig. 16b

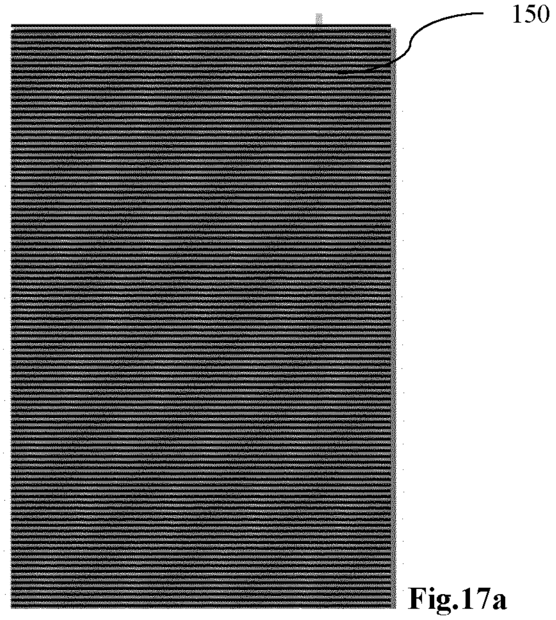

Fig.17a

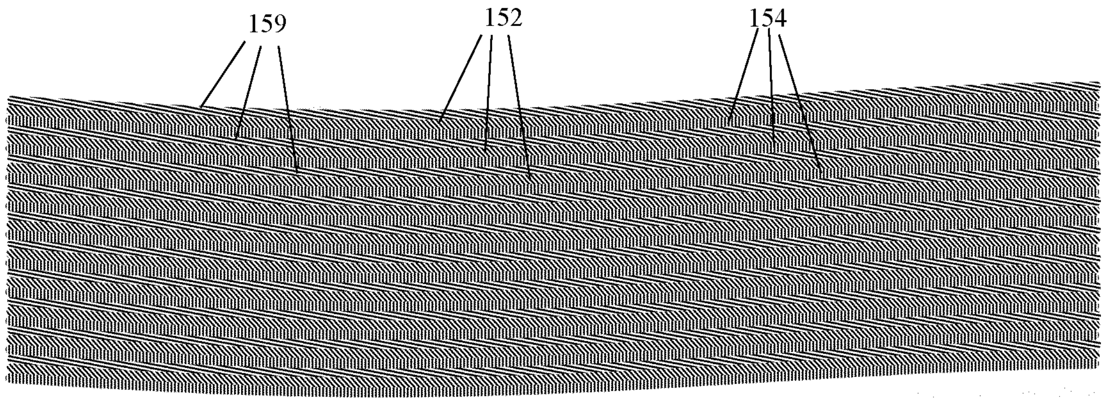

Fig. 17b

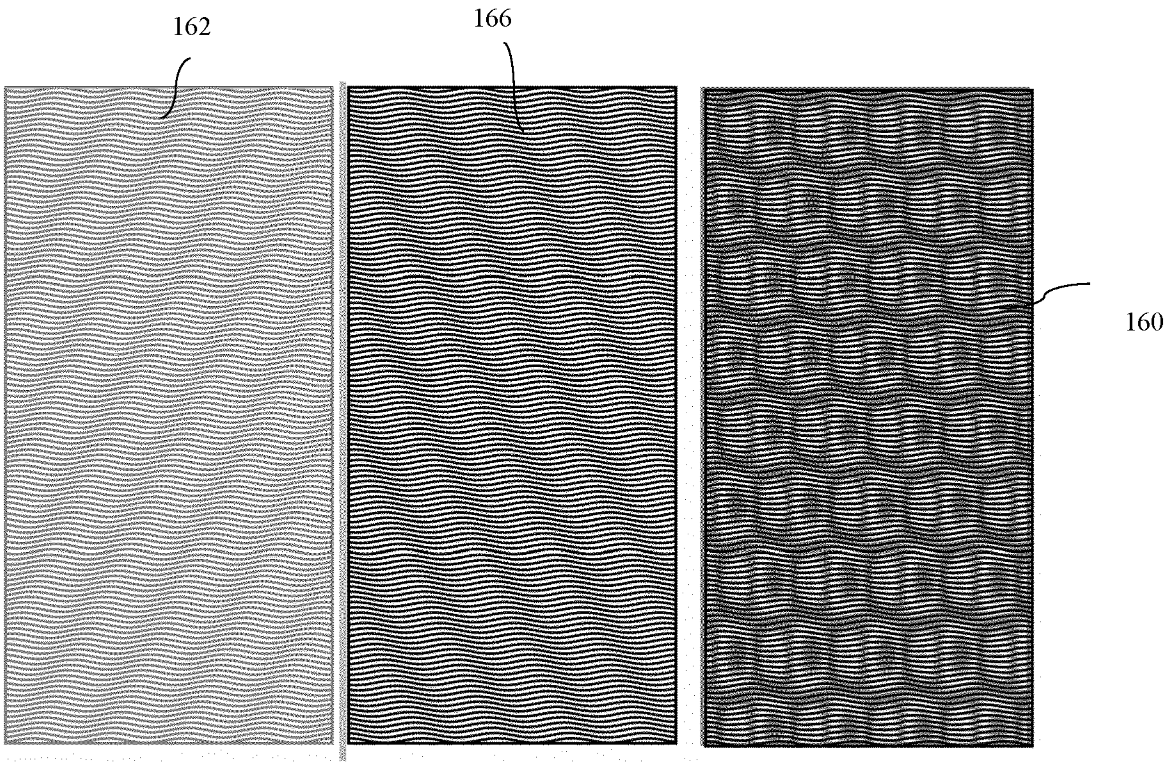

Fig. 18

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 24 02 0282

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	US 2012/189159 A1 (VINCENT REMI [FR]) 26 July 2012 (2012-07-26) * paragraphs [0001], [0031], [0034] - [0039], [0177] - [0186], [0211], [0216] - [0244]; claims; figures 6A-6H, 7 * -----	1-17	INV. B42D25/342 B41M3/14 B42D25/387
A	EP 3 397 500 B1 (OBERTHUR FIDUCIAIRE SAS [FR]) 3 August 2022 (2022-08-03) * the whole document * -----	1-17	
A	US 2006/003295 A1 (HERSCH ROGER D [CH] ET AL) 5 January 2006 (2006-01-05) * claims; figures * -----	1-17	

TECHNICAL FIELDS SEARCHED (IPC)

B42D
B41M

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	14 February 2025	Zacchini, Daniela

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 24 02 0282

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.

14-02-2025

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012189159 A1	26-07-2012	BR 112012000901 A2	22-11-2016
		CA 2768177 A1	20-01-2011
		EP 2454054 A1	23-05-2012
		ES 2425795 T3	17-10-2013
		FR 2948216 A1	21-01-2011
		PL 2454054 T3	31-10-2013
		US 2012189159 A1	26-07-2012
		WO 2011007342 A1	20-01-2011
EP 3397500 B1	03-08-2022	BR 112018013389 A2	04-12-2018
		CN 109070619 A	21-12-2018
		EP 3397500 A1	07-11-2018
		FR 3046111 A1	30-06-2017
		KR 20180098649 A	04-09-2018
		PL 3397500 T3	21-11-2022
		RU 2018123771 A	30-01-2020
		US 2019039402 A1	07-02-2019
		WO 2017114803 A1	06-07-2017
US 2006003295 A1	05-01-2006	AT E399097 T1	15-07-2008
		CA 2591756 A1	19-01-2006
		CN 101010204 A	01-08-2007
		EP 1765602 A1	28-03-2007
		ES 2309771 T3	16-12-2008
		US 2006003295 A1	05-01-2006
		US 2006129489 A1	15-06-2006
		WO 2006006063 A1	19-01-2006

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 1567358 A **[0009]**
- EP 2562726 A **[0010]**
- EP 1554700 A **[0011]**