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(54) **Security paper for laser engraving, security document and method for making security documents**

Sicherheitspapier für die Lasergravur, Sicherheitsdokument und Verfahren zur Herstellung von Sicherheitsdokumenten

Papier sécurisé pour la gravure au laser, document sécurisé et procédé pour la fabrication de documents sécurisés

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## Description

### DESCRIPTION

**[0001]** The invention relates to a security paper for laser engraving, a security document and a method for making security documents.

**[0002]** Security documents may comprise various security features, such as watermarking, microlettering, raised print etc. The security features may be common to all documents of specific type or, preferably, may form personalization markings, i.e. document-individual markings.

**[0003]** Laser engraving is one of the techniques to make markings on security documents. Various attempts have been made to achieve efficient laser engraving of paper-based documents.

**[0004]** A European patent application EP07460036 discloses a paper for personal document sheets, which is coated with a coating mixture containing a pigment, which subjected to laser beam changes color to a contrasting color in relation to the background paper color. Such paper may have personalization markings made thereon by laser engraving, where the laser activates the pigment in the coating.

**[0005]** The aim of the present invention is to provide an improved security paper for laser engraving, a security document comprising the security paper and a method for making security documents, providing improved legibility and clarity of laser-engraved markings.

**[0006]** The object of the invention is a security paper for laser engraving, comprising a paper substrate layer comprising an antimony-oxide-doped tin dioxide laser-marking pigment and titanium white, the paper substrate layer being coated with a coating layer comprising the antimony-oxide-doped tin dioxide laser-marking pigment, such that when the security paper is subject to a laser beam, the antimony-oxide-doped tin dioxide laser-marking pigment causes change of color of the security paper both within the paper substrate layer and the coating layer.

**[0007]** Preferably, the antimony-oxide-doped tin dioxide laser-marking pigment comprises from 95% to 99% by weight of tin dioxide ( $\text{SnO}_2$ ) and from 1% to 5% by weight of antimony oxide ( $\text{Sb}_2\text{O}_3$ ).

**[0008]** Preferably, titanium white comprises rutile form of titanium dioxide ( $\text{TiO}_2$ ).

**[0009]** Preferably, the paper substrate layer comprises from 2,5% to 10%, preferably 5%, by weight of the antimony-oxide-doped tin dioxide laser-marking pigment. Preferably, the paper substrate layer comprises from 2,5% to 10%, preferably 3,5%, by weight of titanium white. Preferably, the coating layer comprises from 0,5% to 3%, preferably 2%, by weight of the antimony-oxide-doped tin dioxide laser-marking pigment.

**[0010]** Another object of the present invention is a security document comprising the security paper according to the invention and comprising laser-engraved markings

having increased visibility in transmitted light, made by activating the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer and in the paper substrate layer by laser beam.

**[0011]** Preferably, at least part of the laser-engraved markings are raised. Preferably, the laser-engraved markings comprise microlettering. Preferably, at least part of the laser-engraved markings are of different shades.

**[0012]** Another object of the present invention is a method for making security documents, comprising the steps of providing a security paper according to the invention and making markings having increased visibility in transmitted light by laser engraving the security paper by activating the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer and in the paper substrate layer by laser beam.

**[0013]** Preferably, the method comprises the step of laser engraving the security paper with a first set of laser beam parameters so as to obtain raised markings. Preferably, the method comprises the step of laser engraving the security paper with a second set of laser beam parameters so as to obtain microlettering markings. Preferably, the method comprises the step of varying the laser beam parameters so as to obtain markings of different shades.

**[0014]** The invention will now be described by way of example and with reference to the accompanying drawings in which:

Fig. 1 shows a structure of a security paper for laser engraving according to the invention.

Fig. 2 shows a structure of a security document according to the invention.

**[0015]** The drawings are not in scale in order to show individual features of the invention more clearly.

**[0016]** A security paper for laser engraving according to the invention has a structure shown in Fig. 1. The paper 100 comprises a paper substrate layer 110 which is coated with a coating layer 120. The paper substrate layer 110 comprises an antimony-oxide-doped tin dioxide laser-marking pigment and titanium white. The coating layer 120 comprises the antimony-oxide-doped tin dioxide laser-marking pigment. Fig. 1 shows the paper substrate layer 110 covered by the coating layer 120 from one side only, but the paper substrate layer 110 may be covered by the coating layer 120 from both sides as well.

**[0017]** The antimony-oxide-doped tin dioxide laser-marking pigment is an absorber, which locally absorbs laser energy and transforms it into thermal energy, causing change of color, such as darkening, of the material in which the pigment is contained. Therefore, when the security paper 100 is subject to a laser beam, the antimony-oxide-doped tin dioxide laser-marking pigment causes change of color of the security paper 100 both within the paper substrate layer 110 and the coating layer 120.

**[0018]** Titanium white allows for increasing the contrast of the laser-engraved markings with respect to the background color of the paper substrate, for example white color. Moreover, use of titanium white results in achieving laser-engraved markings in shades of grey, which have been found to be less susceptible to bleaching as compared to sepia-shaded markings.

**[0019]** The antimony-oxide-doped tin dioxide laser-marking pigment may comprise from 95% to 99% by weight of tin dioxide ( $\text{SnO}_2$ ) and from 1% to 5% by weight of antimony oxide ( $\text{Sb}_2\text{O}_3$ ). Such pigment allows achieving particularly legible and clear laser-engraved markings.

**[0020]** Titanium white may be a rutile form of titanium dioxide ( $\text{TiO}_2$ ).

**[0021]** The paper substrate layer may comprise conventional fibres and additives, and in addition preferably from 2,5% to 10%, preferably 5%, by weight of the antimony-oxide-doped tin dioxide laser-marking pigment, and from 2,5% to 10%, preferably 3,5%, by weight of titanium white.

**[0022]** The coating layer may be made of a conventional coating mixture based on polyvinyl alcohol, which further comprises from 0,5% to 3%, preferably 2%, by weight of the antimony-oxide-doped tin dioxide laser-marking pigment.

**[0023]** The security paper according to the invention may be used to produce various personalized security documents, such as passports, visas, communication documents, marriage status documents, as well as non-personalized security documents, such as banknotes or excise duty documents.

**[0024]** Fig. 2 shows a structure of a security document 200 comprising the security paper according to the invention. The security document 200 comprises markings 231, 232, 233, which can be personalization markings or general security markings, and which are made by activating by laser beam the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer 220 and in the paper substrate layer 210. Due to the fact that the markings are present in both layers 210, 220 of the paper, they have increased visibility in transmitted light, similarly to a watermark, thereby forming a security feature of the document.

**[0025]** At least part 234 of the laser-engraved markings 233 may be raised above the surface of the coating layer 220. Raised markings provide further security features of the document, as well as allow identification of the marking by vision-impaired persons. The raised markings 234 may be achieved by using higher laser beam power, as explained below.

**[0026]** The laser-engraved markings 232 may comprise microlettering, i.e. a string of characters having a small font size, as small as about 0,5 mm in height. Microlettering may also form a security feature of the document. Microlettering 232 markings and other high-quality vector graphics may be achieved by using moderate laser power and relatively low laser beam speed.

**[0027]** Furthermore, at least part of the laser-engraved markings 231 may have different shades. This allows laser-engraving of images with shade-variable background, such as stamps, which may constitute an important security feature of the document. Shade-variable backgrounds 231 may be achieved by varying laser beam power and speed.

**[0028]** The security document according to the invention may be made by providing a security paper 100 according to the invention and laser engraving the security paper 100 by activating by laser beam the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer 120 and in the paper substrate layer 110.

**[0029]** In one embodiment of the method according to the invention, an Nd:YAG 1064 nm laser is used for activating the antimony-oxide-doped tin dioxide laser-marking pigment. In this embodiment, the impulse duration of the laser is set to 15ns.

**[0030]** In order to obtain plain, shaded image, the following laser beam parameters may be used: impulse power from  $1,2 \cdot 10^{14}$  to  $1,8 \cdot 10^{14}$  [W/m<sup>2</sup>], speed 20000 mm/s, impulse frequency from 700 to 1500 Hz. The shade of the marking may be varied by varying the impulse power and frequency: the higher the impulse power and frequency, the darker the shade of the obtained marking.

**[0031]** In order to obtain markings of high quality, such as vector graphics or microlettering, the following laser beam parameters may be used: impulse power from  $1,1 \cdot 10^{14}$  to  $1,4 \cdot 10^{14}$  [W/m<sup>2</sup>], speed from 30 to 60 mm/s, impulse frequency 1500 Hz.

**[0032]** In order to obtain raised markings, the following laser beam parameters may be used: impulse power from  $2,2 \cdot 10^{14}$  to  $2,4 \cdot 10^{14}$  [W/m<sup>2</sup>], speed from 50 to 160 mm/s, impulse frequency 1500 Hz. A higher impulse power leads to higher amount of absorbed energy by the antimony-oxide-doped tin dioxide laser-marking pigment and raising of marking above the surface of the coating layer.

## Claims

1. A security paper for laser engraving, comprising a paper substrate layer (110) comprising an antimony-oxide-doped tin dioxide laser-marking pigment and titanium white, the paper substrate layer (110) being coated with a coating layer (120) comprising the antimony-oxide-doped tin dioxide laser-marking pigment, such that when the security paper (100) is subject to a laser beam, the antimony-oxide-doped tin dioxide laser-marking pigment absorbs the laser beam energy, which is transferred into thermal energy and leading to a change of color of the security paper (100) both within the paper substrate layer (110) and the coating layer (120).
2. The security paper according to claim 1, **character-**

**ized in that** the antimony-oxide-doped tin dioxide laser-marking pigment comprises from 95% to 99% by weight of tin dioxide ( $\text{SnO}_2$ ) and from 1 % to 5% by weight of antimony oxide ( $\text{Sb}_2\text{O}_3$ ).

3. The security paper according to claim 1 or 2, **characterized in that** titanium white comprises rutile form of titanium dioxide ( $\text{TiO}_2$ ).
4. The security paper according to any previous claim, **characterized in that** the paper substrate layer (110) comprises from 2,5% to 10%, preferably 5%, by weight of the antimony-oxide-doped tin dioxide laser-marking pigment.
5. The security paper according to any previous claim, **characterized in that** the paper substrate layer (110) comprises from 2,5% to 10%, preferably 3,5%, by weight of titanium white.
6. The security paper according to any previous claim, **characterized in that** the coating layer (120) comprises from 0,5% to 3%, preferably 2%, by weight of the antimony-oxide-doped tin dioxide laser-marking pigment.
7. A security document comprising the security paper according to any of claims 1 to 6 and comprising laser-engraved markings (231, 232, 233) having increased visibility in transmitted light, made by activating the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer (220) and in the paper substrate layer (210) by a laser beam of parameters such that when the laser beam energy is absorbed by the antimony-oxide-doped tin dioxide laser-marking pigment and transformed into thermal energy, this leads to a change of color of the security paper (100) both within the paper substrate layer (110) and the coating layer (120).
8. The security document according to claim 7, **characterized in that** at least part (234) of the laser-engraved markings (233) are made by activating the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer (220) and in the paper substrate layer (210) by a laser beam having impulse power from  $2,2 \cdot 10^{14}$  to  $2,4 \cdot 10^{14}$  [W/m<sup>2</sup>], speed from 50 to 160 mm/s, impulse frequency 1500 Hz that causes raising of markings above the surface of the coating layer.
9. The security document according to claim 7 or 8, **characterized in that** the laser-engraved markings (232) are made by activating the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer (220) and in the paper substrate layer (210) by a laser beam having impulse power from  $1,1 \cdot 10^{14}$  to  $1,4 \cdot 10^{14}$  [W/m<sup>2</sup>], speed from 30 to 60 mm/s, im-

pulse frequency 1500 Hz that causes forming of microlettering markings.

10. The security document according to any of claims 7 to 9, **characterized in that** at least part of the laser-engraved markings (231) are made by activating the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer (220) and in the paper substrate layer (210) by a laser beam of variable power and speed and having impulse power from  $1,2 \cdot 10^{14}$  to  $1,8 \cdot 10^{14}$  [W/m<sup>2</sup>], speed 20000 mm/s, impulse frequency from 700 to 1500 Hz such that causes forming of shade-variable markings.
11. A method for making security documents, comprising the steps of providing a security paper (100) according to any of claims 1 to 6 and making markings (231, 232, 233) having increased visibility in transmitted light by laser engraving the security paper (100) by activating by laser beam the antimony-oxide-doped tin dioxide laser-marking pigment in the coating layer (120) and in the paper substrate layer (110).
12. The method according to claim 11, comprising the step of laser engraving the security paper (100) with a laser beam having impulse power from  $2,2 \cdot 10^{14}$  to  $2,4 \cdot 10^{14}$  [W/m<sup>2</sup>], speed from 50 to 160 mm/s, impulse frequency 1500 Hz such that causes raising of markings above the surface of the coating layer.
13. The method according to claim 11 or 12, comprising the step of laser engraving the security paper by a laser beam having impulse power from  $1,1 \cdot 10^{14}$  to  $1,4 \cdot 10^{14}$  [W/m<sup>2</sup>], speed from 30 to 60 mm/s, impulse frequency 1500 Hz such that causes forming of microlettering markings..
14. The method according to any of claims 11 to 13, comprising the step of varying the laser beam parameters, having impulse power from  $1,2 \cdot 10^{14}$  to  $1,8 \cdot 10^{14}$  [W/m<sup>2</sup>], speed 20000 mm/s, impulse frequency from 700 to 1500 Hz, so as to obtain markings of different shades (231).

#### Patentansprüche

1. Sicherheitspapier für die Lasergravur, das eine Papiersubstratschicht (110) umfasst, die ein mit Antimonoxid dotiertes Zinndioxid-Lasermarkierungspigment und Titanweiß umfasst, wobei die Papiersubstratschicht (110) mit einer Beschichtungsschicht (120) beschichtet ist, die das mit Antimonoxid dotierte Zinndioxid-Lasermarkierungspigment umfasst, sodass, wenn das Sicherheitspapier (100) einem Laserstrahl ausgesetzt wird, das mit Antimonoxid dotierte Zinndioxid-Lasermarkierungspigment die En-

ergie des Laserstrahls absorbiert, die in thermische Energie umgewandelt wird, was zu einer Farbänderung des Sicherheitspapiers (100), sowohl innerhalb der Papiersubstratschicht (110) als auch innerhalb der Beschichtungsschicht (120), führt.

2. Sicherheitspapier nach Anspruch 1, **dadurch gekennzeichnet, dass** das mit Antimonoxid dotierte Zinndioxid-Lasermarkierungspigment zwischen 95 und 99 Gewichtsprozent Zinndioxid ( $\text{SnO}_2$ ) sowie zwischen 1 und 5 Gewichtsprozent Antimonoxid ( $\text{Sb}_2\text{O}_3$ ) umfasst.
3. Sicherheitspapier nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das Titanweiß die Rutilform des Titandioxids ( $\text{TiO}_2$ ) umfasst.
4. Sicherheitspapier nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Papiersubstratschicht (110) zwischen 2,5 und 10 Gewichtsprozent, bevorzugt 5 Gewichtsprozent, mit Antimonoxid dotiertes Zinndioxid-Lasermarkierungspigment umfasst.
5. Sicherheitspapier nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Papiersubstratschicht (110) zwischen 2,5 und 10 Gewichtsprozent, bevorzugt 3,5 Gewichtsprozent, Titanweiß umfasst.
6. Sicherheitspapier nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Beschichtungsschicht (120) zwischen 0,5 und 3 Gewichtsprozent, bevorzugt 2 Gewichtsprozent, mit Antimonoxid dotiertes Zinndioxid-Lasermarkierungspigment umfasst.
7. Sicherheitsdokument, das das Sicherheitspapier nach einem der Ansprüche 1 bis 6 umfasst und das lasergravierte Markierungen (231, 232, 233) umfasst, die eine höhere Sichtbarkeit in Durchlicht aufweisen, die durch das Aktivieren des mit Antimonoxid dotierten Zinndioxid-Lasermarkierungspigments in der Beschichtungsschicht (220) und in der Papiersubstratschicht (210) durch einen Laserstrahl mit derartigen Parametern zustande kommt, die, wenn die Energie des Laserstrahls durch das mit Antimonoxid dotierte Zinndioxid-Lasermarkierungspigment absorbiert und in thermische Energie umgewandelt wird, zu einer Farbänderung des Sicherheitspapiers (100), sowohl innerhalb der Papiersubstratschicht (110) als auch innerhalb der Beschichtungsschicht (120), führen.
8. Sicherheitsdokument nach Anspruch 7, **dadurch gekennzeichnet, dass** zumindest ein Teil (234) der lasergravierten Markierungen (233) durch das Aktivieren des mit Antimonoxid dotierten Zinndioxid-La-

sermarkierungspigments in der Beschichtungsschicht (220) und in der Papiersubstratschicht (210) durch einen Laserstrahl mit einer Impulskraft von  $2,2 \cdot 10^{14}$  bis  $2,4 \cdot 10^{14}$  [ $\text{W}/\text{m}^2$ ], einer Geschwindigkeit von 50 bis 160 mm/s und einer Impulsfrequenz von 1500 Hz zustande kommt, der das Bilden von erhabenen Markierungen über der Oberfläche der Beschichtungsschicht veranlasst.

9. Sicherheitsdokument nach Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** die lasergravierten Markierungen (232) durch das Aktivieren des mit Antimonoxid dotierten Zinndioxid-Lasermarkierungspigments in der Beschichtungsschicht (220) und in der Papiersubstratschicht (210) durch einen Laserstrahl mit einer Impulskraft von  $1,1 \cdot 10^{14}$  bis  $1,4 \cdot 10^{14}$  [ $\text{W}/\text{m}^2$ ], einer Geschwindigkeit von 30 bis 60 mm/s und einer Impulsfrequenz von 1500 Hz zustande kommen, der das Bilden von Mikrotex-Markierungen veranlasst.
10. Sicherheitsdokument nach einem der Ansprüche 7 bis 9, **dadurch gekennzeichnet, dass** die lasergravierten Markierungen (231) zumindest teilweise durch das Aktivieren des mit Antimonoxid dotierten Zinndioxid-Lasermarkierungspigments in der Beschichtungsschicht (220) und in der Papiersubstratschicht (210) durch einen Laserstrahl mit variabler Kraft und Geschwindigkeit und einer Impulskraft von  $1,2 \cdot 10^{14}$  bis  $1,8 \cdot 10^{14}$  [ $\text{W}/\text{m}^2$ ], einer Geschwindigkeit von 20000 mm/s und einer Impulsfrequenz von 700 bis 1500 Hz zustande kommen, sodass das Bilden von Markierungen mit variablen Schattierungen veranlasst wird.
11. Verfahren zur Herstellung von Sicherheitsdokumenten, das die Schritte des Bereitstellens eines Sicherheitspapiers (100) nach einem der Ansprüche 1 bis 6 und des Herstellens von Markierungen (231, 232, 233), die eine höhere Sichtbarkeit in Durchlicht aufweisen, durch Lasergravur des Sicherheitspapiers (100) durch das Aktivieren des mit Antimonoxid dotierten Zinndioxid-Lasermarkierungspigments in der Beschichtungsschicht (120) und in der Papiersubstratschicht (110) mit einem Laserstrahl umfasst.
12. Verfahren nach Anspruch 11, das den Schritt der Lasergravur des Sicherheitspapiers (100) mit einem Laserstrahl mit einer Impulskraft von  $2,2 \cdot 10^{14}$  bis  $2,4 \cdot 10^{14}$  [ $\text{W}/\text{m}^2$ ], einer Geschwindigkeit von 50 bis 160 mm/s und einer Impulsfrequenz von 1500 Hz umfasst, sodass das Bilden von erhabenen Markierungen über der Oberfläche der Beschichtungsschicht veranlasst wird.
13. Verfahren nach Anspruch 11 oder 12, das den Schritt der Lasergravur des Sicherheitspapiers mit einem Laserstrahl mit einer Impulskraft von  $1,1 \cdot 10^{14}$  bis

$1,4 \cdot 10^{14}$  [W/m<sup>2</sup>], einer Geschwindigkeit von 30 bis 60 mm/s und einer Impulsfrequenz von 1500 Hz umfasst, sodass das Bilden von Mikrotext-Markierungen veranlasst wird.

14. Verfahren nach einem der Ansprüche 11 bis 13, das den Schritt des Variierens der Laserstrahlparameter mit einer Impulskraft von  $1,2 \cdot 10^{14}$  bis  $1,8 \cdot 10^{14}$  [W/m<sup>2</sup>], einer Geschwindigkeit von 20000 mm/s und einer Impulsfrequenz von 700 bis 1500 Hz umfasst, um Markierungen mit unterschiedlichen Schattierungen (231) zu erhalten.

## Revendications

1. Papier sécurisé pour gravure au laser, comprenant une couche de substrat de papier (110) comprenant un pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine et du blanc de titane, la couche de substrat de papier (110) étant appliquée avec une couche de revêtement (120) comprenant le pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine, de sorte que lorsque le papier sécurisé (100) est soumis à un faisceau laser, le pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine absorbe l'énergie du faisceau laser, qui est transférée en énergie thermique et qui entraîne un changement de couleur du papier sécurisé (100) aussi bien dans la couche de substrat de papier (110) que dans la couche de revêtement (120).
2. Papier sécurisé selon la revendication 1, **caractérisé en ce que** le pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine comprend de 95 % à 99 % en poids de dioxyde d'étain (SnO<sub>2</sub>) et de 1 % à 5 % en poids d'oxyde d'antimoine (Sb<sub>2</sub>O<sub>3</sub>).
3. Papier sécurisé selon la revendication 1 ou 2, **caractérisé en ce que** le blanc de titane comprend la forme rutil de dioxyde de titane (TiO<sub>2</sub>).
4. Papier sécurisé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la couche de substrat de papier (110) comprend de 2,5 % à 10 %, de préférence 5 % en poids de pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine.
5. Papier sécurisé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la couche de substrat de papier (110) comprend de 2,5 % à 10 %, de préférence 3,5 % en poids de blanc de titane.
6. Papier sécurisé selon l'une quelconque des reven-

dications précédentes, **caractérisé en ce que** la couche de revêtement (120) comprend de 0,5 % à 3 %, de préférence 2 % en poids de pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine.

7. Document sécurisé comprenant le papier sécurisé selon l'une quelconque des revendications 1 à 6 et comportant des marques (231, 232, 233) gravées au laser ayant une visibilité accrue en lumière transmise, réalisées par activation du pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine dans la couche de revêtement (220) et dans la couche de substrat de papier (210) par un faisceau laser de paramètres tels que lorsque l'énergie du faisceau laser est absorbée par le pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine et transformée en énergie thermique, ceci conduit à un changement de couleur du papier sécurisé (100) aussi bien dans la couche de substrat de papier (110) que dans la couche de revêtement (120).
8. Document sécurisé selon la revendication 7, **caractérisé en ce qu'**au moins une partie (234) des marques (233) gravées au laser sont réalisées par activation du pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine dans la couche de revêtement (220) et dans la couche de substrat de papier (210) par un faisceau laser ayant une puissance d'impulsions de  $2,2 \times 10^{14}$  à  $2,4 \times 10^{14}$  [W/m<sup>2</sup>], une vitesse de 50 à 160 mm/s, une fréquence d'impulsions de 1500 Hz qui provoque une remontée des marques au-dessus de la surface de la couche de revêtement.
9. Document sécurisé selon la revendication 7 ou 8, **caractérisé en ce que** les marques (232) gravées au laser sont réalisées par activation du pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine dans la couche de revêtement (220) et dans la couche de substrat de papier (210) par un faisceau laser ayant une puissance d'impulsions de  $1,1 \times 10^{14}$  à  $1,4 \times 10^{14}$  [W/m<sup>2</sup>], une vitesse de 30 à 60 mm/s, une fréquence d'impulsions de 1500 Hz qui provoque la formation de marques sous forme de micro-lettres.
10. Document sécurisé selon l'une quelconque des revendications 7 à 9, **caractérisé en ce qu'**au moins une partie des marques (231) gravées au laser sont réalisées par activation du pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine dans la couche de revêtement (220) et dans la couche de substrat de papier (210) par un faisceau laser ayant une puissance et une vitesse variables et ayant une puissance d'impulsions de  $1,2 \times 10^{14}$  à  $1,8 \times 10^{14}$  [W/m<sup>2</sup>], une vitesse de 20000 mm/s, une

fréquence d'impulsions de 700 à 1500 Hz telle qu'elle provoque la formation de marques variables en termes de nuance.

11. Procédé de fabrication de documents sécurisés, comprenant les étapes consistant à fournir un papier sécurisé (100) selon l'une quelconque des revendications 1 à 6 et réaliser des marques (231, 232, 233) ayant une visibilité accrue en lumière transmise par gravure au laser du papier sécurisé (100) par activation par faisceau laser du pigment de marquage par laser de dioxyde d'étain dopé à l'oxyde d'antimoine dans la couche de revêtement (120) et dans la couche du substrat de papier (110). 5  
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12. Procédé selon la revendication 11, comprenant l'étape de gravure au laser du papier sécurisé (100) avec un faisceau laser ayant une puissance d'impulsions de  $2,2 \times 10^{14}$  à  $2,4 \times 10^{14}$  [W/m<sup>2</sup>], une vitesse de 50 à 160 mm/s, une fréquence d'impulsions de 1500 Hz telle qu'elle provoque la remontée des marques au-dessus de la surface de la couche de revêtement. 15  
20
13. Procédé selon la revendication 11 ou 12, comprenant l'étape de gravure au laser du papier sécurisé par un faisceau laser ayant une puissance d'impulsions de  $1,1 \times 10^{14}$  à  $1,4 \times 10^{14}$  [W/m<sup>2</sup>], une vitesse de 30 à 60 mm/s, une fréquence d'impulsions de 1500 Hz telle qu'elle provoque la formation de marques sous forme de micro-lettres. 25  
30
14. Procédé selon l'une quelconque des revendications 11 à 13, comprenant l'étape consistant à faire varier les paramètres du faisceau laser, ayant une puissance d'impulsions de  $1,2 \times 10^{14}$  à  $1,8 \times 10^{14}$  [W/m<sup>2</sup>], une vitesse de 20000 mm/s, une fréquence d'impulsions de 700 à 1500 Hz, de façon à obtenir des marques de différentes nuances (231). 35  
40  
45  
50  
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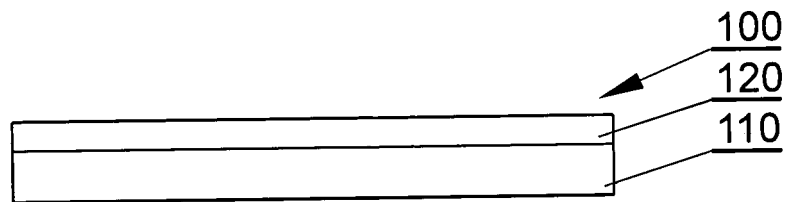


Fig. 1

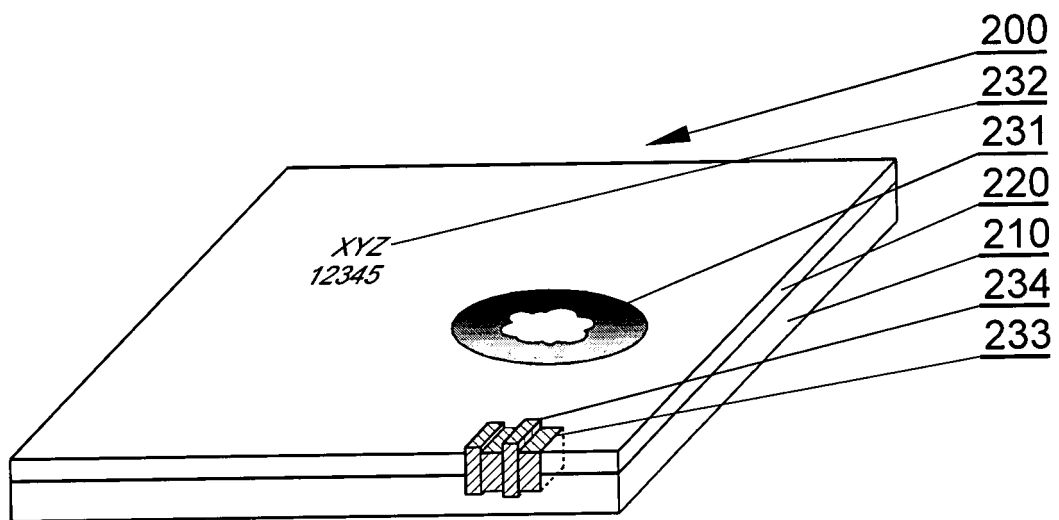


Fig. 2



**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- EP 07460036 A [0004]