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(54) **METHOD FOR PRINTING AN IMAGE ONTO A THERMOPLASTIC SUBSTRATE, PERFORMING PLATE USED THEREFOR AND SECURITY INSTRUMENT MADE THEREFROM**

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(57) **ABSTRACT**

A method is provided by the invention for printing surface applied images to a thermoplastic substrate to provide improved durability to the printed image. A preforming plate (e.g. lamination plate) for making a thermoplastic substrate used by the method and a security instrument made by the method are also provided by the invention. A thermoplastic substrate comprises in a predetermined area a pattern, preferably a cell pattern, of recessed image receiving surfaces below a nominal surface of the thermoplastic substrate and a pattern of bridges separating the recessed image receiving surfaces, the depths of the recessed image receiving surfaces and the areas of the bridges separating the recessed image receiving surfaces, relative to the areas of the recessed image receiving surfaces, chosen to provide durability to the image after the image has been printed onto the predetermined area. The image may be printed by ink jet printing. To additionally provide security features to the security instrument, latent and hidden images may be formed by latent image recesses and hidden image recesses, respectively, below the nominal surface.

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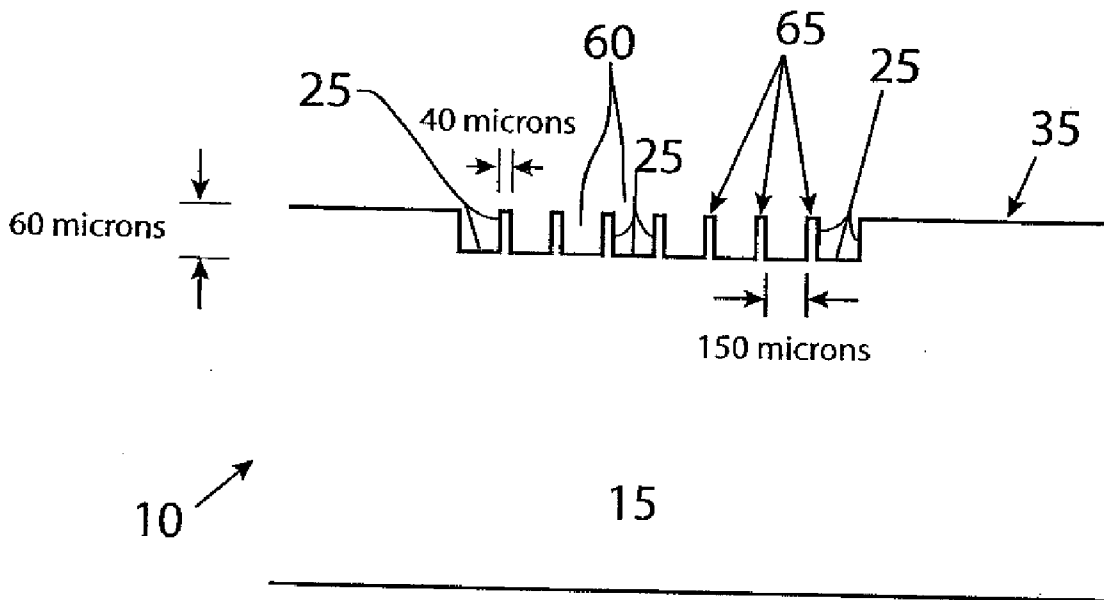
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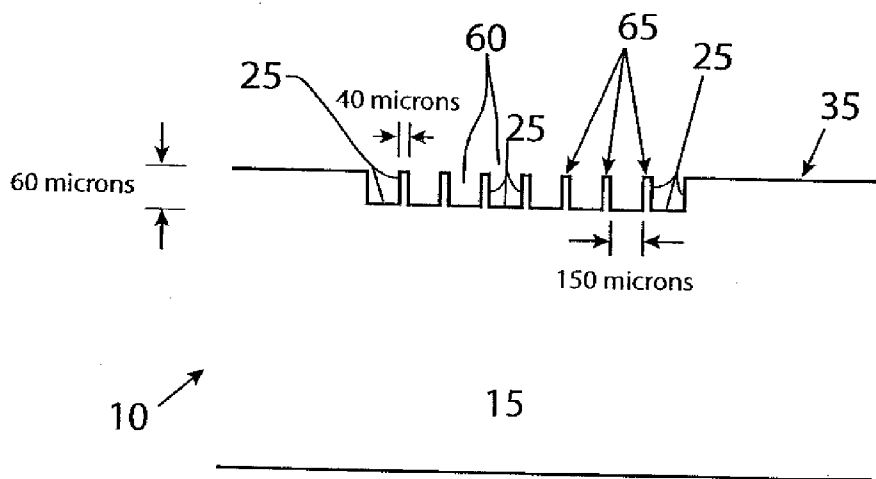
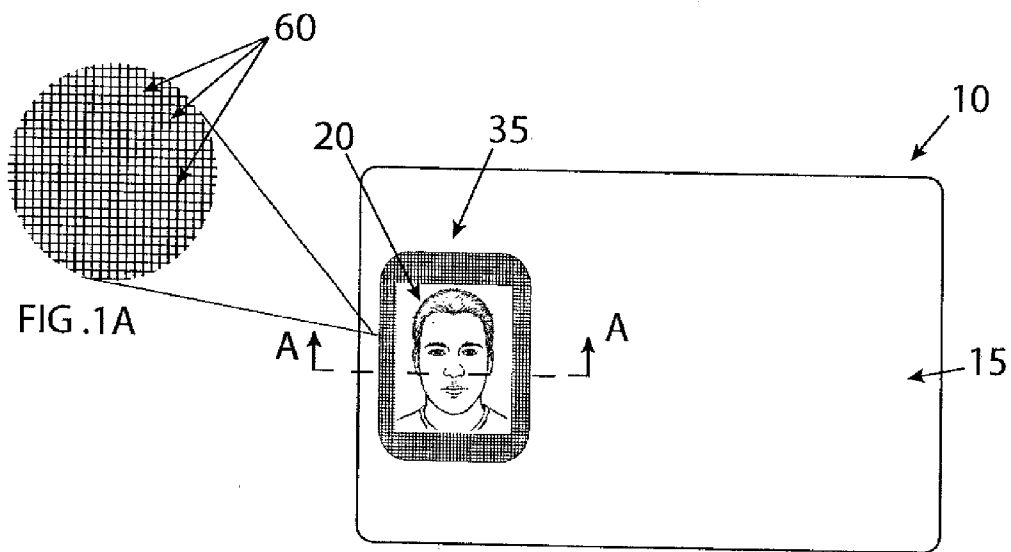
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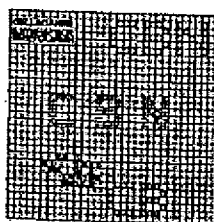


FIG. 5A

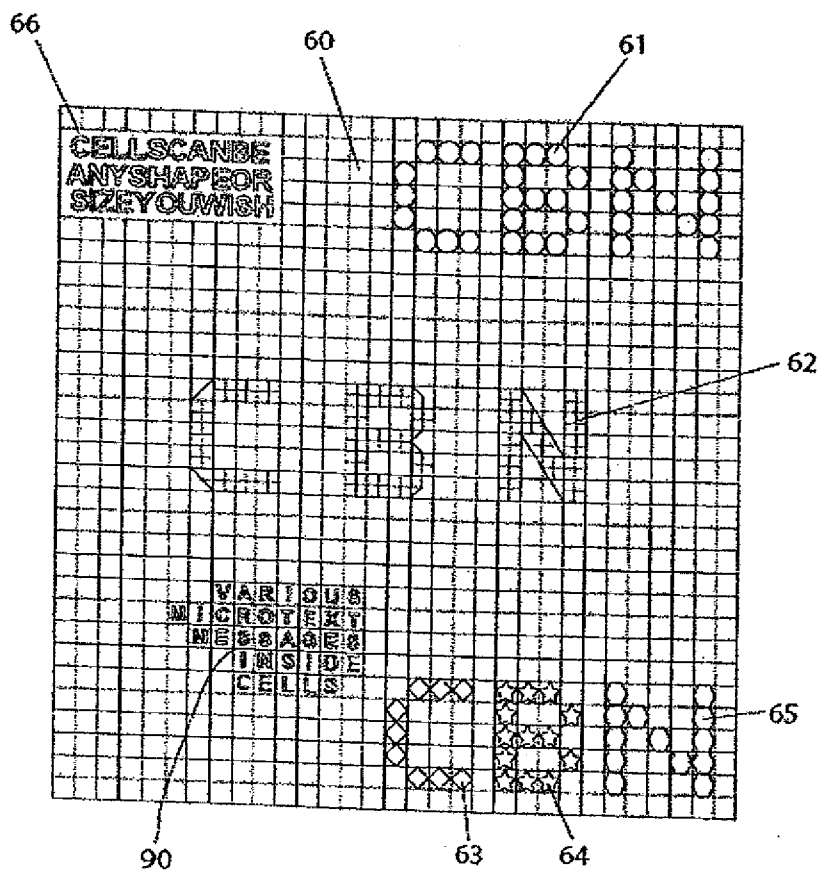


FIG. 5B

**METHOD FOR PRINTING AN IMAGE ONTO
A THERMOPLASTIC SUBSTRATE,
PER-FORMING PLATE USED THEREFOR
AND SECURITY INSTRUMENT MADE
THEREFROM**

FIELD OF THE INVENTION

[0001] The invention relates generally to printing surface-applied images onto thermoplastic substrates used for security instruments such as identification cards and sheets, and, more particularly, to printing onto thermoplastic substrates surface-applied images having improved durability and security.

BACKGROUND

[0002] Security instruments such as identification cards and sheets normally include one or more printed images which are used to identify the cardholder and authenticate the security instrument. For example, a security instrument in the form of an identification card, a driver's license or personal identification sheet of a passport may be made of a thermoplastic substrate and bear a printed photograph of the person to whom the card, license or passport was issued to identify and verify a person holding the instrument. Typically, this photograph may be printed onto the thermoplastic substrate by means of ink jet printing using an ultraviolet (UV) curable ink. According to presently used ink jet printing methods, the UV cured ink jet image is applied to the surface of the thermoplastic substrate of the card which has a generally smooth or matte surface. After the personalization image has been printed onto the surface of the substrate a clear coating, or patch, may be printed over it to provide additional protection to the image. A protective patch typically comprises a UV cured varnish which is also applied by means of ink jet printing. Alternatively, hot lamination of a polyester patch is sometimes used. Disadvantageously, however, using a patch will increase the manufacturing cost for the security instrument and, depending upon the application, the patch may be prone to separate from the image.

[0003] To improve the adherence of the printed image to the surface of the thermoplastic substrate of a card an adhesion promoter may be used. It has been found, however, that the resulting images provide poorer characteristics of adhesion than desired.

[0004] One durability test method that is used for secure instruments comprising printed images, as an indicator of the wear resistance of the image is the Taber Abrasion Test. For example, using this test, a thermoplastic identification card comprising a personalization image printed by means of ink jet printing is typically expected to withstand 5,000 abrasion cycles during testing, without any degradation of the personalized areas on the card including those areas on which the personalization image appears.

[0005] In addition to improving both the adhesion and durability, it is desirable that personalization images (i.e. images used to authenticate a person's identity) applied to secure instruments be resistant to tampering by forgers, such as by replacing an authentic, personalized image with a non-authentic image. Increased security may be provided by incorporating predetermined features for detection and verification of the instrument for authenticity which are difficult to reproduce by a forger.

[0006] Therefore, it is desirable to provide one or more of the characteristics of improved adhesion, durability and security to secure instruments having surface applied printed images thereon.

SUMMARY OF THE INVENTION

[0007] The invention provides means for surface application of images, by printing, to preformed recessed image receiving surfaces of a thermoplastic substrate whereby the preformed recessed image receiving surfaces are below a nominal surface of the thermoplastic substrate and have dimensions designed according to the level of security and degree of durability desired for the particular application. For example, using preformed recesses of larger depth below the nominal surface of the substrate will generally provide greater durability and using preformed recesses of larger area below the nominal surface will accommodate a greater number and/or type of images in order to increase security. The preformed recessed image receiving surfaces may comprise of a pattern of cell structures of predetermined dimensions separated by a bridge pattern of predetermined dimensions which is preformed and recessed below a nominal surface of the substrate, wherein the predetermined dimensions of both the cell pattern and bridge pattern are chosen according to the level of security and degree of durability desired.

[0008] In accordance with the invention a method is provided for printing an image onto a predetermined area of a thermoplastic substrate. A thermoplastic substrate comprises in the predetermined area a pattern of recessed image receiving surfaces below a nominal surface of the thermoplastic substrate and a pattern of bridges separating the recessed image receiving surfaces, the depths of the recessed image receiving surfaces and the areas of the bridges separating the recessed image receiving surfaces, relative to the areas of the recessed image receiving surfaces, chosen to provide durability to the image after the image has been printed onto the predetermined area. The thermoplastic substrate so provided is printed with the image on the predetermined area, thereby forming a security instrument. The printing may be by ink jet printing. Preferably the pattern of recessed image receiving surfaces comprises a cell pattern of predetermined dimensions separated by a bridge pattern of predetermined dimensions, for example, the cells having a depth in the range of approximately 50-80 microns and a nominal breadth or diameter in the range of approximately 100-200 microns, and the bridges having a breadth in the range of approximately 40-60 microns.

[0009] Optionally, the recessed image receiving surfaces may comprise a pattern of latent image recesses recessed below the recessed image receiving surfaces, the pattern of latent image providing a visibly distinct latent image after the image has been printed onto the predetermined area and the printed image is viewed from directly above the image but is not visible when viewed from other angles. The thermoplastic substrate may also comprise a pattern of relatively shallow hidden image recesses below both the nominal surface of the thermoplastic substrate and the recessed image receiving surfaces. Also optionally, the cells of the cell pattern may comprise nominal cells having the same nominal shape and embedded-image-forming cells having a different shape from the nominal shape which together form a distinct embedded image within the nominal cells.

[0010] The thermoplastic substrate is preformed and may be provided by a lamination process using a preforming lami-

nation plate whereby the preforming lamination plate comprises, in an area corresponding to the predetermined area of the thermoplastic substrate, a pattern of raised surfaces formed as a mirror image of the recessed image receiving surfaces of the thermoplastic substrate.

[0011] The thermoplastic substrate may be opaque and may include a thermoplastic transparent window. In a further embodiment the predetermined area comprising the pattern of recessed image receiving surfaces and pattern of bridges separating the recessed image receiving surfaces is provided on a back side of the transparent window and a mirror image of the image is printed onto the back side of the transparent window over the recessed image receiving surfaces.

[0012] Also in accordance with the invention a preforming plate, for example a lamination plate, is provided for preforming a predetermined area of a thermoplastic substrate comprising a pattern of recessed image receiving surfaces below a nominal surface of the thermoplastic substrate and a pattern of bridges separating the recessed image receiving surfaces. The preforming plate comprises a pattern of raised surfaces in an area corresponding to the predetermined area of the thermoplastic substrate wherein the pattern of raised surfaces is formed as a mirror image of the pattern of recessed image receiving surfaces and pattern of bridges. Where the recessed image receiving surfaces of the thermoplastic substrate comprise a pattern of latent image recesses recessed below the recessed image receiving surfaces, the pattern of raised surfaces of the preforming plate comprises raised surfaces formed as a mirror image of the pattern of latent image recesses.

[0013] Also in accordance with the invention there is provided a security instrument comprising a thermoplastic substrate and an image printed onto a predetermined area of the thermoplastic substrate (e.g. by ink jet printing), the predetermined area of the thermoplastic substrate comprising a pattern of recessed image receiving surfaces below a nominal surface of the thermoplastic substrate and a pattern of bridges separating the recessed image receiving surfaces. The depths of the recessed image receiving surfaces and the areas of the bridges separating the recessed image receiving surfaces, relative to the areas of the recessed image receiving surfaces, are predetermined to protect the image against wear of the security instrument.

[0014] Preferably, the pattern of recessed image receiving surfaces comprises a cell pattern of predetermined dimensions separated by a bridge pattern of predetermined dimensions. Optionally, the recessed image receiving surfaces may comprise a pattern of latent image recesses recessed below the recessed image receiving surfaces, the pattern of latent image providing a visibly distinct latent image when the printed image is viewed from directly above the image, the latent image being not visible when viewed from other angles. Also optionally, the cell pattern may comprise nominal cells having the same nominal shape and embedded-image-forming cells having a different shape from the nominal shape which together form a distinct embedded image within the nominal cells.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The invention is described in detail below with reference to the following drawings drawn to facilitate illustration of features described herein and not to scale.

[0016] FIG. 1 illustrates a plan view of an exemplary security instrument comprising a thermoplastic substrate with

preformed recessed image receiving surfaces on which a personalization image has been printed in accordance with the invention.

[0017] FIG. 1A illustrates a plan view of an enlarged portion of the surface area of the thermoplastic substrate of FIG. 1 prior to printing of the personalization image there over, to illustrate the preformed recessed image receiving surfaces of the invention which, in this example, are provided by a pattern of cell structures of predetermined dimensions separated by a bridge pattern of predetermined dimensions.

[0018] FIG. 2 illustrates a sectional view, at section A-A of the thermoplastic substrate of the exemplary security instrument of FIG. 1, prior to printing the image, showing preformed recessed image receiving surfaces in the area of the substrate to which the image is to be printed to make the security instrument illustrated in FIG. 1.

[0019] FIG. 3 illustrates a sectional view of a portion of a preforming lamination plate configured for making the thermoplastic substrate illustrated in FIG. 2, showing the portion of the plate configured to form the substrate section shown by FIG. 2.

[0020] FIG. 4 illustrates a sectional view of a portion of a thermoplastic substrate prior to printing an image thereon, similar to FIG. 2 but for a different exemplary security instrument, showing preformed recessed image receiving surfaces according to the invention and comprising latent and hidden images formed therein in the area to be printed with the image.

[0021] FIG. 5A illustrates a plan view of a portion of a surface area of another exemplary thermoplastic substrate, prior to printing an image thereon, and FIG. 5B is an enlarged view of FIG. 5A, showing preformed recessed image receiving surfaces in the form of exemplary alternative patterns of cell structures whereby the cell patterns form the illustrated exemplary embedded images "CBN", "VARIOUS MICRO-TEXT MESSAGES INSIDE CELLS" and "CELLS CAN BE ANY SHAPE OR SIZE YOU WISH".

DETAILED DESCRIPTION

[0022] The invention provides an improved method for making a security instrument having a thermoplastic substrate preformed with recessed image receiving surfaces and an image printed onto the surface of the preformed thermoplastic substrate. In preferred embodiments illustrated herein the image is printed by means of ink jet printing; however, it is to be understood that the invention is not limited to such method of printing. The invention also provides a preforming plate for making a preformed thermoplastic substrate having recessed image receiving surfaces. Further, the invention provides a security instrument made in accordance with the improved method. The term "security instrument" used herein means any document, card, sheet, booklet or other item for which authenticity is a characteristic that may become subject to risk or question and includes, without limitation, identification cards, licenses (e.g. driver's licenses), personal information sheets in passports and records of citizenship.

[0023] Referring to the examples of FIGS. 1, 1A and 2, an image 20 has been printed onto a thermoplastic substrate 15 of a security instrument 10 (e.g. an identification card) by means of ink jet printing. FIG. 1A shows a plan view of an enlarged portion of the print area of the thermoplastic substrate 15 prior to printing of the image 20. In this area of the substrate 15 recessed image receiving surfaces 25 are provided by preformed recesses below a nominal surface 35 of

the substrate **15**. As will be readily understood by persons skilled in the art, relative to the small scale of the recesses required for the recessed image receiving surfaces **25**, being in the order of microns (e.g. 60 microns deep by 150 microns wide, in this illustrated example), the surface level of the thermoplastic substrate **15** may vary over the print area but it is not the surface level at any particular point in the area from which the recesses are formed or measured but instead a representative surface over the area. To account for this, the term “nominal surface” is used herein to mean a representative surface level over and immediately surrounding the print area in which the recessed image receiving surfaces **25** are provided.

[0024] In the illustrated embodiments the preformed recessed image receiving surfaces **25** of the thermoplastic substrate **15** are provided by a pattern of cells **60** of predetermined dimensions separated by a pattern of bridges **65** of predetermined dimensions. The particular cell pattern to be chosen for a particular application may be a honeycomb pattern, a square or diamond cell pattern, an irregular pattern or any other pattern suitable for the application. For an application in which an identification card is to follow the ISO 7810 standard a thermoplastic substrate of 0.030 inches (plus or minus 10%) is used to produce a card having a surface area of 53.98×85.6 square millimeters and a thickness of 0.762 millimeters (762 microns). The size of a print area for a photograph image may also be governed by a standard specification depending upon the application, for example the AAMVA, ICAO or other standard. For example, the AAMVA standard for driver's licenses (2005) specifies a minimum height of 25 microns and width of 22 microns and a maximum height of 40 microns and width of 35 microns. As an example, and depending upon the particular application, the recessed image receiving surfaces **25** may be provided as a pattern of cells having a 100-200 micron square diameter or nominal breadth, a depth of 30-70 microns and a pattern of bridges between the cells of 30-80 microns. For the particular examples of the illustrated embodiments the recessed cells **60** are square in shape and, apart from print areas comprising hidden images (as detailed more fully hereinafter), have a diameter of 150 microns and depth of 60 microns below the nominal surface **35** of the substrate **15**, with bridges **65** of 40 microns separating the cells. The image **20** is printed onto the pre-formed thermoplastic substrate **15** by ink jet printing and an ultra-violet light (UV) curable ink was chosen for this.

[0025] For the illustrated embodiments, the thermoplastic substrate **15** is made by laminating together multiple layers of a thermoplastic material and the recessed image receiving surfaces **25** are made by means of a preforming lamination plate **100**. As shown by FIG. 3, in the area of the thermoplastic substrate **15** which corresponds to the image **20**, the lamination plate **100** is embossed with raised surfaces **110** configured to mirror the desired recessed image receiving surfaces **25** of the thermoplastic substrate **15** to be made using the lamination plate **100**. As illustrated by FIGS. 2 and 3, the raised surfaces **110** (embossments) of the lamination plate **100** mirror the recessed image receiving surfaces **25** of the thermoplastic substrate **15** which was formed by laminating layers together using the lamination plate **100**. During lamination layers of thermoplastic material are subjected to heat and pressure as per a conventional lamination process and pressed against the lamination plate **100** which causes the layers to bond together to form the thermoplastic substrate **15**

and at the same time form the desired recessed image receiving surfaces **25** below a nominal surface **35** of the thermoplastic substrate **15**.

[0026] The material of the thermoplastic substrate **15** used for the illustrated embodiments is polycarbonate which has been found to provide good protection against bending, impact and other stresses that an identity card or other type of security instrument is likely to encounter. However, it is to be understood by the skilled reader that although polycarbonate is selected for use in this example there are many other thermoplastic materials that may, alternatively, be used to provide characteristics of hardness and durability, including PVC (polyvinyl chloride), PET (Polyethylene terephthalate), PETG (copolymerized PET), acrylic and any other similar material that is suitable.

[0027] Other embodiments of the invention may be used to additionally provide security features to the printed security instrument **10**, if desired, in the form of a latent image **80** and/or hidden image **60**, as described in greater detail in the following with reference to FIG. 4.

[0028] To include a latent image within the printed image **20** of the security instrument **10** a latent image pattern of latent image recesses **80** is formed in the recessed image receiving surfaces **25** as shown by FIG. 4. The latent image pattern may, for example, form a text message such as “AUTHENTIC”, a crest or emblem, or any other image that may be desired for a given application. For the embodiment of this particular illustration, the latent image recesses **80** have a depth of 10 microns below the recesses of the recessed image receiving surfaces **25** and breadth(s) determined according to the particular latent image to be formed, whereas the recessed image receiving surfaces **25** have a depth of 60 microns and nominal breadth of 150 microns. When the image **20** is ink jet printed onto the substrate **15** over the recessed image receiving surfaces **25** and latent image recesses **80** therein, more of the ink is collected in the deeper latent image recesses **80** and the latent image pattern appears as a visible image when viewed from angles directly or nearly above the printed substrate surface but is not visible when viewed from other angles. This latent visibility results from the multi-level planes created by the relief pattern in the recessed image receiving surfaces **25**. The resulting latent image advantageously serves as a security feature for the printed security instrument **10**.

[0029] A hidden image may also be included within the printed image **20** of the security instrument **10** to provide a feature that is not normally visible but will be revealed (i.e. will become visible) if and when the instrument **10** is tampered with by forcibly abrading the surface of the card, such as when one attempts to scratch off a printed personalization image and replace it with an unauthentic image. To do so a pattern of relatively shallow recesses, referred to herein as hidden image recesses **85**, is formed below both the nominal surface **35** of the substrate **15** and the recessed image receiving surfaces **25** in a predetermined area of the substrate **15** comprising the recessed image receiving surfaces **25**. By relatively shallow depth it is meant that the depth of the hidden image recesses **85** is far enough below the nominal substrate surface **35** that normal wear of the surface will not wear away the surface **35** by the relatively shallow depth but close enough to the surface **35** that forced abrasion of the surface to scratch off the printed image would abrade the surface by the relatively shallow depth and thereby render visible the hidden image that is defined by the pattern of

hidden image recesses **85**. In the illustrated embodiment shown in FIG. **4** the depth of the hidden image recesses **85** is 10 microns whereas the depth of the recesses of the image receiving surfaces is 60 microns. The hidden image pattern may, for example, be a text message such as "CAUTION", a symbol or sign, or any other image that may be desired for a given application. The hidden image pattern is normally not discernible. However, if one were to tamper with the security instrument **10** by forcibly abrading the surface to remove a printed image above the pattern of hidden image recesses **85**, the hidden image pattern would become visible as the abrading depth reaches the shallow depth of the hidden image recesses **85**. The hidden image pattern so revealed is referred to herein as a hidden image and it advantageously serves as a security feature for the printed security instrument **10**.

[0030] FIG. **5A**, and the enlarged version thereof shown by FIG. **5B**, illustrate a further embodiment of the invention which incorporates embedded images, being the images "CBN", "CELLSCANBEANYSHAPEORSIZEYOUWISH" and "VARIOUS MICROTTEXT MESSAGES INSIDE CELLS" in this illustration. The embedded images "CBN" are distinct "CBN" patterns formed by groups of cells **61**, **63-64** of the same but different shape relative to the shape of nominal cells **60** in the areas surrounding those embedded image patterns, or by groups of cells **62** of the same but different size relative to the size of nominal cells **60** in the areas surrounding those embedded image patterns. The embedded image "CELLSCANBEANYSHAPEORSIZEYOUWISH" in this illustration is formed by cells **66** which are shaped to form the pattern of the embedded image. The embedded image "VARIOUS MICROTTEXT MESSAGES INSIDE CELLS" in this illustration is formed by printed microtext whereby microtext is printed within individual cells **60** of a group of cells **60**. The embedded images so formed may be discerned by viewing the security instrument **10** using magnification means but are not readily visible to the naked eye.

[0031] In a further embodiment of the invention (not illustrated) a transparent window may be provided in the thermoplastic substrate **15** and configured to protect the printed image **20**. The embossed preforming lamination plate **100** is applied to the back side of the thermoplastic layers and window for lamination and, thus, after lamination of the layers, forms a pattern of recessed image receiving surfaces below a nominal surface of the back side of the window with a pattern of bridges separating the recessed image receiving surfaces. The mirror image of image **20** is printed onto the back side of the window over the recessed image receiving surfaces and when looking at the window from the front side of the window it appears as a clear image area with the image **20** visible. If it desired that the image be visible from the front side of the substrate only, the back side of the entire window area can be covered with an opaque coating to match the material of the thermoplastic substrate of the security instrument **10** (e.g. a white ink coating for a white polycarbonate substrate), and then further covered by a clear protective coating (e.g. a clear ink or varnish). Apart from the window area, the thermoplastic substrate **15** is printed on the front side and to a viewer viewing a security instrument **10** made therefrom it appears that the image **20** has also been printed on the front side. This provides to the printed image the greater durability of the invention and also greater security against tampering because a person attempting to remove the image is likely to do so

from the front surface of the window whereas the printed image is protected by being located well below that surface.

[0032] For the illustrated embodiments the substrate **15** was preformed with the recessed image receiving surfaces **25** and, in the case of the embodiment of FIG. **4** with the latent image recesses **80** and hidden image recesses **85**, during lamination by means of matching lamination plates (i.e. lamination plates having mirror image surfaces). Alternatively, however, the recessed image receiving surfaces **25** and latent image and/or hidden image recesses **80**, **85** could be preformed in a substrate **15** by means of a preforming plate applied to the substrate using a process other than lamination or, by laser ablation or by mechanical means. By these methods, the desired pattern of recessed image receiving surfaces is drilled or ablated into the substrate **15** and in those areas where a pattern of latent or hidden image recesses is desired the drilling/ablating is deeper or shallower, respectively in those areas.

[0033] The details of the illustrated embodiment may be varied as considered expedient to a person skilled in the art and are not to be considered essential to the invention by reason only of inclusion in the embodiments illustrated herein. Rather, the invention is defined by the appended claims.

What is claimed is:

1. A method for printing an image onto a predetermined area of a thermoplastic substrate, the method comprising:

(a) providing a thermoplastic substrate comprising in the predetermined area a pattern of recessed image receiving surfaces below a nominal surface of the thermoplastic substrate and a pattern of bridges separating the recessed image receiving surfaces, the depths of the recessed image receiving surfaces and the areas of the bridges separating the recessed image receiving surfaces, relative to the areas of the recessed image receiving surfaces, chosen to provide durability to the image after the image has been printed onto the predetermined area; and,

(b) printing the image onto the predetermined area of the thermoplastic substrate.

2. The method of claim **1** whereby the printing is by ink jet printing.

3. The method of claim **1** whereby the pattern of recessed image receiving surfaces comprises a cell pattern of predetermined dimensions separated by a bridge pattern of predetermined dimensions.

4. The method of claim **2** whereby the pattern of recessed image receiving surfaces comprises a cell pattern of predetermined dimensions separated by a bridge pattern of predetermined dimensions.

5. The method of claim **4** whereby the predetermined dimensions of cells of the cell pattern comprise a depth in the range of approximately 50-80 microns and a nominal breadth or diameter in the range of approximately 100-200 microns, and the predetermined dimensions of bridges of the bridge pattern comprise a breadth in the range of approximately 40-60 microns.

6. The method of claim **2** whereby the recessed image receiving surfaces comprise a pattern of latent image recesses recessed below the recessed image receiving surfaces, the pattern of latent image providing a visibly distinct latent image after the image has been ink jet printed onto the pre-

determined area and the printed image is viewed from directly above the image but is not visible when viewed from other angles.

7. The method of claim 2 whereby the thermoplastic substrate comprises a pattern of relatively shallow hidden image recesses below both the nominal surface of the thermoplastic substrate and the recessed image receiving surfaces.

8. The method of claim 4 whereby the cells of the cell pattern comprise nominal cells having the same nominal shape and embedded-image-forming cells having a different shape from the nominal shape which together form a distinct embedded image within the nominal cells.

9. The method of claim 1 whereby providing the thermoplastic substrate includes preforming the thermoplastic substrate by a lamination process using a preforming lamination plate whereby the preforming lamination plate comprises, in an area corresponding to the predetermined area of the thermoplastic substrate, a pattern of raised surfaces formed as a mirror image of the recessed image receiving surfaces of the thermoplastic substrate.

10. The method of claim 2 whereby the thermoplastic substrate is opaque, a thermoplastic transparent window is provided in the opaque thermoplastic substrate, the predetermined area comprising the pattern of recessed image receiving surfaces and pattern of bridges separating the recessed image receiving surfaces is provided on a back side of the transparent window, and a mirror image of the image is printed onto the back side of the transparent window over the recessed image receiving surfaces.

11. The method of claim 2 whereby a security document is formed.

12. A preforming plate for preforming a predetermined area of a thermoplastic substrate comprising a pattern of recessed image receiving surfaces below a nominal surface of the thermoplastic substrate and a pattern of bridges separating the recessed image receiving surfaces, the preforming plate comprising a pattern of raised surfaces in an area corresponding to the predetermined area of the thermoplastic substrate wherein the pattern of raised surfaces is formed as a mirror image of the pattern of recessed image receiving surfaces and pattern of bridges.

13. The preforming plate of claim 12 wherein the recessed image receiving surfaces of the thermoplastic substrate comprise a pattern of latent image recesses recessed below the recessed image receiving surfaces and the pattern of raised surfaces of the preforming plate comprises raised surfaces formed as a mirror image of the pattern of latent image recesses.

14. The preforming plate of claim 12 wherein the pattern of recessed image receiving surfaces of the thermoplastic sub-

strate comprises a cell pattern of predetermined dimensions separated by a bridge pattern of predetermined dimensions.

15. The preforming plate of claim 14 wherein the cells of the cell pattern comprise nominal cells having the same nominal shape and embedded-image-forming cells having a different shape from the nominal shape which together define a distinct embedded image within the nominal cells.

16. The preforming plate of claim 12 wherein the preforming plate is a lamination plate.

17. A security instrument comprising a thermoplastic substrate and an image printed onto a predetermined area of the thermoplastic substrate by ink jet printing, the predetermined area of the thermoplastic substrate comprising a pattern of recessed image receiving surfaces below a nominal surface of the thermoplastic substrate and a pattern of bridges separating the recessed image receiving surfaces, the depths of the recessed image receiving surfaces and the areas of the bridges separating the recessed image receiving surfaces, relative to the areas of the recessed image receiving surfaces, predetermined to protect the image against wear of the security instrument.

18. The security instrument of claim 17 wherein the pattern of recessed image receiving surfaces comprises a cell pattern of predetermined dimensions separated by a bridge pattern of predetermined dimensions.

19. The security instrument of claim 18 wherein the predetermined dimensions of cells of the cell pattern comprise a depth in the range of approximately 50-80 microns and a nominal breadth or diameter in the range of approximately 100-200 microns, and the predetermined dimensions of bridges of the bridge pattern comprise a breadth in the range of approximately 40-60 microns.

20. The security instrument of claim 17 wherein the recessed image receiving surfaces comprise a pattern of latent image recesses recessed below the recessed image receiving surfaces, the pattern of latent image providing a visibly distinct latent image when the printed image is viewed from directly above the image, the latent image being not visible when viewed from other angles.

21. The security instrument of claim 18 wherein the cells of the cell pattern comprise nominal cells having the same nominal shape and embedded-image-forming cells having a different shape from the nominal shape which together form a distinct embedded image within the nominal cells.

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