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ABSTRACT

An optical security device and method of manufacturing an optical security device is disclosed including a substrate having a first surface and a second surface; and a metallic nanoparticle ink provided intermittently in at least one area on the first surface to produce a reflective or partially reflective patch or patches. A coating is applied over the area or areas in which the metallic nanoparticle ink is provided, the coating adhering to the first surface where the metallic nanoparticle ink is not present, thereby retaining the metallic nanoparticle ink between the first surface and the coating. The metallic nanoparticle ink can also be applied over a relief structure, such as a diffractive optical element allowing the diffractive structure to be viewed in reflection. Applying the metallic nanoparticle ink to the opposite side of a transparent substrate to a diffractive optical element can allow the the diffractive structure to be viewed in transmission or reflection.

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OPTICAL SECURITY DEVICE WITH NANOPARTICLE INK

FIELD OF THE INVENTION

This invention relates to optical security devices and methods for their manufacture. More particularly, it relates to optical security devices which utilise a nanoparticle ink in their construction.

BACKGROUND TO THE INVENTION

Optical security devices are commonly used in security documents as a means of avoiding unauthorised duplication or forgery of such documents. Typically, such a device will produce an optical effect which is difficult for a potential counterfeiter to replicate.

A wide range of optical security devices are known in the art. Frequently, such devices rely upon the application of a reflective coating or a semitransparent coating with a high refractive index in order to display the optical effect. For example, it is common for an optical security device to be constructed by embossing a diffraction pattern into a polymer layer to form a surface relief pattern, and providing a thin reflective metal layer over the pattern. In this manner, the effect created by the diffraction pattern is viewable in reflection. Alternatively, the metal layer is substituted for a transparent layer with a high refractive index, allowing the diffractive effect to be viewed but also allowing any information behind the device to be visible.

The thin metal reflective layer may be provided in a number of ways. One way is to use a vacuum deposition process. In this process, the material to be coated is placed in a vacuum, and the metal is vaporised. When the vaporised metal contacts the material, it condenses and forms a metallic layer on the material. This procedure is effective in providing a reflective layer, however is relatively costly.

An alternative to the vacuum deposition process is to utilise a metallic nanoparticle ink to coat the required surface. The application of such an ink may be achieved at a substantially reduced cost compared to the vacuum deposition process, while still providing a thin coating that may either be highly reflective, or

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semitransparent with a high refractive index depending on the composition of the ink.

The use of metallic nanoparticle inks has previously been problematic, as such inks display weak adhesion to the surfaces to which they are applied. Consequently, despite the attractive optical properties of these inks, it has proved difficult to effectively use these types of inks in producing optical security devices.

It is therefore desirable to provide an optical security device utilising metallic nanoparticle inks that addresses the difficulties presented by the poor adhesion of such inks. It is also desirable to provide a method for manufacturing such optical security devices.

DEFINITIONS

Security document

As used herein, the term security document includes all types of documents and tokens of value and identification documents including, but not limited to the following: items of currency such as banknotes and coins, credit cards, cheques, passports, identity cards, securities and share certificates, driver's licences, deeds of title, travel documents such as airline and train tickets, entrance cards and tickets, birth, death and marriage certificates, and academic transcripts.

Metallic Nanoparticle Ink

As used herein, the term metallic nanoparticle ink refers to an ink having metallic particles of an average size of less than one micron.

Diffractive Optical Elements (DOEs)

As used herein, the term diffractive optical element refers to a numerical-type diffractive optical element (DOE). Numerical-type diffractive optical elements (DOEs) rely on the mapping of complex data that reconstruct in the far field (or reconstruction plane) a two-dimensional intensity pattern. Thus, when substantially collimated light, e.g. from a point light source or a laser, is incident upon the DOE, an interference pattern is generated that produces a projected image in the reconstruction plane that is visible when a suitable viewing surface is located in the reconstruction plane, or when the DOE is viewed in transmission at the reconstruction plane. The transformation between the two planes can be

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approximated by a fast Fourier transform (FFT). Thus, complex data including amplitude and phase information has to be physically encoded in the micro-structure of the DOE. This DOE data can be calculated by performing an inverse FFT transformation of the desired reconstruction (i.e. the desired intensity pattern in the far field).

DOEs are sometimes referred to as computer-generated holograms, but they differ from other types of holograms, such as rainbow holograms, Fresnel holograms and volume reflection holograms.

SUMMARY OF THE INVENTION

According to one aspect of the invention, there is provided an optical security device, including a substrate having a first surface and a second surface; and a metallic nanoparticle ink provided intermittently in at least one area on the first surface to produce a reflective or partially reflective patch or patches; wherein a high refractive index coating is applied over the area or areas in which the metallic nanoparticle ink is provided, the high refractive index coating adhering to the first surface where the metallic nanoparticle ink is not present, thereby retaining the metallic nanoparticle ink between the first surface and the high refractive index coating.

Preferably, the reflective or partially reflective patch or patches at least partly overlies a relief structure. The relief structure may be provided on the first surface of the substrate. Alternatively, the relief structure is provided on the second surface of the substrate. The relief structure may be a diffractive structure, and further may be a diffractive optical element.

Alternatively, the relief structure may be q high-resolution or high aspect ratio grating such as a polarisation grating.

The metallic nanoparticle ink may be provided in a plurality of substantially parallel lines on the first surface. Where the metallic nanoparticle ink is provided in this manner, preferably each line has a width of 1 nm to 200 μm, and further preferably, the lines are spaced apart by 1nm to 200 μm.

Alternatively, the metallic nanoparticle ink is provided in a plurality of substantially circular spots. Where the metallic nanoparticle ink is provided in this manner, preferably each substantially circular spot has a diameter of 1 nm to 200 μm, and further preferably the spots are spaced apart by 1 nm to 200 μm.

Preferably the size and spacing of the substantially parallel lines or substantially circular spots produces an optical density of greater than 0.1.

The coating may be a curable coating.

The metallic nanoparticle ink may form a substantially opaque, reflective layer. Alternatively the metallic nanoparticle ink may form a semitransparent layer with a refractive index greater than that of the relief structure.

The metallic nanoparticle ink may be a silver nanoparticle ink. Where this is the case, the silver nanoparticle ink preferably has less than 40% silver.

Alternatively, the metallic nanoparticle ink may be an aluminium nanoparticle ink. Further alternatively the metallic nanoparticle ink is a titanium nanoparticle ink.

According to a further aspect of the invention, there is provided a method of manufacturing an optical security device, including applying a metallic nanoparticle ink intermittently in at least one area on a first surface of a substrate, and applying a high refractive index coating over the or each area in which the metallic nanoparticle ink has been applied, whereby the high refractive index coating adheres to the first surface where the metallic nanoparticle ink is not present, thereby retaining the metallic nanoparticle ink between the first surface and the high refractive index coating.

The method may further included the step of providing a relief structure on the first surface of the substrate prior to applying the metallic nanoparticle ink.

The method may also include the step of providing a relief structure on a second surface of the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

Specific embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a representative cross section of an optical security device according to an embodiment of the invention.

Figure 2 is a representative cross section of an optical security device according to an alternative embodiment of the invention.

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DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figure 1, there is shown a cross section of an optical security device, where a metallic nanoparticle ink 104 is provided intermittently in an area of the first surface of a substrate 102. A coating 106 is applied over the area in which the metallic nanoparticle ink 104 is provided. The coating 106 adheres to the surface of the substrate 102 in the areas 108 between the regions of metallic nanoparticle ink 104 where the metallic nanoparticle ink 104 is not present. In this manner the individual regions of metallic nanoparticle ink 104 are retained in position between the surface of the substrate 102 and the coating 106 despite the weak adhesion of the metallic nanoparticle ink 104 to the surface of the substrate 102.

The regions of metallic nanoparticle ink 104 together produce a reflective or partially reflective patch on the substrate 102. Multiple areas of a substrate may be provided with metallic nanoparticle ink in this manner if multiple reflective patches or partially reflective patches are desired.

In an alternative embodiment of the invention, the metallic nanoparticle ink may be used to apply a thin reflective coating to a relief structure, such as a diffractive structure. Such an arrangement is shown in Figure 2, in which a diffractive structure 208 is provided on the first surface of a substrate 202. The diffractive structure may be integral with the substrate, for example being embossed into a polymer substrate, or alternatively may be applied as a separate element. A metallic nanoparticle ink 204 is provided intermittently in an area of the diffractive structure 208. A coating 206 is applied over the area in which the metallic nanoparticle ink 204 is provided. Preferably, the coating 206 is a high refractive index (HRI) coating, as this will assist in ensuring that the optical effect produced by the diffractive structure 208 remains visible even the metallic nanoparticle ink 204 is applied in a very thin layer. The coating 206 adheres to the diffractive structure 208 in the areas 210 between the regions of metallic nanoparticle ink 204 where the metallic nanoparticle ink 204 is not present. In this manner, a reflective patch or patches may be provided over the diffractive structure. Where this patch forms a substantially opaque reflective layer, the diffractive effect produced by the diffractive structure may be viewed in reflection in the area where the patch or patches are provided.

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Alternatively, as shown in Figure 3, a diffractive structure may be provided on the opposite side of the substrate to metallic nanoparticle ink. Here, the metallic nanoparticle ink 304 and coating 306 are provided on the first side of the substrate, with a diffractive structure 308 provided on the second side of the substrate 302. A protective varnish 310 may be applied to the diffractive structure 308. The protective varnish 310 in this case should be a high refractive index coating (having a refractive index different from the substrate 302 by at least 0.2), otherwise the diffractive structure 308 will not be clearly visible. In this arrangement, it is preferable that at least part of the substrate 302 and diffractive structure 308 are transparent, and the patch formed by the metallic nanoparticle ink is a semi-transparent layer with a refractive index greater than that of the substrate and the diffractive structure. In this manner, the diffractive effect produced by the diffractive structure 308 may be viewed in transmission by a viewer positioned at 322 whilst being visible in reflection by a viewer positioned at 321. This result is possible as the use of the nanoparticle ink may provide a highly reflective surface, but also permits enough light through to allow the diffractive effect to be visible in transmission. Furthermore, nanoparticle inks give reflectivity which is equivalent to that achieved by vacuum metallisation, but can be provided more cheaply and efficiently as the ink is applied by a printing method.

Referring to both Figure 2 and 3, the diffractive structure 208 or 308 could readily be replaced by any desired relief structure such as for example a diffractive optical element. Alternatively, high-resolution or high aspect ratio gratings such as polarisation gratings could be used, in which case nanoparticles less than 100 nm should be utilised.

In one embodiment of the invention, the metallic nanoparticle ink is a silver nanoparticle, having less than 40% silver. However, a range of other metallic nanoparticle inks will also be suitable for use in accordance with the invention, for example, silver nanoparticle inks with greater then 40% silver, aluminium naoparticle inks and titanium nanoparticle inks.

It will be appreciated that a suitable coating should demonstrate one or all of the following attributes: good adhesion to the substrate, highly transparent, generally colourless, and robust. Possible coatings may include a transparent,

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non-high refractive varnish. By varnish it is meant a material that results in a durable protective finish. Exemplary transparent varnishes may include, but are not limited to, nitrocellulose and cellulose acetyl butyrate. Alternatively, the coating may be a high refractive index coating, being a coating having a metal oxide component of small particle size and high refractive index dispersed in a carrier, binder or resin. Such a high refractive index coating contains solvent as it is a dispersion. Where a high refractive index coating of this type is used, it may be air cured or UV cured. Alternatively, a high refractive index coating utilising a non-metallic polymer, such as sulfur-containing or brominated organic polymers may also be used.

The metallic nanoparticle ink is preferably applied to the surface of the substrate in either a plurality of substantially parallel lines, or a plurality of substantially circular spots. If the metallic nanoparticle ink is provided in a plurality of substantially parallel lines, the lines preferably have a width of 1 nm to 200 μm, and preferably spaced apart by 1 nm to 200 μm. If the metallic nanoparticle ink is provided in a plurality of substantially circular spots, the spots preferably have a diameter of 1 nm to 200 μm and are preferably spaced apart by 1 nm to 200 μm. Further preferably, the ink stripes or spots have a width or diameter of around 100 μm, and are spaced apart by around 100 to 200 μm. These spacings have been found to provide an appropriate optical density to deliver the desired reflectivity. Preferably, the optical density is greater than 0.1.

The metallic nanoparticle ink may be applied by one of several techniques that will be apparent to the person skilled in the art. Preferably, the ink is applied by gravure, however may also be applied by other suitable techniques such as flexography or offset printing.

CLAIMS:

1. An optical security device, including a substrate having a first surface and a second surface; and a metallic nanoparticle ink provided intermittently in at least one area on the first surface to produce a reflective or partially reflective patch or patches; wherein a high refractive index coating is applied over the area or areas in which the metallic nanoparticle ink is provided, the high refractive index coating adhering to the first surface where the metallic nanoparticle ink is not present, thereby retaining the metallic nanoparticle ink between the first surface and the high refractive index coating.

2. The optical security device as claimed in claim 1, wherein the reflective or partially reflective patch or patches at least partly overlies a relief structure, the relief structure being provided on the first or second surface of the substrate.

3. The optical security device as claimed in claim 2, wherein the relief structure is a diffractive optical element.

4. A method of manufacturing an optical security device, including applying a metallic nanoparticle ink intermittently in at least one area on a first surface of a substrate, and applying a high refractive index coating over the or each area in which the metallic nanoparticle ink has been applied, whereby the high refractive index coating adheres to the first surface where the metallic nanoparticle ink is not present, thereby retaining the metallic nanoparticle ink between the first surface and the high refractive index coating.

5. The method as claimed in claim 4, further including the step of providing a relief structure on the first or a second surface of the substrate prior to applying the metallic nanoparticle ink.

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Figure 1

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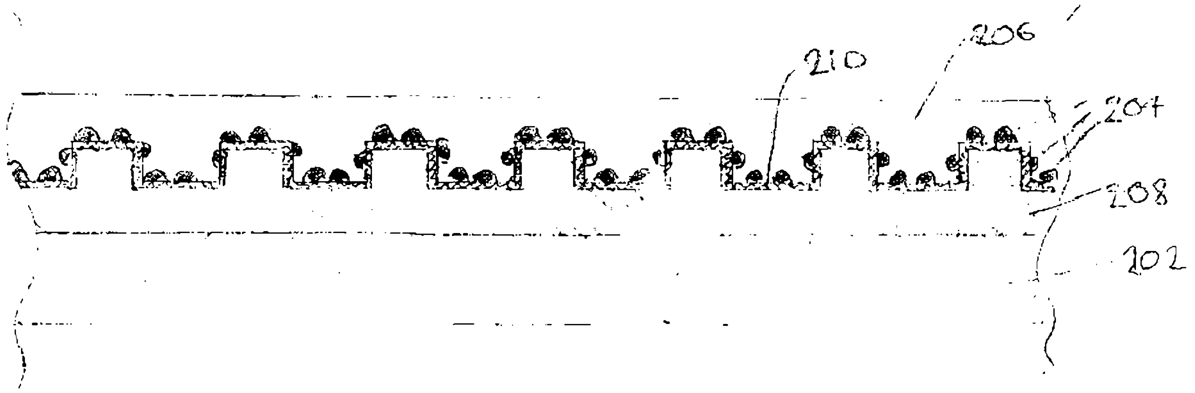

Figure 2

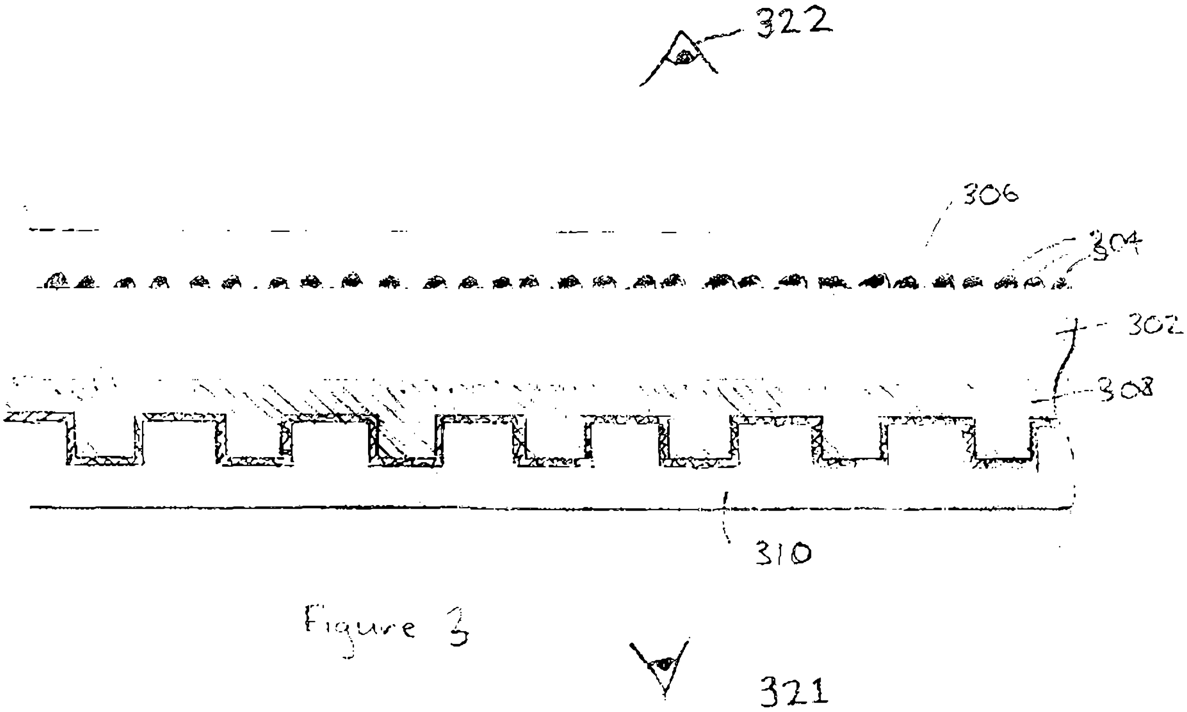

Figure 3