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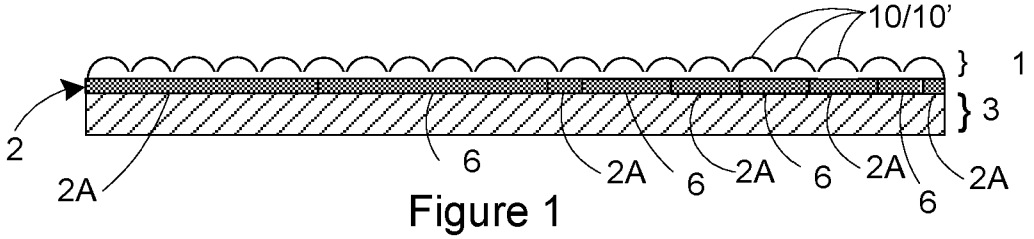

Figure 1

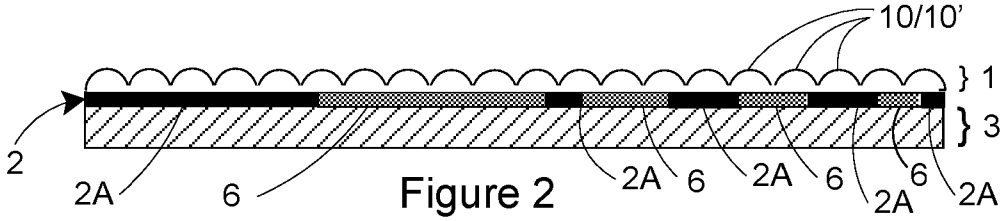

Figure 2

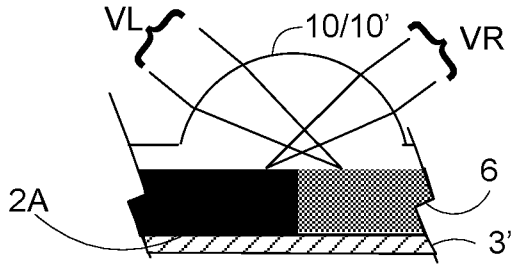

Figure 3

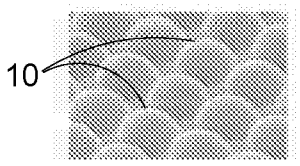

Figure 4

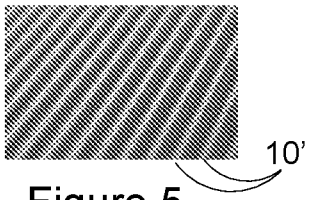

Figure 5

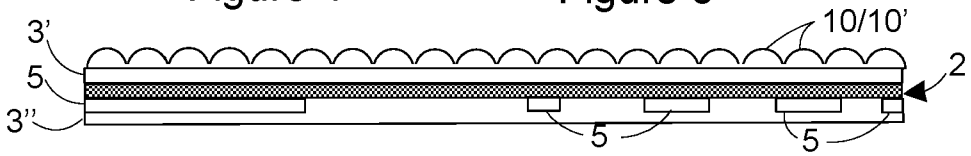

Figure 6

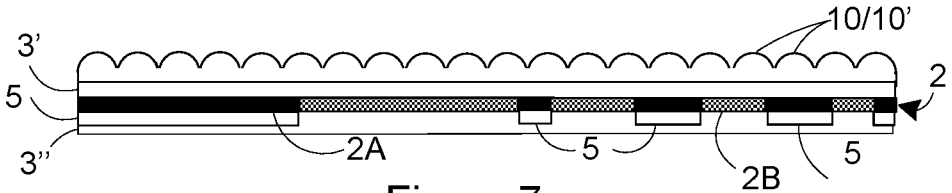

Figure 7

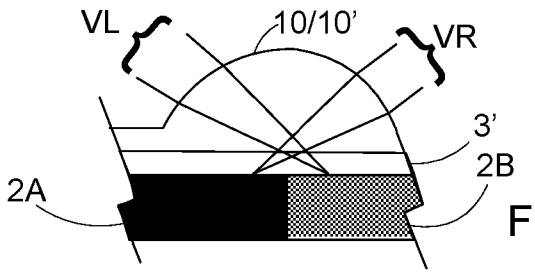

Figure 8

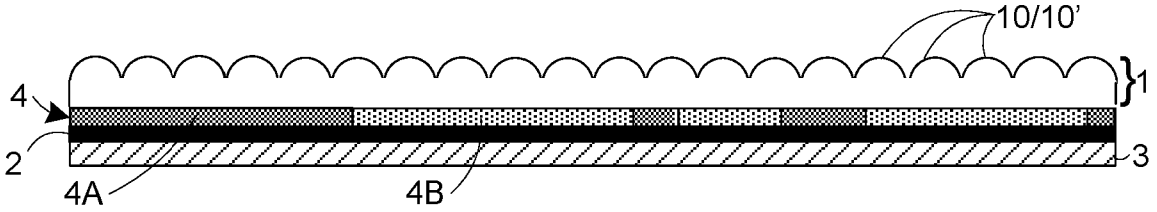

Figure 9

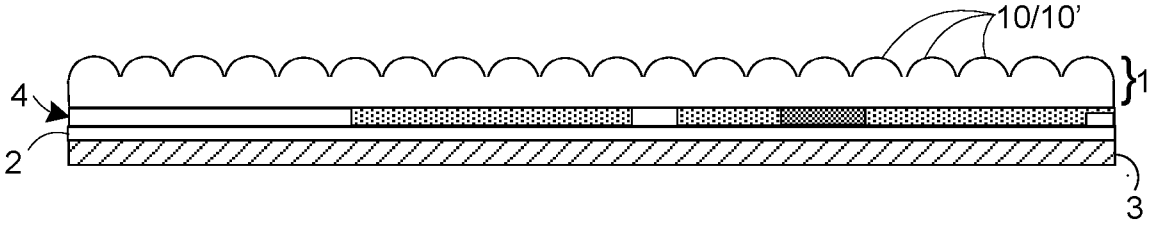

Figure 10

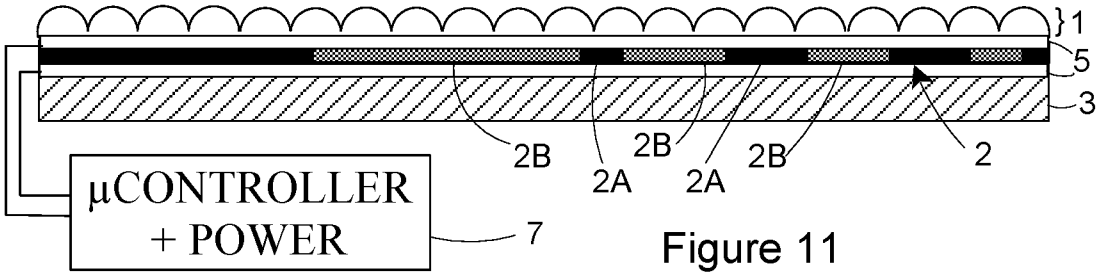

Figure 11

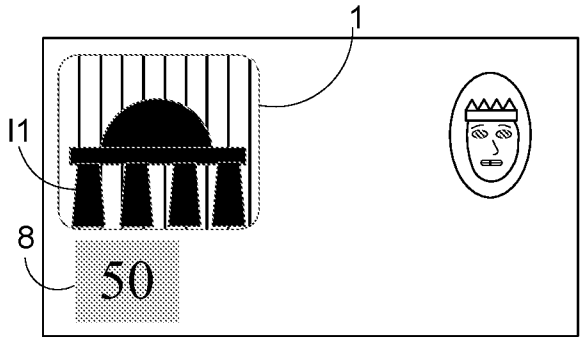

Figure 12A 20

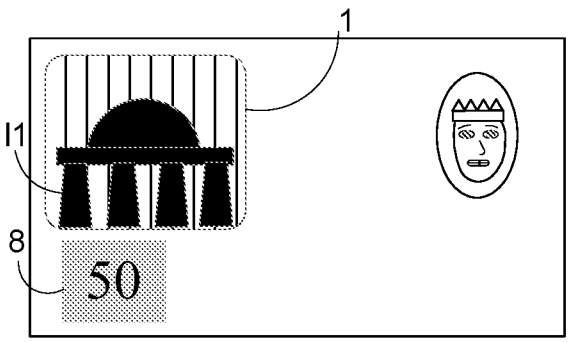

Figure 12B 20

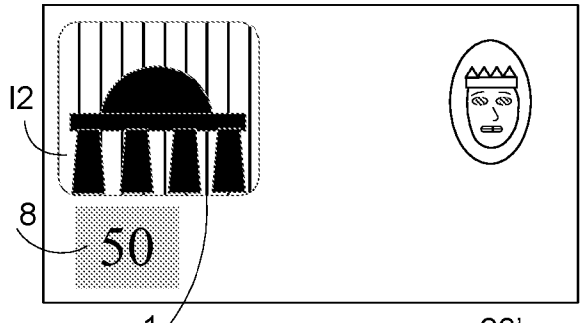

Figure 13A 20'

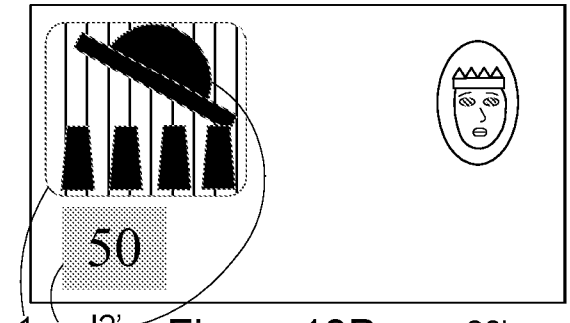

Figure 13B 20'

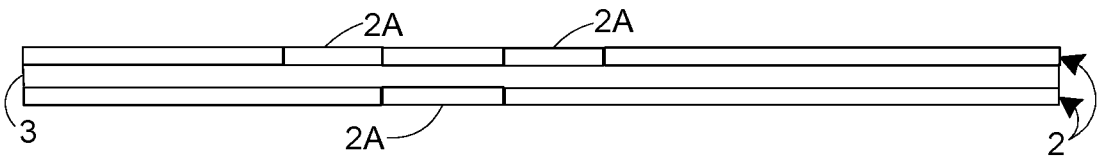

Figure 14

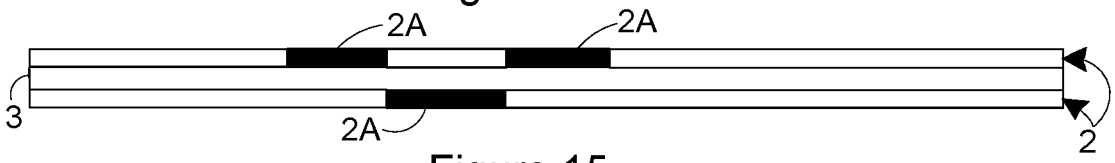

Figure 15

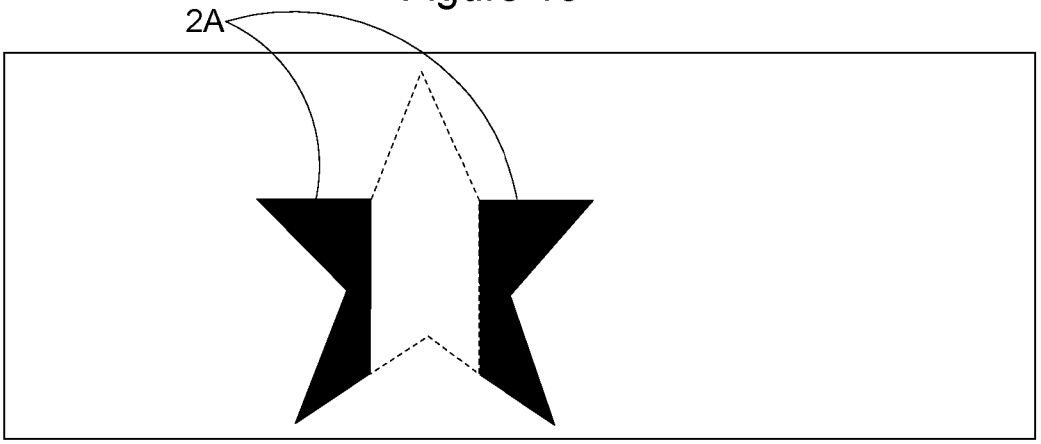

Figure 16

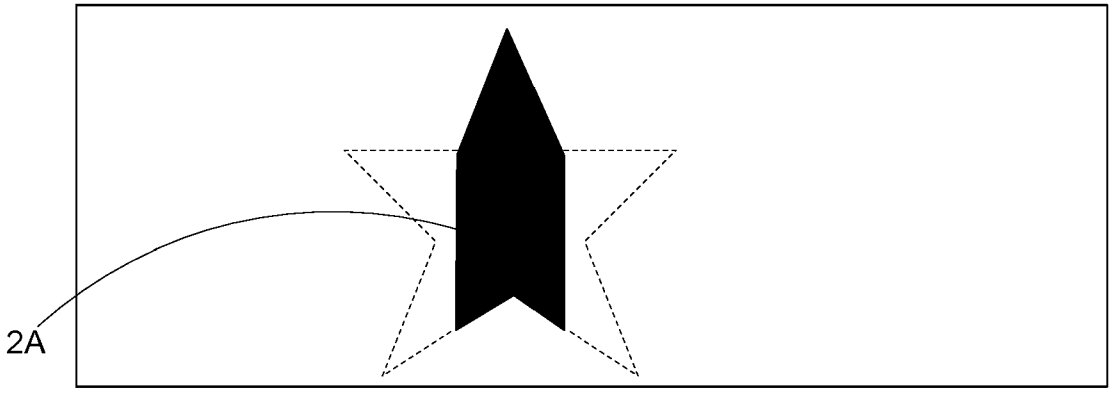

Figure 17

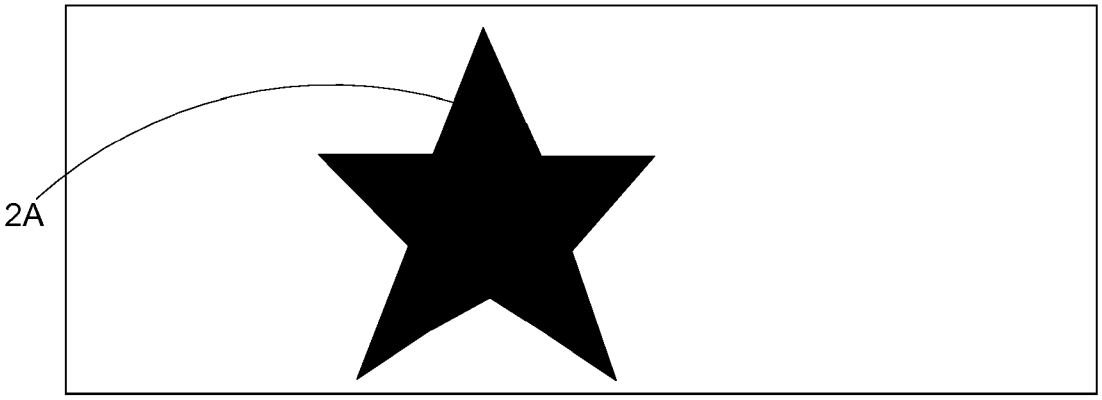

Figure 18

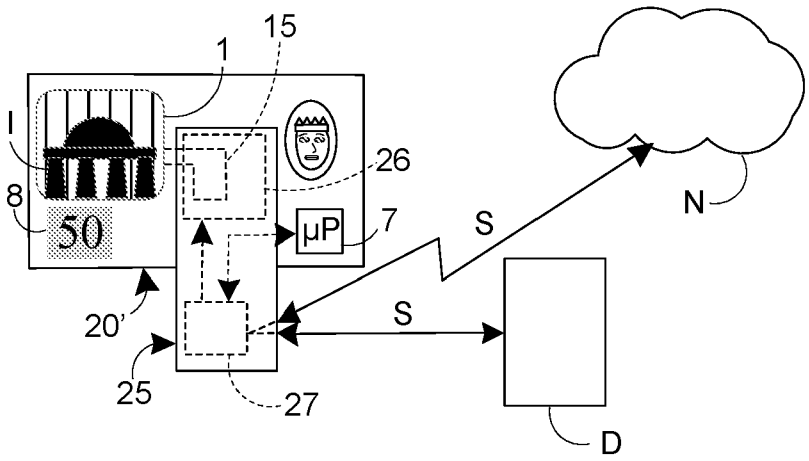

Figure 19

Security document

The present invention concerns a security document and relates particularly but not exclusively to banknotes and banknote sheets.

Other security documents include licences, certificates, cheques and passports for example. In order to deter counterfeiting by scanning and printing copies, such security documents have traditionally included very finely detailed images in combination with "Level 1" security features (i.e. features recognisable by the general public) such as metal threads, stamped foils, perforations etc.

However the availability of high resolution scanners and colour printers has necessitated further security features which typically include optically variable features. In the present specification, by "optically variable feature" is meant any optical structure applied to a security document which results in a variation in the surface appearance of the security document according to the orientation from which it is viewed. Such optical structures include both iridescent structures such as lenticular arrays, colour-shifting inks, holograms, diffraction gratings and thin films for example and non-iridescent structures such as watermarks and double-sided printing for example which appear differently according to whether they are viewed from the obverse or the reverse or in transmission (i.e. illuminated from behind the surface facing the viewer).

It is known from e.g. WO 2006/110622A to provide electrically-switchable structures in product authentication labels, utilising electrochromic ink to change the appearance in response to an electric signal. The label may incorporate film electrodes of e.g. Indium Tin Oxide (ITO) to apply the electric signal to a region of electrochromic ink. It is also known from e.g. US 10,198,890 to provide hybrid banknotes incorporating printed electronic circuitry.

It would be desirable in the field of security documents, particularly in a banknote, to be able to switch its state by means of an external signal. For example, this would enable the monetary value of the banknote to be transferred to a user's account in conjunction with visibly cancelling the note by switching (ON or OFF) a predetermined image on the note with an external electric signal applied to an electrochromic ink region of the banknote.

However such a procedure would be open to abuse by copying the predetermined image formed by the electrochromic ink region.

An object of the present invention is to provide a security document which is externally switchable but with higher security.

Accordingly, in one aspect the invention provides a switchable security document having an optically variable feature which is coupled to a switchable visible region, the switchable visible region having a first state in which the optically variable feature is deactivated and being switchable to a second state in which the optically variable feature is activated and thereby visibly apparent to a user.

Because an optically variable feature cannot be reproduced by scanning and printing, the security of such a security document is considerably enhanced.

Preferably the security document comprises a banknote.

In another aspect the invention provides method of switching a switchable security document in accordance with the first aspect in which the switchable visible region is switched between the first and second states in association with the transmission of a signal over a network or to or from a remote device.

Preferably the transmitted signal encodes information (e.g. the monetary value) represented by the security document.

Preferably the transmitted signal is encrypted.

Further preferred features are defined in the dependent claims.

Preferred embodiments of the invention are described below by way of example only with reference to Figures 1 to 19 of the accompanying drawings, wherein:

Figure 1 is a diagrammatic cross-section of a banknote in accordance with the present invention in a first, deactivated state;

Figure 2 is a diagrammatic cross-section of the banknote of Figure 1 in a second, activated state;

Figure 3 is a diagrammatic representation of an expanded portion of the banknote of Figures 1 and 2, illustrating its change in appearance between different viewpoints;

Figure 4 is a perspective view of a cylindrical lenticular array usable in the banknote of Figures 1 and 2;

Figure 5 is a perspective view of a two-dimensional micro-lens array usable in the banknote of Figures 1 and 2;

Figure 6 is a diagrammatic cross-section of a further banknote in accordance with the invention in which the information layer is sandwiched between two substrate sheets, the banknote being in a first, deactivated state;

Figure 7 is a diagrammatic cross-section of the banknote of Figure 6 in a second, activated state;

Figure 8 is a diagrammatic representation of an expanded portion of the banknote of Figures 6 and 7, illustrating its change in appearance between different viewpoints;

Figure 9 is a diagrammatic representation of a further banknote in accordance with the present invention in a second, activated state;

Figure 10 is a diagrammatic representation of the banknote of Figure 9 in a first, de-activated state;

Figure 11 is a diagrammatic representation of a further banknote in accordance with the invention, provided with switching electrodes and a microcontroller;

Figure 12A is a view from above left of an embodiment of a banknote in accordance with the present invention in a first, deactivated state;

Figure 12B is a view from above right of an embodiment of a banknote in accordance with the present invention in its first, deactivated state;

Figure 13A is a view from above left of the banknote of Figures 12A and 12B in its second, activated state;

Figure 13B is a view from above right of the banknote of Figure 13B in its second, activated state;

Figure 14 is a diagrammatic cross-section of a further embodiment of a banknote in accordance with the present invention in a first, deactivated state;

Figure 15 is a diagrammatic cross-section of the banknote of Figure 14 in a second, activated state;

Figure 16 is a view from above (obverse surface) of the banknote of Figure 15 in its activated state;

Figure 17 is a view from below (reverse surface) of the banknote of Figure 15 in its activated state;

Figure 18 is a view from above or below of the banknote of Figure 15 in its activated state when viewed in transmission, and

Figure 19 is a diagrammatic representation of a banknote in accordance with the present invention being read by an electronic reader and switched to generate a signal which is transmitted to a remote device and/or network.

Referring to Figure 1, a banknote is shown comprising a substrate 3 of e.g. paper on which is printed an electrochromic or other switching layer 2. A lenticular layer 1 is deposited on the electrochromic switching layer by known methods. The lenticular layer may comprise a two-dimensional array of micro-lenses 10 as shown in Figure 4 or an array of cylindrical lenses 10' as shown in Figure 5. In each case the lenticular array is focused on the surface of the electrochromic switching layer 2.

The electrochromic switching layer 2 is deposited in predetermined regions 2A bounded by regions of background colour 6 which match the optical properties of regions 2A (e.g. colour, opacity) only in the unactivated state of regions 2A, as shown in Figure 1. In the state shown in Figure 1, the entire layer 2 including regions 2A and 6 has a uniform appearance. Accordingly, in this state there are no colour transitions in switching layer 2 and hence the lenticular layer 1 does not generate an optically variable effect; i.e. the optically variable feature is deactivated. In this state, the banknote has the same appearance whether viewed from top left or top right.

In this embodiment the regions of background colour 6 are formed of a non-electrochromic material which matches the colour properties of the electrochromic

ink of regions 2A in one state of the electrochromic ink. In other embodiments, discussed below, the regions of background colour may be formed of the same electrochromic material as regions 2A but may be non-switchable, e.g. because switching electrodes (not shown) are selectively formed in registration with regions 2A only.

In the second, activated state of the banknote as shown in Figure 2, distinct colour transitions appear at the boundaries of regions 2A of the electrochromic switching layer 2. As shown in Figure 3, when seen from viewpoint VL (top left) a region 6 is seen through lenticular element 10/10' overlying a colour transition whereas when seen from viewpoint VR (top right) a region 2A is seen. A large number of such colour transitions will be present in electrochromic switching layer 2, resulting in an iridescent appearance on tilting the banknote, as will occur naturally during e.g. a payment transaction. Such an optically variable feature cannot be mimicked by photocopying or even by high resolution scanning and printing.

Figures 6 and 7 show a variant of the above embodiment in which a lenticular array, comprising a two-dimensional array of micro-lenses 10 or an array of cylindrical lenses 10', is deposited on a flexible transparent polymer layer 3', on the opposite side of which is deposited a switching layer 2 of electrochromic material over its entire area. Transparent electrodes 5 of e.g. Indium Tin Oxide (ITO) are deposited on selected regions of the underside of electrochromic layer 2 and are protected by a further layer of flexible transparent polymer layer 3" which acts as a substrate. If necessary, the layer 3' or any additional layers or components may be provided with sufficient conductivity to act as a counter-electrode to electrodes 5.

In the first, deactivated state of the banknote shown in Figure 6 the appearance of switching layer is uniform. Hence no optically variable feature is seen.

As shown in Figure 8, the lenticular elements 10/10' are focused on the surface of the switching layer 2.

Accordingly, as shown in Figure 7, when charge of appropriate polarity is applied to the electrodes 5, the electrochromic switching layer 2 changes colour in selected regions 2A overlying the electrodes but not in the intermediate regions 2B. Accordingly, colour transitions are visible at the mutual boundaries of regions 2A and 2B which result in iridescence on shifting the viewpoint of a user from VL (upper left) to VR (upper right) as shown in Figure 8. These colour transitions appear as iridescence on tilting the banknote.

In other embodiments, optically variable features other than iridescence are obtained in the second, activated state of the switchable visible region.

Figures 9 and 10 show a variant of the embodiment of Figures 1 and 2 in which a security document such as a banknote has a switching layer (eg an electrochromic switching layer) 2 which is deposited over a light-transmissive polymer substrate 3 and acts as a background to an image layer 4 sandwiched between a lenticular layer 1 and the switching layer. Image layer 4, when it is visible, generates an optically variable feature as a result of its contrasting regions 4A and 4B, which may be formed in a finely detailed design. For example, image layer 4 may have a holographic image formed therein.

In the first, deactivated state shown in Figure 9 the image layer 4 is invisible and no optically variable feature is apparent to a user.

In the second, activated state shown in Figure 10, transmitted light reaches the underside of image layer 4 and the resulting illumination of image layer 4 gives rise to an optically variable feature. For example, the hologram may become visible to a user viewing the security document from above.

Figure 11 shows diagrammatically a security document such as a banknote in which electrodes 5 (e.g. ITO or other transparent electrodes) are formed above and below

an electrochromic switching layer 2 and arranged to generate contrasting regions 2A and 2B constituting an image in the activated state. The electrodes are powered by a micro-controller and power supply circuit arrangement 7, as shown, which may be incorporated into the banknote or other security document. A lenticular layer 1 overlies the sandwich of switching layer 2 and electrodes 5 and generates an optically variable feature only in the second, activated state shown in Figure 11.

Figures 12A to 13B illustrate another embodiment of a banknote 20/20' in which a lenticular layer 1 is formed on a region of the banknote and a composite image is formed by a combination of a conventional printed image and an image formed by a switching layer (not shown) underlying the lenticular layer. The banknote includes conventional indicia 8 showing eg its denomination.

Figures 12A and 12B show views from upper left and upper right respectively of the banknote 20 in its first, deactivated state, i.e. in which the switching layer is deactivated. In this state, there are no colour transitions between adjacent regions of the switching layer, nor are any such colour transitions in the conventional printed image. Accordingly, the composite image I1 appears the same in both views.

Figures 13A and 13B show views from upper left and upper right respectively of the banknote 20' which is in the second, activated state, i.e. in which the switching layer is activated. In this state, there are colour transitions between adjacent regions of the switching layer which cause its associated image to appear differently when viewed through the lenticular layer 1 according to whether the view is from upper left (Figure 13A) or upper right (Figure 13B).

Referring to Figure 13A, the image I2 formed by the switching layer as seen from upper left overlaps with that of the associated conventional printed image and is substantially identical to image I1 of Figure 12A.

Referring to Figure 13B, the image I2' as seen from upper right is substantially different from image I2 because a different portion of the image formed by the switching layer is seen through the lenticular layer (cf e.g. Figure 3). Accordingly, as the activated banknote us tilted, the image seen by the user flips between I2 and I2'.

Figure 14 shows a security document (e.g. a banknote or a sheet of banknotes) comprising a translucent paper or flexible polymer substrate layer 3 on the opposite surfaces of which are deposited switching layers 2. These are arranged to be switchable only in selected regions 2A thereof, the regions on opposite sides of layer 3 having a predetermined registration.

In the first, deactivated state shown in Figure 14, the switching layers 2 are of uniform appearance. Accordingly, the do not exhibit any optically variable features.

As shown in Figure 15 and Figure 16, in which the switchable visible region of the security document is in the second, activated state, the regions 2A change colour. Consequently, when the security document is viewed from above with illumination from above (viewing in reflection) the upper regions 2A are visible as shown in Figure 16. In this embodiment the upper regions 2A are in the form of opposite parts of a star shape. Regions 2A can be independently activatable – i.e. one or both sides can be independently activated, as can one or more regions 2A on a given side.

When the security document is viewed from below with illumination from below (viewing in reflection) the lower region 2A is visible as shown in Figure 17. In this embodiment, lower region 2A is in the form of an arrow constituting the middle portion of a star shape.

When the security document is viewed in transmission, i.e. illuminated from the surface opposite the surface which is viewed, the upper regions 2A combine visually with the lower region 2 to form a star shape, as shown in Figure 18.

Thus the appearance of the security document changes dramatically according to whether it is viewed from the top (obverse) in reflection, from the underside (reverse) in reflection or in transmission, from either obverse or reverse.

The state of the electrochromic switching layer 2 may be switched to transition the optically variable feature from activated to deactivated and *vice versa* by applying a signal, e.g. via electrodes, of appropriate polarity.

In principle any switchable material may be used for switching layer 2, eg electrochromic, photochromic, piezochromic or other material whose optical properties can be switched from a first, deactivated state to a second, activated state by a suitable input signal.

In preferred embodiments, both states are stable.

Figure 19 shows a banknote 20' provided with an embedded pickup (eg an inductive or capacitive pickup) 15 which is coupled to its electrode arrangement (not shown) to control its electrochromic switching layer (not shown) which is disposed beneath a lenticular layer 1. The banknote is optionally also provided with an embedded microprocessor 7 and associated electronic memory in which data corresponding to indicium 50 of the banknote is stored.

Banknote 20' is in its second, activated state and thus exhibits an optically variable feature such as iridescence or a change in appearance of an image I as explained above with reference to Figures 13A and 13B.

The banknote 20' is coupled to a read/write device 25 which has a transducer 26 (e.g. a coil if pickup 15 is inductive) which can couple to pickup 15. The coil 26 is energised and controlled by control circuitry 27 which optionally also includes means for transferring data to and from microprocessor 7 and its associated memory.

In use of the read/write device 25, a signal is transmitted to pickup 15 which switches the electrochromic switching layer to change the state of the banknote 20 from an activated state to a deactivated state in which it no longer exhibits the optically variable feature. Control circuitry 27 is arranged to read out data via microprocessor 7 indicative of the denomination of the banknote and to transmit a corresponding encrypted signal S either to a remote device D or a computer network N (which may be the internet or a cloud-based network for example). In this manner the value in the banknote is electronically transferred into e.g. a savings account or a merchant.

The read/write device 25 may also be arranged to carry out the reverse transaction, in which, in response to reception of a signal S from network N or device D, a deactivated banknote is activated to put it into its second state in which the optically variable feature is activated. In this manner, monetary value is transferred to the banknote from e.g. a savings account or a merchant.

In other embodiments, the electrodes may be dispensed with and the electrochromic switching layer 2 may be switched by capacitive electrodes in the read/write device which apply an appropriate signal to the electrochromic switching layer.

In other embodiments, the read/write device may be coupled to other security documents with the appropriate activatable or deactivatable optically variable features as described above, such as certificates, passports, licences or bank cards (e.g. debit or credit cards) for example.

Claims

1. A switchable security document having an optically variable feature which is coupled to a switchable visible region comprising a colour-shifting ink, a photochromic ink, a thermochromic ink, a piezochromic ink, a fluorescent ink or a magnetic optically variable ink (MOVI), the switchable visible region having a first state in which the optically variable feature is deactivated and being switchable to a second state in which the optically variable feature is activated and thereby visibly apparent to a user;

   wherein the optically variable feature comprises a micro-optical layer;

   wherein the micro-optical layer comprises a lenticular array; and

   wherein the lenticular array is a two-dimensional array of micro-lenses or an array of cylindrical lenses.

2. A switchable security document according to claim 1 wherein the optically variable feature comprises printed regions of the security document which are mutually offset in the depth direction and have a predetermined registration so as to generate optical variation between views from different viewpoints.

3. A switchable security document according to either one of claim 1 or claim 2 wherein the switchable visible region comprises a switching layer for generating said first and second states.

4. A switchable security document according to claim 3 wherein said switching layer is electrochromic.

5. A switchable security document according to claim 4 further comprising an electrode arrangement arranged to energise said electrochromic switching layer.

6. A switchable security document according to claim 5 further comprising a pickup arranged to power said electrode arrangement.

7. A switchable security document according to any preceding claim, further comprising a memory storing electronic data.

8. A switchable security document according to any preceding claim, further comprising an electronic processor for controlling data transfer to and/or from the switchable security document.

9. A switchable security document according to any preceding claim which comprises a substrate of light-transmissive polymer on which said switchable visible region is formed.

10. A switchable security document according to any preceding claim which comprises a flexible substrate and wherein the switchable visible region is deposited on the flexible substrate.

11. A switchable security document according to claim 10 which comprises a banknote.

12. A switchable banknote according to claim 11 which has monetary value only when the optically variable feature is activated.

13. A method of switching a switchable security document as defined in any preceding claim in which the switchable visible region is switched between the first and second states in association with the transmission of a signal over a network or to or from a remote device.

14. A method according to claim 13 wherein the transmitted signal encodes information represented by the switchable security document.

15. A method according to claim 14 wherein the transmitted signal represents a transfer of monetary value associated with the switchable security document.