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RAN 4701/153

5 The invention relates to an optical component comprising a layer structure made up of an anisotropic layer of cross-linked liquid crystalline monomers in contact with an orientation layer on a substrate. The invention also relates to the production and preferred use of the aforementioned components.

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Anisotropic transparent or coloured polymer network layers with the optical axis oriented in three dimensions, either uniformly or pre-set point by point, are of great importance in many branches of display technology, integrated optics, etc.

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Substances having these properties in principle, i.e. certain cross-linkable liquid crystalline diacrylates and diepoxides, have been known for some years. These substances in monomer form, i.e. before cross-linking, can be oriented in cells by means of conventional orientation layers or under the action of external fields, e.g. magnetic or electric fields, in the LC phase and can be photo cross-linked in a second stage by conventional means, i.e. by irradiation with non-polarized light, without losing the orientation impressed in the monomeric state.

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Layer structures of this kind are known e.g. from EP-A-331 233. They are produced by orienting a monomer layer in an external field and then irradiating part of it through a mask. Cross-linking is initiated only in the irradiated region. The direction of the external field is then changed, and the monomer regions which have not yet been cross-linked are re-oriented in the new field direction. The latter region is then cross-linked by illumination. Clearly, this method cannot result in an orientation structure with high local resolution, since, owing to the shading of the mask, the radical cross-linking reaction is not sharply defined.

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Methods of generating orientation layers with locally variable orientation properties have become known recently. For example US-A-4 974 941 describes orientation by photolithography of dichroic dye molecules incorporated in the polymer.

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Layer structures comprising a film of cross-linked liquid crystalline monomers in contact with an orientation layer of a photo-orientatable polymer network (PPN) are described in the as yet unpublished Swiss Patent Application number 488/93. These layer structures are produced by orienting the liquid crystalline monomers by interaction with the PPN layer and by fixing the orientations in a subsequent cross-linking step. For other details, reference should be made to Swiss Patent Application No. 2016/94.

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The aim of the invention is to provide other possibilities for optical and electro-optical components and equipment, using layer structures of the above-mentioned kind.

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To this end, according to the invention, the substrate comprises a reflector. The reflector can be a diffuse or specular metal surface or reflecting polymers, e.g. containing pigments as in the case of metallised car paints, or reflecting paper or dielectric mirrors or the like. The reflectors must at least partly retain the state of polarization of the incident light. An arrangement of this kind according to the invention is particularly suitable for use in prevention of forgery and copying of banknotes or documents, or for generating reflective liquid crystal displays or for producing optical components for integrated optics, such as waveguides, gratings, non-linear optical (NLO) active substrates, or electro-optical Mach-Zender modulators, etc.

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Owing to the high-quality copying techniques which are available, there is an increasing need and requirement to prevent forgery of security elements in banknotes, credit cards, documents etc, which however must clearly be recognised for what they are by the general public. Most security features in use

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at present, e.g. holograms or kinegrams (J. F. Moser, "Document Protection by Optically Variable Graphics", in "Optical Document Security", R. L. van Renesse (ed.), Artech House, Boston, London, page 169) are based on diffraction of light on gratings. To check
5 their authenticity, these safety features must be observed at different angles of vision. This results in three-dimensional images, iridescence or cinematic effects which have to be examined in accordance with rules specific to the pattern. This results in the difficulty that the general public needs to know a
10 number of these complicated rules in order visually to check that a security element of this kind is genuine. Security features based on diffraction are also very complicated to check, particularly mechanically. There is no practical possibility of manual reading-in of individual items, e.g. images or numbers
15 coded by these techniques.

EP-A 435 029 describes security elements in the form of cholesteric liquid crystals, of the kind known e.g. in liquid crystal thermometers. Cholesteric liquid crystals, like mechanical
20 gratings, have a periodic structure which has the property, known since 1888, that the colour of reflected light varies with the angle of observation. The test for genuineness based on the associated iridescence is therefore beset with the same problems as with mechanical gratings.

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An embodiment of the invention will now be described with reference to the accompanying drawing.

The drawing is a diagrammatic detail of a layer structure in
30 a forgery-proof banknote. The basis or substrate of the layer structure is a paper layer 1, which is identical with conventional banknote paper. Many conventional banknotes already comprise a metal strip or filament, the aim being to give some protection against forgery. Accordingly, a metal layer 2 covers parts of the
35 surface of paper 1. An orientation layer 3 is disposed on the metal layer and has an orienting effect on a retarder layer 4 above it. The orientation layer 3 has a pattern which is transferred to the retarder layer 4 before cross-linking thereof and is

then present as a pattern 5 in the retarder layer. When the metal strip coated with the retarder pattern is observed in non-polarized light, the normal metal filament is visible. If the configuration is examined through a polarization filter, the pattern becomes visible. The pattern can be recognised either visually or by machine, using polarization-sensitive detectors.

This is a method of incorporating very elegant means against copying or forgery of banknotes, credit cards, documents etc. The retarder pattern can e.g. contain an image or a text. It can also be used e.g. to make normally invisible codes visible when observed through a polarization filter.

Owing to the invisibility of the retarder pattern when observed with non-polarized light, the layer structure can also be disposed over other security features without influencing the properties thereof. This combination with other anti-copying methods can further increase the protection against forgery.

Alternatively a retarder layer whose optical axis is at an angle to the surface can be incorporated in the security element. The layer can then be tilted to produce colours or light and dark effects which are asymmetrical relative to the position before tilting.

Compared with known security elements, the invention is characterized in that the genuineness of the safety feature can easily be checked by the general public, since it is not necessary first to learn to recognise complicated iridescence or cinematic effects.

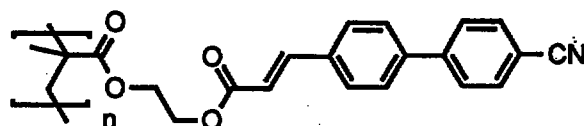
Other details of the invention will be clear from the following examples.

Example 1

Production of a PPN layer

- 5 The PPN material can e.g. be cinnamic acid derivatives. A PPN material having a high glass transformation point ($T_g = 133^\circ\text{C}$) was chosen for the example:

Polymer:



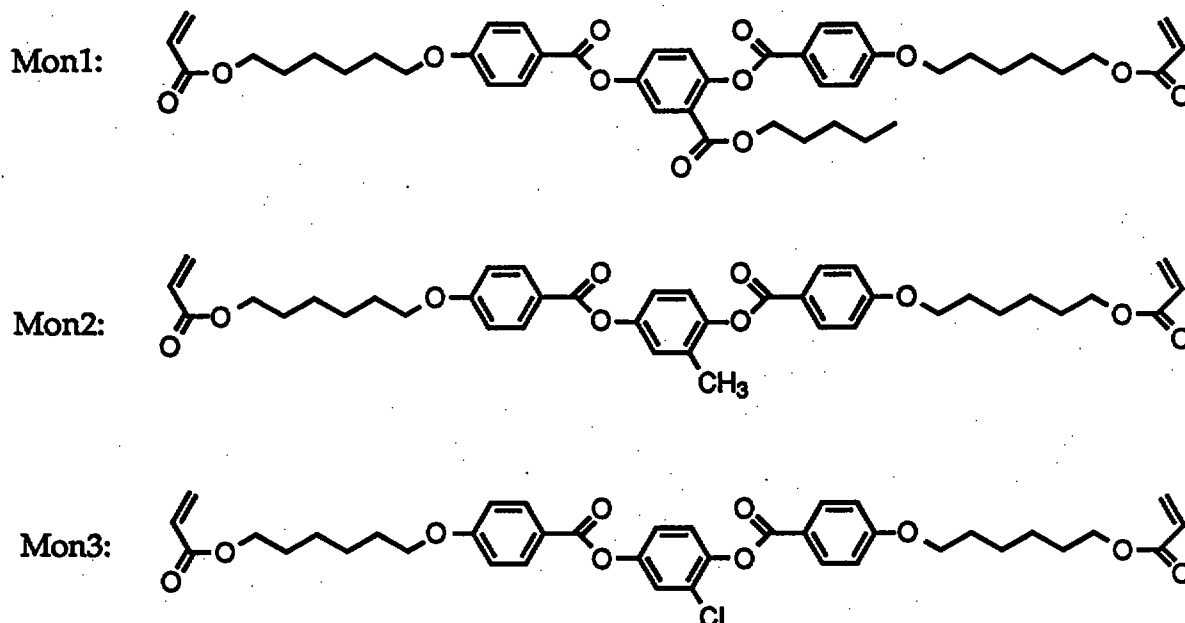
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- A glass plate was spin-coated with a 5% solution of the PPN material in NMP for 1 minute at 2000 rpm. The layer was then dried at 130°C on a heating bench for 2 hours and was dried for a further 4 hours in a vacuum at 130°C . The layer was then
- 15 illuminated with linear polarized light from a 200 W Hg very high-pressure lamp at room temperature for 5 minutes. The layer could then be used as an orientation layer for liquid crystals. However, the thermal stability of the orientation layer was too small for many applications. For example the orientation
- 20 capacity was lost after 15 minutes, e.g. at 120°C .

Example 2

- A mixture of cross-linkable LC monomers for the LCP
- 25 layers

The following diacrylate components were used as cross-linkable LC monomers in the examples:



These components were used to develop a super-coolable nematic mixture M_{LCP} having a particularly low melting point ($T_m \approx 35^\circ\text{C}$), so that the LCP layer could be prepared at room temperature.

The diacrylate monomers were present in the mixture in the following proportions:

Mon. 1: 80%
Mon. 2: 15%
Mon. 3: 5%

In order to accelerate the cross-linking process, 2% of Ciba-Geigy photo-initiator IRGACURE 369 was added. The mixture $MLCP$ was dissolved in anisole and applied to a PPN substrate. The thickness of the LCP layer could be adjusted over a wide range, via the concentration of $MLCP$ in anisole.

For the purpose of photo-induced cross-linking of the LC monomers, the layers after orientation were irradiated with isotropic light from a 150 W xenon lamp for about 30 minutes, thus fixing the orientation.

Example 3

A retarder on a specular or diffuse reflection metal surface

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A PPN layer was applied to a glass plate vapour-coated with aluminium, and was then irradiated with linear polarized UV light. The direction of polarization during illumination of one half of the plate was rotated through 45° relative to the direction of polarization when illuminating the other half. A 30% solution of MLCP in anisole was applied to the illuminated PPN layer by spin coating (2 min. at 2000 rpm). These conditions resulted in a layer which, after cross-linking, had an optical retardation of about 140 nm. However, the light reflected by the metal layer underwent twice the optical retardation, i.e. 280 nm. This approximately corresponded to a $\lambda/2$ plate, relative to an average wavelength in the visible part of the spectrum.

When the reflecting light was observed without using a polarizer, only an optically unstructured reflecting plate was visible. If however a polarizer was held in front of the plate so that the direction of transmission coincided with one of the two directions determined by the illumination, the corresponding half of the plate appeared light whereas the other half appeared deep blue.

It is therefore possible to write information on reflecting surfaces which can be read only by using a polarizer. These retardation patterns can be used e.g. for prevention of copying and for checking the genuineness of documents, banknotes or the like.



CLAIMS

1. An optical component comprising a layer structure made up of an anisotropic layer of cross-linked liquid crystalline monomers in contact with an orientation layer on a substrate, wherein the substrate comprises a specular or diffuse reflector.
2. An optical component according to claim 1, wherein the substrate consists of the reflector.
3. An optical component according to claim 1, wherein the substrate consists of a transparent material.
4. An optical component according to claim 3, wherein the reflector is disposed on the side of the substrate opposite the orientation layer.
5. An optical component according to claim 3, wherein the reflector is disposed above the LCP layer, the optical information on the LCP layer being observed through the substrate.
6. An optical component according to claim 3, wherein the transparent substrate is provided on both sides with a layer structure comprising an anisotropic layer of cross-linked liquid crystalline monomers in contact with an orientation layer.
7. An optical component according to claim 3, wherein one side of the substrate surface has a layer structure comprising an anisotropic layer of cross-linked liquid crystalline monomers in contact with an orientation layer, whereas the other substrate surface has a non-photostructured retarder layer or retarder foil.
8. An optical component according to any of claims 3 to 7, wherein the substrate is optically anisotropic.



9. An optical component according to any of the preceding claims, wherein the orientation layer induces a tilting angle in the LCP layer, so that its optical axis is at an angle to the substrate surface.

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10. An optical component according to any of the preceding claims, wherein the orientation layer and the liquid crystal have a pattern with a locally varying arrangement of molecules.

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11. An optical component according to any of the preceding claims, wherein the LCP layer contains dichroic dye molecules.

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12. An optical component according to any of the preceding claims, wherein the reflector is of metal in the form of a metallic filament.

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14. An optical component according to any of claims 1 to 13, wherein the layer structure comprising cross-linked liquid crystalline monomers and the orientation layer are disposed over other security features.

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15. Use of an optical component according to any of the preceding claims for prevention of forgery and copying.

16. Use of an optical component according to any of claims 1 - 14 in banknotes.

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17. Use of an optical component according to any of claims 1 - 14 in credit cards.

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18. Use of an optical component according to any of claims 1 - 14, wherein the information is detected in manually or automatically operated optical reading devices.

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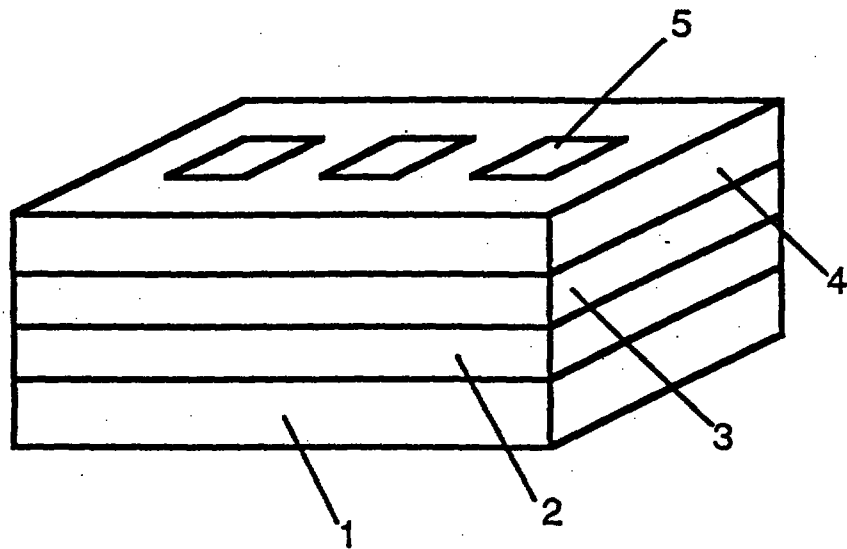
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Abstract

By combination of a hybrid layer consisting of an orienting layer and a layer of a cross-linked liquid crystalline monomer with a reflector and by appropriate local structuring of the molecule orientation an optical pattern is obtained which cannot be copied in conventional photocopiers. This pattern is useful as means for protecting documents, banknotes etc. from being copied.

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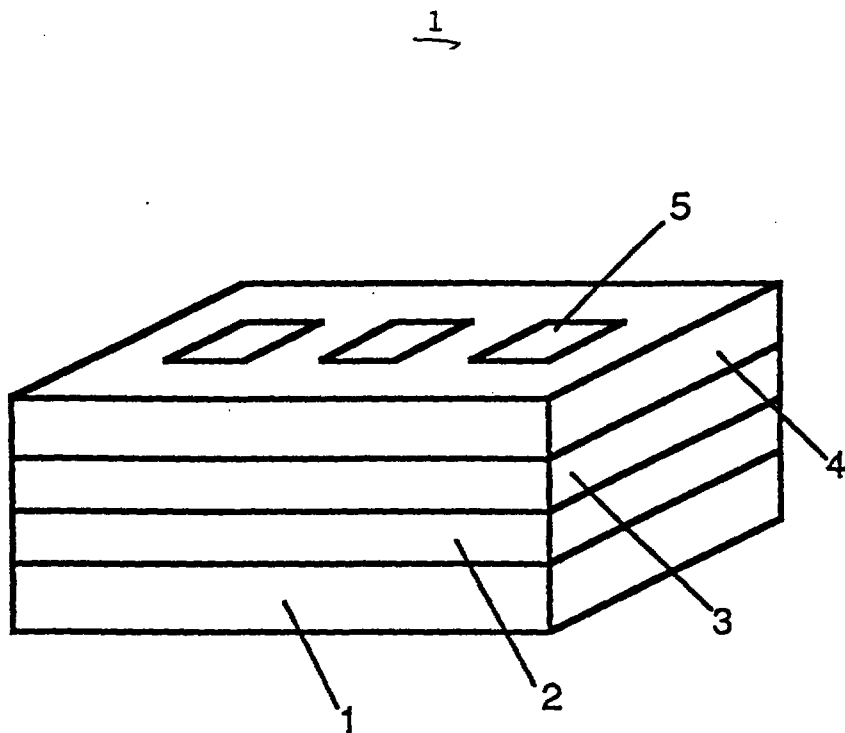


Figure 1

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OPTICAL COMPONENT

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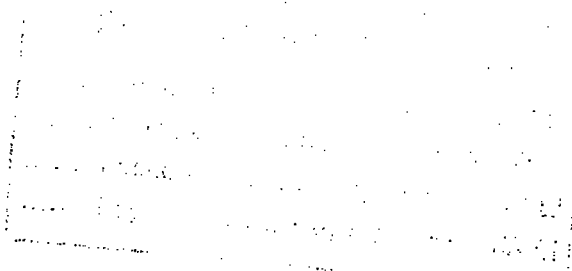
Figure 1

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TEXT OF THE ABSTRACT

OPTICAL COMPONENT

By combination of a hybrid layer consisting of an orienting layer and a layer of a cross-linked liquid crystalline monomer (3,4) with a reflector (2) and by appropriate local structuring of the molecule orientation an optical pattern (5) is obtained which cannot be copied in conventional photocopiers. This pattern (5) is useful as means for protecting documents, banknotes etc. from being copied.

Fig. 1.

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