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(54) **PHOTOLUMINESCENT FIBRE, SECURITY PAPER AND OTHER SECURITY ARTICLES**

PHOTOLUMINESZIERENDE FASER, SICHERHEITSPAPIER UND ANDERE SICHERHEITSARTIKEL

FIBRE PHOTOLUMINESCENTE, PAPIER FIDUCIAIRE ET D'AUTRES ARTICLES DE SECURITE

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a photoluminescent fibre for the incorporation into a security article. In particular the present invention relates to photoluminescent, i.e. fluorescent or phosphorescent fibres which are to be embedded in paper like structures like for example banknote paper etc.. The present invention also relates to security articles comprising such photoluminescent fibres and to a method to produce such security articles and to a use of the latter.

BACKGROUND OF THE INVENTION

[0002] It is commonly known that for security papers and security articles in general, for example for banknotes, checks, stocks, bonds, identification cards, passports, drivers licenses, tickets, stamps and similar documents such as bank cards, credit cards, and the like, security elements in particular in the form of photoluminescent fibres can be employed, which have the purpose to prevent or stifle forgery of those objects by unauthorised persons. Such security elements are also used to mark the authenticity or validity of object, or generally to enable or facilitate the identification of objects. It is, for example, widely known to use security threads or security strips which can consist of, among other things, a metal coated polymer, in security paper, especially for the application in banknotes and similar documents. When such security threads or strips are, for example, embedded in the security paper and the paper is subsequently printed, the thread or strips cannot be readily discerned in reflective light but immediately appear as a dark image when the document is viewed in transmitted light.

[0003] In order to ensure and enhance the security of security articles against modern counterfeiting techniques, in recent times it was repeatedly proposed to provide the security elements with specific properties, such that not the mere presence of the security element alone, but the presence of its specific properties shall guarantee the authenticity of the secured object (US 4,897,300; US 5,118,349; US 5,314,739; US 5,388,862; US 5,465,301, DE-A 1,446,851; GB 1,095,286). However, it is generally considered a grave disadvantage of all these known security elements that either the characteristic authenticity marks are rather difficult to recognise for a laymen, or that complex instruments have to be used for their detection. On the other hand, security elements which can easily be recognised can usually relatively easily be forged. Furthermore, it is in the nature of security articles that they are replaced by novel products with novel security elements after a comparably short time; in particular with the purpose to stifle forgery and abuse. Therefore an urgent need exists for novel, security elements of high security which are easily recognised, for applications in security paper and security articles in general.

[0004] For example WO 00/19016 describes such novel security elements based on their dichroic properties. The document describes security elements or segments incorporated into a paper or the like, which security elements show either linearly polarised photoluminescence and/or linearly polarised absorption. These security elements provide security paper and security articles in general which are characterised by secure, easily recognisable security elements. The document additionally describes security paper and security articles in general, the identification of which is enabled or facilitated through such security elements and it also describes the development of methods for the production of these security articles and the use of the latter.

[0005] However, problems arise when trying to incorporate such security elements into paper, as on the one hand the elements have the tendency not to be sufficiently fixed within the paper matrix and the polarisation efficiency (absorption as well as emission) is reduced when these elements are incorporated in the paper.

SUMMARY OF THE INVENTION

[0006] To start with, some of the most important terms shall be defined:

[0007] The term security article relates articles which substantially are made from paper from a synthetic material. It particularly but not exclusively relates to non-woven, flat, fibre-containing data carriers. In particular cotton containing paper as it is heavily being used in the field of banknotes is a possible security article. The security article may also be a more complex article like a passport, a banknote etc..

[0008] In order to describe the operation and properties of photoluminescent fibres in particular when polarisation comes into play, and the conditions of experiments, the following common definitions of the several axes will be used:

[0009] The polar axis of a linear polarizer or analyzer is the direction of the electrical field vector of the light that is transmitted by the polarizer films. The polar axis of a photoluminescent fibre or other object is the direction of the electrical field vector of the light that is emitted or absorbed by the respective segment, photoluminescent fibre, or other object.

[0010] The term segment is used for a part of an object, in particular of a photoluminescent fibre, for which the characteristic degree of polarization and polar axis for absorption and emission can be determined in appropriate manner.

[0011] The degree of emission polarization (also referred to as degree of polarization in emission) is expressed as

the emission dichroic ratio (also referred to as dichroic ratio in emission). The emission dichroic ratio is defined as the ratio of the integrated emission spectra measured through a linear polarizer (analyzer) with its polar axis parallel and perpendicular to the polar axis of the investigated segment, using unpolarized excitation light.

[0012] The degree of absorption polarization (also referred to as degree of polarization in absorption) is expressed as the absorption dichroic ratio (also referred to as dichroic ratio in absorption). The absorption dichroic ratio is defined as the ratio of the absorption measured with incident light linearly polarised parallel and perpendicular to the polar axis of the investigated segment or photoluminescent fibre, and is measured at the wavelength used for excitation.

[0013] The excitation wavelength is defined as the wavelength that is used for optical excitation (to generate photoluminescence) of the security element or its photoluminescent segments, respectively. The terms absorption and emission relate to optical processes.

[0014] It is the object of the present invention to overcome the problems of the prior art photoluminescent fibres and security articles. In particular the invention relates to photoluminescent fibres for the incorporation into a security article. Generally a problem of such photoluminescent fibres is that if incorporated into a matrix material like for example into paper or paper like structures, the major part of the fibres is buried in the matrix material and not close to the surface of the corresponding security article. Since the actual aim of such a photoluminescent fibre is to be seen upon irradiation, this means that most of the fibre does not give rise to the desired effect.

[0015] This problem is solved according to the present invention by providing a fibre which has an anisotropic cross-section. Anisotropic basically means that two principal axes are of different length. Surprisingly, it has been found that fibres with such anisotropic cross-sections not only have the tendency to align with and be arranged more closely to the surface of the corresponding security article into which they are incorporated, but they also align such that the large principal axis of the cross-section is substantially parallel to the surface of the security article. This means that on the one hand the fibres are more effective due to their increased closeness to the surface, but also their visibility is particularly pronounced since the wide side faces the viewer.

[0016] The photoluminescent fibre is **characterised in that** the short principal axis is between 5-20 μm, preferably between 10-15 μm long, and in that the long principal axis is between 50 - 150 μm, preferably between 75 - 125 μm long. These dimensions are particularly useful if such a fibre is to be incorporated into a paper like for example a banknote paper, which typically has a high cotton content. To be sufficiently bonded to the security article by two at the same time show an efficient effect, such a photoluminescent fibre preferably has a length below 10 mm, preferably in the range of 1 to 5 mm, most preferably around 3 mm or 3.5 mm.

[0017] According to a first preferred embodiment of the present invention, such a photoluminescent fibre shows a ratio of the lengths of the short principal axis to the long principal axis of the anisotropic cross-section in the range of 1:1.5 to 1:100. It is also possible to choose that ratio to be in the range of 1:2 to 1:50, preferably in the range of 1:2 to 1:25 or 1:5 to 1:25 and most preferably in the range of 1:2 to 1:15 or 1:8 to 1:15. Typically, ratios of about 1:8 have proven to be useful and effective.

[0018] The anisotropic cross-section can have various shapes, and it may for example be of substantially oval, polygonal, rectangular, triangular or lens-type shape.

[0019] In particular in the context of photoluminescent fibres which are characterised by a linearly polarised photoluminescence and/or linearly polarised absorption, well visible and easily detectable effects due to embedded photoluminescent segments can be achieved.

[0020] The fibres can preferably be embedded in a paper or paper-like structure composed of 30 to 99 percent in dry weight paper-fibres and 70 to 1 percent in dry weight filler and optionally further additives, complementing to 100 percent in total. Such additives may be the ones conventionally used for paper like e.g. binder, resin, surfactants, colorants, antifoaming agent, and additives to e.g. provide desired surface/printing properties etc..

[0021] It is found that usually problems arise when embedding photoluminescent fibres or generally security elements into paper or paper-like structures due to the fact that security elements which are partially or fully buried under a layer of paper or paper-like matrix, do not show the expected (linearly polarised) photoluminescence and/or (linearly polarised) absorption anymore to the extent as observed for the isolated security element or fibre. Surprisingly however, this problem can be largely overcome when the content in paper-fibres is adjusted within the range given in the characterising portion. Due to the structural orientation and due to the associated inherent fluorescent properties of paper fibres, and/or rather due to residual substances present in conventional paper fibres like lignines, resins, abietic acids etc., the desired effect of the security elements of fibres embedded within such paper-fibres is disturbed.

[0022] According to a preferred embodiment, the paper or paper-like structure is additionally substantially free of brightener and/or additives which itself have fluorescent properties in particular which itself show linearly polarised photoluminescence and/or linearly polarised absorption. In other words, such substances should not be excessively present in the matrix. There is quite a large number of additives commonly used in the production of paper which comprise chromophores with fluorescent properties when irradiated with ultraviolet irradiation. There are for example binders with particular resins exhibiting such properties detrimental to the present application. Additionally, many of the brighteners commonly used in the production of paper or paper-like structures are based on dyes which comprise chromophores

which themselves have fluorescent properties. These additionally hamper the efficiency of the photoluminescent fibres. One particular class of brighteners commonly used are stilbene-based brighteners which have pronounced fluorescent properties, and therefore these brighteners should not be present to the extent that they interfere with the desired security feature. If such substances are present in the matrix of the security article, this matrix exhibits a very bright appearance when irradiated with ultraviolet irradiation leading to a low contrast between the matrix and the photoluminescent fibres. Additionally, in the case of linearly polarised absorption or linearly polarised fluorescence, transfer between these fluorescent chromophores and the photoluminescent fibres may lead to a destruction of the polarisation efficiency as macroscopically detectable when e.g. looking at the irradiated photoluminescent fibres e.g. through a rotating polarization filter or observing the photoluminescent fibres in linearly polarised light.

[0023] According to another preferred embodiment, the security article is **characterised in that** the filler has high scattering properties and/or high absorption properties in the spectral range used in particular for irradiation and/or also for detection. To enhance particular macroscopically detectable polarisation effects (by enhancing the contrast of security element and matrix) or rather not to disturb the polarising effects due to the fluorescent fibres, the filler should be chosen such as to absorb as much of the incident polarised or not polarised radiation as possible. Among the various species useful for this purpose, in particular, titanium dioxide in its rutile and/or in its anatase modification proves to be of use as well as zinc oxides. A particularly pronounced beneficial effect is achieved when employing titanium dioxide in its rutile-modification. Already amounts in the range of 0.5 to 5%, preferably 1 to 3% w/w of rutile may suffice to achieve the desired effect even when other fillers which do not have these absorption properties are at the same time present. Usually less than 5% w/w suffice. It has to be noted however, that if for example additives or brightener are present in the matrix of the security article which have fluorescent properties, a larger amount of filler with the above-mentioned absorbing properties may be necessary. When e.g. rutile is used as filler (at least in a fraction as mentioned above), the paper-like structure appears completely dark when irradiated with ultraviolet irradiation which means that the incident light is completely absorbed by this filler. Also anatase and zinc oxide filler show this effect, but to a slightly lesser degree. This leads to two effects which are particularly advantageous in the present context:

1. almost no incident light reaches photoluminescent fibres which are buried under a (thin) layer of paper-matrix thus avoiding that these buried elements are irradiated by light which is not highly polarised in case of polarised excitation. When polarised light is used for polarised excitation, this polarisation is partially or fully lost when this light passes through layers of the matrix carrying the photoluminescent fibre. Correspondingly, light emitted by a buried photoluminescent fibre is also not highly polarised anymore leading to a masking of the desired bright/dark effect when for example rotating the polarisation axis of the incident light. The same is of course true if the incident light is not polarised but if detection is carried out using a polarisation filter (linearly polarised photoluminescence). In this case the photoluminescence emitted by the photoluminescent fibres which are buried is also reduced in its polarisation when passing through the layer covering the buried photoluminescent fibre leading to a masking or even to a loss of the bright/dark effect. Surprisingly, it has been observed, that if rutile (or another filler, organic or inorganic, having these properties, namely to be isotropically absorbing the irradiated light on a macroscopic scale) is being at least partially present in the filler, this effect can be reduced or avoided. This is due to the high scattering effects of the rutile particles and/or due to the absorption properties of these particles. The particularly high refractive index of rutile (which is higher than e.g. for the anatas-modification of titanium dioxide) is quite well known. However, that this leads to the advantageous effects in the context of the present application of embedding photoluminescent fibres is surprising finding. Even more so as the particle size of the titanium dioxide in rutile-modification does not seem to have a determining influence in this question. The highly symmetric structure of the unit cell of the rutile structure leads to fully isotropic properties when polarised light is irradiated, which in fact also seems to have influence in the present context.

2. Another advantage of using rutile or another functionally similar substance at least partially as filler is due to the black appearance of the paper-like structure when irradiated with light thus increasing the contrast between the paper matrix and the bright/dark appearance of the photoluminescent fibres.

[0024] According to another preferred embodiment of the present invention, the paper-fibres at least partially comprise synthetic-fibres like for example polypropylene-fibres, polyethylene-fibres, aramide-fibres, polyacrylonitrile-fibres and/or at least partially comprise natural raw material based fibres selected from the group of wood-fibres, cotton-fibres, grass-fibres, cellulose-fibres, viscose-fibres, lyocell-fibres, rayon-fibres.

[0025] According to a further preferred embodiment of the present invention, the photoluminescent fibre is characterised by linearly polarised absorption and/or linearly polarised fluorescence. In particular in relation with the application in the field of detection of false banknotes, irradiation with e.g. ultraviolet light of rotating polarisation (for example provided by an ultraviolet lamp which is covered by a rotating polarisation filter) the bright/dark effect can be observed very easily while using as little instrumentation as possible.

[0026] According to a further preferred embodiment of the present invention, the photoluminescent fibre is characterised by a dichroic ratio of 2 or more in absorption and/or emission, preferably of 5 or more in absorption and/or emission, and even more preferably by dichroic ratio of 10 or more in absorption and/or emission. In particular in the field of photoluminescent fibres for banknotes dichroic ratios of more than 5 are useful. The photoluminescent fibres may be either be homogeneously distributed within the paper or paper-like matrix or may also be provided in particular arrangements to further beneficially enhance the bright/dark effect. Also possible are stripes extending substantially across the entire security article.

[0027] In another preferred embodiment, the photoluminescent fibre can be excited to photoluminesce through exposure to electromagnetic irradiation of a wavelength between 200 and 500 nm. Ultraviolet irradiation is particularly useful as sources for providing such light are quite cheap and may be used without any human noticing it unless some of these particular photoluminescent fibres with particular dyes are being brought near such light.

[0028] There are different carrier materials which are particularly suitable for forming said photoluminescent fibres if they are to show linearly polarised absorption and/or linearly polarised emission (fluorescence). The carrier material carrying the photoactive dye must allow an incorporation of the dye leading to a macroscopic polarisation effect. Usually that requires that the carrier allows an oriented incorporation/embedding of the dye which means that it should usually have some structural orientational order which may be achieved by stretching for example. For crystalline species, this high orientational order is measurable e.g. by wide-angle x-ray diffraction, where the order should be characteriseable by a half width at half height of less than 25 degrees, preferably of less than 15 degrees, and even more preferably of less than 10 degrees. Another possible mechanism allowing for oriented adsorption of the dye on the surface of the security carrier may be a particularly orientationally structured surface of said carrier, for example through graphoepitaxy. On the one hand the photoluminescent fibres may be made of a polymer carrier, preferably polyethylene, polypropylene, polycarbonate, polyester, polyamide, polyacrylonitrile, polyvinyl alcohol, aramide, or other materials e.g. used in the field of textile fibres, or mixtures thereof, dyed with a photoluminescent dye. On the other hand said photoluminescent fibres may be made of a cellulose-based carrier dyed with a photoluminescent dye. This carrier is of particular advantage as fibres or other photoluminescent fibres made of such carrier provide surface properties allowing for firm and easy embedding into a common, cellulose-based paper matrix. Cellulose-based fibres shows the same behaviour with respect to hydrogen bonding as the material being used for the paper matrix, thus ensuring tight attachment to this particular paper matrix. Especially, such photoluminescent fibre may be made of viscose, or lyocell. The fibre may e.g. be in the form of fibres with a length of 0.5 to 25 mm, preferably of 1.0 to 10 mm at 1 to 50 dtex, preferably at 5 to 20 dtex, which fibres may be incorporated/embedded into a paper matrix.

[0029] The particular shape of the cross-section of the fibres can be obtained by using correspondingly shaped extrusion nozzles.

[0030] Further generally possible are textile fibres with more than 1 dtex. Particularly well suited due to their high degree of orientation and due to their ease with respect or dying are lyocell-fibres as obtained by the NMMO-process, such as those manufactured by for example Lenzing. Particularly distinct effects can be achieved if the fibres are as little distorted as possible and show as little fibrillation as possible. A high transparency of the fibres is of advantage as well.

[0031] The security elements may also be patterned or otherwise modified after the dying/stretching process, for example to destroy the polarisation effect in certain regions. This may be achieved by methods like local heating such that the structural order in the heated region gets lost due to melting leading to isotropic distribution of dye in these regions(so called embossing). Another possibility is to irradiate selected regions of the dyed security elements with high-energy (ultraviolet) irradiation leading to destruction of the chromophores and subsequent bleaching of the irradiated regions. Both methods allow the design of particular forms, stripes, characters, logos, etc. on the security elements adding to the securing effect of such elements.

[0032] According to still another preferred embodiment, the paper or paper-like structure is composed of 80 to 97 percent in dry weight fibres and 20 to 3 percent in dry weight filler and optionally additives, complementing to 100 percent in total.

[0033] Further preferred embodiments of the photoluminescent fibre according to the present invention are described in the depending claims.

[0034] The present invention additionally concerns the application of a security article as described above for objects the forgery of which shall be made difficult or impossible, or for an object selected from the group consisting of banknotes, checks, stocks, bonds, identification cards, passports, drivers licenses, tickets, stamps, bank cards and credit cards.

[0035] Furthermore, the present invention also concerns processes for the production of security articles, **characterised in that** at least one fibre with anisotropic cross-section is dyed with a photoluminescent dye preferably prior or after its structural orientation, and is then embedded in a paper-like matrix. As mentioned above, the photoluminescent fibre/segment may subsequently also be treated in certain regions to selectively modify or erase the polarisation effect in these regions.

[0036] Concerning the embedding/incorporation of photoluminescent fibres in the paper-like matrix, this may be achieved by using conventional paper-making techniques. It is, however, also possible to introduce the photoluminescent

fibres only in certain layers, preferentially in the surface layers of the security article (e.g. multi-layer paper or data carrier) to prevent that a large number of fibres is buried within the security article without substantially giving rise to desired fluorescence and/or polarisation effects. Such a multi-layer paper may for example be produced by laminating 2 flow boxes immediately behind the 2 vats/cylinders, where only one of them comprises polarising fibres. It may additionally be possible to incorporate fibres in a particular coating covering a security article.

SHORT DESCRIPTION OF THE FIGURES

[0037] In the accompanying drawings preferred embodiments of the invention are shown in which:

Figure 1 a) is a perspective view of a photoluminescent fibre according to the state-of-the-art including a magnified view of a straight segment; b) shows fibres according to figure 1a) as incorporated into a security article in a sectional representation orthogonal to the surface of the security article;

Figure 2 a) -h) are views of anisotropic cross-sections of fibres; and

Figure 3 a) shows fibres according to figure 2 as incorporated into a security article in a sectional representation orthogonal to the surface of the security article; b) a sectional representation orthogonal to the surface of the security article orthogonal to review according to figure 3a).

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0038] Figure 1a) shows a photoluminescent fibre 1 according to the state-of-the-art. Such fluorescent or phosphorescent fibres are widely being used to be incorporated into a paper or paper-like structures to render them security papers. Articles provided with such photoluminescent fibres 1 in their matrix reveal, if irradiated with corresponding electromagnetic radiation, generally in the UV-range, the fibres, which are otherwise invisible. To enhance the effects, normally these fibres 1 are coloured differently. As visualised in figure 1a), these fibres generally have a quasi-circular cross-section 3 and may be tilted or straight (see in particular segment 2). If such a photoluminescent fibre 1 is incorporated into a security article 4 like for example a banknote paper, the fibres, which form part of the pulp out of which the paper is made, are arranged randomly within the matrix. This means that generally only a small fraction 5 of the fibres 1 is close to one of the two surfaces 6 or 7, while a large fraction 8 of the fibres is buried within the matrix of the security article 4. This on the one hand makes sure that the fibres are well fixed to the matrix of the security article 4, but on the other hand the visibility of the fluorescence effect is hampered due to the fact that most of the fibres is buried within the paper structure.

[0039] Surprisingly it has been found, that the alignment of fibres within such a structure 4 can be influenced by changing the cross-section of such a fibre 12. If the fibre 12 is allowed to have an anisotropic cross-section, ie a cross-section which shows a long principal axis and a short principal axis, such fibres align as is displayed in figure 3. The fibres 12 not only align close to the surfaces 6 or 7 of the security article 4 due to the paper production process, but they also align such that their maximum width is exposed to the surface, and therefore to the viewer. This means that the large principal axes of the anisotropic cross-sections are generally aligned substantially parallel to the surfaces 6,7. This leads to a substantial enhancement of the visibility of the fluorescence effects, in particular so, if the fluorescent fibres show linearly polarised absorption and/or linearly polarised fluorescence, and if such a security article is viewed under a rotating polarizer or if irradiated with light showing rotating polarisation direction.

[0040] Figure 2a)-h) show different possible anisotropic cross-sectional shapes. For the sake of ease of display, the ratio of the short principal axis 10 to the long principal axis 11 has always be chosen in the range of 1:2 to 1:4. However, it has to be noted that this ratio may well exceed these values and for example be 1:8, as is realised when the short side of a rectangular shape (cf e.g. figure 2b) is in the range of 10 to 15 μm while the long side of the rectangular shape is about 100 μm. The length is preferably chosen to be around 3 mm or 3.5 mm.

[0041] The present invention is additionally based on the finding that photoluminescent materials which are characterised by linearly polarised photoluminescence or linearly polarised absorption or both and can be made in a form, can be employed to produce photoluminescent fibres that can be used for the production of security paper and security articles in general. However, problems may arise when embedding the photoluminescent fibres into paper or some other security article due to the fact that this matrix may reduce or disturb the efficiency of the photoluminescence effects that can be observed.

[0042] The general fact that certain luminescent materials can exhibit linearly polarised absorption and emission has been known for long times; these effects have first been observed in inorganic crystals (E. Lommel, Ann. d. Physik und Chemie, Vol. 8, pp. 634-640 (1879)) and later in oriented blends of ductile polymers and low-molecular weight luminescent materials (A. Jablonski, Acta Phys. Polon., Vol. A 14, pp. 421-434 (1934)). Since, a number of materials has been

described that exhibit linearly polarised absorption and emission (J. Michl et al. "Spectroscopy with polarised light" (1986), VCH Publishers, New York) including, for example, oriented blends of ductile polymers and oligomeric photoluminescent materials with significant uniaxial component (M. Hennecke et al., Macromolecules, Vol. 26, pp. 3411-3418 (1993)), oriented photoluminescent polymers (P. Dyreklev et al., Adv. Mater., Vol. 7, pp. 43-45 (1995)) or blends thereof and a ductile polymer (US Patent 5,204,038; T. W. Hagler et al., Polymer Comm., Vol. 32, pp. 339-342 (1991); Ch. Weder et al., Adv. Mater., Vol. 9, pp. 1035-1039 (1997)), liquid crystalline systems (N. S. Sariciftci et al., Adv. Mater., Vol. 8, p. 651 (1996); G. Lüssem et al., Adv. Mater., Vol. 7, p. 923 (1995)) or oriented photoluminescent materials grown onto orienting substrates (K. Pichler et al., Synth. Met., Vol. 55-57, p. 454 (1993); N. Tanigaki et al., Mol. Cryst. Liq. Cryst., Vol. 267, p. 335 (1995); G. Lüssem et al., Liq. Cryst., Vol. 21, p. 903 (1996); R. Gill et al., Adv. Mater. Vol. 9, pp. 331-334 (1997)). Also recently materials have been described that are characterised by an essentially unpolarized absorption but a linearly polarised emission (C. Weder et al., Nature, Vol. 392, p. 261; European Patent Application 98101520.9). Similarly materials can be obtained that are characterised by an essentially unpolarized emission but a linearly polarised absorption (European Patent Application 97111229.7; European Patent Application 98101520.9).

[0043] Such materials can be brought in an appropriate shape and be used for the production of security elements that can be employed for the production of security papers and other security articles.

[0044] In case of photoluminescent segments, it can be advantageous if normal daylight does not or only weakly lead to the excitation of the luminescent material. In contrast, it can be advantageous if an additional light source is employed that emits, for example, in the UV, in order to stimulate the photoluminescence of the fibre. The linearly polarised photoluminescence of such fibres leads to the situation that the emitted light is absorbed by an external polarizer (analyzer) more or less strongly, depending on the orientation of the polar axis of the polarizer (analyzer) and the polar axis of the segment. This, for example, in the case of inspection with the naked eye (and through a polarizer/analyzer), can lead to a strong bright/dark contrast. Of course, this effect can also be detected with suitable sensors. The linearly polarised absorption of such fibres, in similar fashion, leads to the situation that linearly polarised excitation light which, for example, can be generated by an external light source in combination with a linear polarizer, is absorbed unequally strong by the fibre; depending on the orientation of the polar axis of the excitation light and the polar axis of the fibre.

[0045] The term segment is used for a part of an fibre for which the characteristic degree of polarization and polar axis for absorption and emission can be determined in appropriate manner. It is obvious to the one skilled in the art that the shape and the size of these segments can vary from case to case and that the measurement of absorption and emission polarization can be performed with a variety of experimental set-ups, for example conventional spectrometers, microscopic methods, etc. If, for example, a fibre based on the some photoluminescent material of a diameter of 0.5 mm and a length of 20 cm that is formed into a circle is considered to be a combination of many segments, because polarization measurements exhibit a strong positional dependence. Of course, also this element exhibits optical effects, analogous to the ones described above and according to the present invention, which can be described by a combination of individual segments.

Dyes:

[0046] The photoluminescent fibres in security articles according to the present invention comprise one or more luminescent dyes in suitable concentration and of suitable properties, i.e. which if desired also cause the polarization characteristics. Usually dyes only have anisotropic polarisation characteristics in absorption or emission if also the underlying chromophore is structurally anisotropic. Suitable luminescent dyes can, for example, be found in European Patent Applications 97111229.7 and 98101520.9 and in the patent applications and publications cited therein.

[0047] Furthermore, the following dyes can be used: 1,4-Bis(5-phenyl-2-oxazolyl)benzene (POPOP, Fluka 15150), 4,4'-Bis(2-benzoxazolyl)stilbene (Uvitex OB ONE, Aldrich 368590), Pergasol Flavin 7G (available also under the trade name Pergasol Gelb GA from Ciba Speciality Chemicals or under the trade name Solophenylflavin 7 GFF; C I Direct yellow 96), Tinopal ABP liquid (particularly suitable for cellulose based elements and for elements based on polar synthetic carrier, also available under the trade name Blankophor P, Bayer, Leverkusen; C I fluorescent brightener 220), , Oxonol 595 (Aldrich 44052-3), Keystone Fluorescent Yellow 10G (available through Keystone Aniline Corp, Chicago, IL 606112). Additionally, a number of azo-dyes such as Congo Red and Sudan Red B are particularly suitable for the described effect in absorbance. The choice of these dyes for particular carrier materials for the fibres can be made by the person skilled in the art based on the usual consideration of the compatibility/polarity of the dye and the carrier. Generally, additional suitable dyes can for example be found in the field of laser dyes and dyes for fluoroimmunoassays.

[0048] Other suitable luminescent dyes can be found among optical brighteners as used in textile or paper industry. Many optical brighteners have polarisation characteristics as requested according to the present invention and can therefore be used for dying the security elements. Possible products are for example Blankophor (R) P (liquid), which is a derivative of 4,4'-Diamino-stilhene-2,2'-disulfonic acid (available from Bayer, Leverkusen). This optical brightener gives blue fluorescent effects and is particularly suited for dying elements based on cellulose, namely lyocell, rayon or viscose threads, fibres, etc and those based on polar synthetic polymers such as aramide, polyamide, polyvinyl alcohol

and the like. Another suitable optical brightener is Uvitex OB-One, which is a 4,4'-bis(benzoxazol-2yl)stilbene (available from Ciba Speciality Chemicals). This optical brightener also gives blue fluorescent effects after excitation in the ultraviolet range and is particularly useful for dying elements based on a less polar polymer carrier (polypropylene, polyethylene etc.).

[0049] Other suitable dyes are generally given by stilbene based textile dyes or other textile dyes. The stilbene unit leads to the anisotropic absorption or emission properties due to its anisotropic geometry. Of course, also other dyes used in textile industry with an anisotropic chromophore not based on the stilbene-unit can be advantageously used. One particular dye used in textile industry which is particularly useful for dying security elements based on cellulose, namely lyocell, rayon or viscose, is available under the name Pergasol Gelb 8 GA, which is a stilbene-dye (available from Ciba Speciality Chemicals). Also this dye can be excited in the ultraviolet range leading to emission of yellow radiation. Absorption as well as emission can be polarised.

[0050] Other suitable dyes are inorganic transition metal-ion dyes which also have polarised absorption and/or emission properties.

[0051] Of course, also mixtures of the above-mentioned dyes can be used.

[0052] Generally speaking, care has to be taken that the material does not have some surface layer/coating which disturbs or even annihilates the polarisation effects when a dye is incorporated/embedded/adsorbed or which prevents or hampers oriented embedding/adsorption. In particular in the case of fibres, and even more particularly in the field of textile fibres, final coatings are quite common, and these may have to be washed off prior to the dying process. For example in case of textile fibres, the so-called avivage should preferably be removed if the used material interferes with the desired orientation effect. Also, these layers may contain brighteners, colorants and other additives which can have the same detrimental effect as the brighteners and additives possibly present in the matrix of the security article.

Carrier material for the fibres:

[0053] As mentioned above, the carrier material carrying the dye must allow an incorporation of the dye leading to a macroscopic polarisation effect, which can be observed by the naked eye or by a particular detector. Usually this requires that the carrier allows an oriented incorporation/embedding of the dye which in turn means that it should usually have some structural orientational order which may be achieved by stretching for example. This high orientational order is measurable e.g. by wide-angle x-ray diffraction, where the order should be characteriseable by a half width at half height of less than 20 degrees, preferably of less than 15 degrees, and even more preferably of less than 10 or even 7 degrees. Another possible mechanism allowing for oriented adsorption of the dye on the surface of the security carrier may be a particularly orientationally structured surface of said carrier.

Polymer based carrier material:

[0054] Among the polymer materials suitable in the context of the present invention and also generally for producing fibres with polarised emission or absorption are the following:

[0055] According to a particular embodiment, the carrier polymer allows for the fabrication of blends comprising at least one PL dye and at least one carrier polymer by melt-mixing, which can be shaped by melt-processing. Production of the polymer carrier can however also be carried out by different methods like solution casting or spinning.

[0056] We have found that semicrystalline polyolefins such as polyethylene polypropylene, for example, are useful as carrier polymer in preferred embodiments of the present invention. For example, we have found that if for example linear low-density polyethylene (LLDPE) is used as a carrier polymer, security elements can be manufactured, according to the present invention, that exhibit unusually high dichroic ratios in absorption. Other examples of semicrystalline or amorphous polymers that are preferably used as carrier polymer in preferred embodiments of the present invention, are polyvinylidene halides, polyesters, and polyamides, polyacrylonitriles, polyvinylalcohols, aramides, polycarbonates and so forth, and mixtures thereof. In the context of the present invention, also copolymers can be used as the carrier polymer, for example ethylene/propylene copolymers and so forth. The molecular weight of the carrier polymer employed may vary within wide limits. Polymers having lower molecular weights have, as a rule, good melt processing characteristics. At the other hand, it is well known in the art, that the maximal achievable draw ratio usually increases with molecular weight. As another rule, linear polymers are used by preference on account of their high degree of orientability. The one skilled in the art should be deemed capable of selecting the right carrier polymer, depending on the envisaged application and the dye employed. The orientation within the polymer can e.g. be achieved by drawing after or during the production process of the fibres/threads. Usually, the dye can be incorporated into these fibres either prior to drawing or after, and the dye can either be introduced into the fibre by a diffusion or a solution process.

[0057] E.g., oriented polypropylene (e.g. isotactic polypropylene, Polysciences; polypropylene Fina 3374; REO Flock&Faser, e.g. rohweiss, 5mm, 17dtex), polyvinyl-alcohol (e.g. Aldrich 36, 315-4 98-99 %, Mw 85000-146000), aramide fibres or threads are being used in lengths of between 0.5 to 20 mm, preferably of 1 to 5 mm, at 1 to 50 dtex, preferably at between 5 and 20 dtex.

Cellulose based carrier material:

[0058] Also possible as material for the carrier of the fibres are cellulose based structures with suitable orientation. These include among others cellophane, lyocell, viscose, rayon etc. Viscose threads with lengths between 1 to 10 mm at 2 to 20 dtex are suitable. In particular products like Bocell (Akzo Nobel), Fortisan (CERMAV), Tencel fibre and cut (CERMAV), Flax, Ramie, viscose polymeric (all CERMAV). In particular certain Bocell, Fortisan, and Tencel fibres show high orientation and were found to be suitable for the present applications.

[0059] Particularly suitable are also lyocell-fibres/threads as manufactured by Lenzing. These are available under the trade name Lenzing-Lyocell and show a high degree of orientation at little fibrillation and little crumpling. These fibres can be easily dyed leading to polarised absorption and/or polarised emission of the adsorbed/incorporated dyes and can therefore be used not only for the incorporation into the security articles according to the present invention but also for many other applications. These other applications may for example be in the field of cloth, textiles, garments, woven and non-woven labels, films, credit cards, etc.

[0060] Generally in the context of fibres (synthetical or natural) it has to be pointed out that possible coatings interfering with the present polarisation effects should preferably be removed, that the fibres should preferably be transparent in the visible range, and that the fibres should be free from defects and distortions such as kinks as much as possible. Preferentially, if kinks are present, the straight segments should be longer than the typical length for the detection of the polarisation effect. So in case of observation by the naked eye, which usually allows a resolution of about 10 μm, the majority of the straight segments should preferably be longer than this unit. If this is not the case, the bright/dark effect may not be readily recognised by the naked eye.

[0061] For the incorporation into a paper matrix like for example into a banknote, such fibres should be highly oriented (wide-angle x-ray scattering have width at half height of less than 10 degrees), should have a clean, i.e. smooth surface, should be free from defects and kinks i.e. should be straight, should have a length between 3 to 5 mm and a thickness in the range of 10 to 40 dtex, preferably of in the range of 17 dtex. It is also possible to mix natural carriers with polymeric substances as mentioned above and to extrude them together into their final form of a thread, rod, tape, film, etc.

[0062] The dyed security elements may be treated after the dying process by methods like embossing and/or by bleaching out certain regions using high-energy a radiation destroying the chromophores in these regions (so-called patterning).

Surface treatment of the fibres:

[0063] In order to allow better embedding/fixing of the fibres in the security article/paper, in particular the surface of polymer based fbres/threads or also the surface of polymer coated natural raw material based elements can be modified. Of course, cellulose based fibres usually do not need this surface treatment as for example for the embedding of such fibres into common cellulose-based paper hydrogen bonding possibilities are inherently available in this carrier. Principally this is sometimes necessary to allow a better interaction (e.g. via hydrogen bonds) between the surface of the fibre/thread and the surrounding matrix of the security article/paper. Possible methods of modification are fluorination (carried out in the liquid or in the gas phase), etching with sodiumnaphthalinate (immersion in a solution) or plasma-surface modification and the like. These methods aim at introducing mechanical possibilities of attachment of the fibres/threads in the matrix of the security article/paper or at introducing polar groups at the surface in order to allow the formation of hydrogen bonds between the matrix material and the polymer fibre/thread. The effectiveness of the surface treatment can easily be checked by means of the measurement of the contact angle/of the wettability.

Dying of the fibres:

[0064] Suitable methods for the preparation of fibres for the application according to the present invention can, for example, be found in European Patent Applications 97111229.7 and 98101520.9 and in the Patent applications and publications cited therein. As will be evident from the following examples, the fibres or segments of such fibres for the application in security articles according to the present invention, can be produced by the anisotropic deformation of ductile mixtures. As mentioned above, the dying can be carried out either prior to the deformation of the security elements to introduce the structural order necessary for the dyed security elements to exhibit polarising properties or the dye can be introduced into or onto the oriented carrier of the security element. Principally, different dying processes are possible, of which the particularly useful are diffusion based dying processes and solvent based dying processes.

[0065] Usually the dye is dissolved in a suitable solvent (the choice of the solvent or mixture of solvents depending on the polarity of the dye and of the fibre/thread to be treated), the fibres are subsequently added and this mixture is then either kept still or stirred and/or heated and/or refluxed for a certain period of time. In case of cellulose based carrier material the fibres/threads may have to be dried for several hours e.g. in vacuo prior to the dying process. After that the fibres/threads are removed (e.g. by using a filter) and washed once or repeatedly with either the same solvent or another

solvent. For less polar dyes and polymeric matrices for the security elements solvents like toluene, benzene, N-Methylpyrrolidone, xylene and the like or mixtures of these solvents can be used for the dying processes. For polar dyes and cellulose based matrices water can be used advantageously as the solvent but also other polar solvents are possible.

[0066] Another possible dying mechanism can be vapour deposition of the dye.

[0067] Care has to be taken when dying the security elements as for certain carrier material and dye-combinations an excess of dye might lead to a weakening of the polarisation effect.

[0068] In particular in case of Lyocell Lenzing fibres water can be used and the dying process is preferably carried out that elevated temperatures like above 80 degrees Celsius washing the isolated dyed fibres two to three times using water of about the same temperature. The resulting fibres show a high degree of polarisation in absorption as well as emission and can therefore be used also for other purposes than for incorporating/embedding into security articles/papers as claimed within this application.

Method of incorporating fibres into paper or the like:

[0069] The basic concept can principally be applied for all prior art security articles and security papers which comprise at least one security element that is comparable with the one disclosed here, apart, of course, from the linearly polarised photoluminescence, absorption or both. For example, security papers can be made, into which one or multiple photoluminescent fibres are embedded. If a multitude of such fibres are used, they can, also exhibit different emission colours and can be arranged in certain patterns, for example, with a specific arrangement of their polar axis'. The fibres can exhibit different shapes; for example, they can be straight or curled, which leads to different optical effects.

Paper fibres:

[0070] The fibres which can be used in the present context are synthetic fibres as well as natural raw material based fibres. In case of natural raw material based fibres e.g. wood- based-fibres (chemical wood pulp), cotton-fibres, grass-fibres, cellulose-fibres, viscose-fibres, lyocell-fibres, rayon-fibres, and mixtures of these fibres can be used. It has to be noted that also these fibres usually show some degree of orientation and might influence the polarisation effects of the security elements to be embedded within the paper-like matrix. Therefore a careful choice as well as a carefully chosen amount of these fibres has to be found for an optimum effect.

[0071] The fibres are preferably milled to a length in the range of 0.4 to 4 mm, preferably to a length of in the range of 0.6 to 1.2 mm.

Filler:

[0072] A number of fillers can be used for the paper-like structure to carry the security element. Usually fillers are added due to their low price, and to produce certain properties like opacity, stiffness, printing properties etc. E.g. titanium dioxide either in its rutile or in its anatase modification as well as zinc oxide can be used, as well as zinc sulphide, lithopone (zinc sulphide and barium sulfate), caoline, silicates, carbonates and the like. To enhance the particular polarisation effects or rather not to disturb the polarising effects due to the security elements, the filler can be chosen such as to absorb as much of the incident polarised or not polarised radiation as possible. For example the use of titanium dioxide in its rutile or at anatase modification as well as zinc sulphide prove to be particularly useful. In particular when rutile is used as filler or at least added to the filler in a sufficient amount of usually 1 to 2 % (this percentage, as mentioned above, sometimes preferentially being higher in case of the additional presence of certain resins, brighteners and the like in the matrix), the paper-like structure appears completely dark when irradiated with ultraviolet irradiation which means that the incident light is completely absorbed by this filler. Alternatively it is possible to intensively dye the paper in the mass. It is also possible to incorporate organic or other inorganic ultraviolet absorbers into the matrix to achieve the same results, i.e. to eliminate all irradiated ultraviolet irradiation which is not harvested by a particular fibre. This leads to two effects which are particularly advantageous in this context:

[0073] First of all, almost no incident light reaches security elements which are buried under a layer of paper-matrix thus avoiding that these buried elements are irradiated by light which is not highly polarised in case of polarised excitation. When polarised light is used for polarised excitation, polarisation gets partially or fully lost when this light passes through layers of the matrix carrying the security element. Correspondingly, light emitted by buried security elements is also not highly polarised anymore leading to a masking of the wanted bright/dark effect when for example rotating the polarisation axis of the incident light. The same is of course true if the incident light is not polarised but if detection is carried out using a polarisation filter. In this case the linearly polarised photoluminescence emitted by the security elements which are buried is also reduced in its polarisation when passing through the layer covering the buried security element leading to a masking or even to a loss of the bright/dark effect. Surprisingly, it has been observed, that if rutile (or to a lesser degree also anatase or zinc oxide) is being used as filler or at least sufficiently added to the filler, this effect can be

avoided. It is due to the high scattering effects of the rutile particles and/or due to the absorption properties of these particles. The particularly high refractive index of rutile (which is higher than for the anataso-modification) is quite well known. However, that this leads to the advantageous effects in the context of the present application of embedding security elements is surprising finding. Even more so as the particle size of the titanium dioxide in mtile-modification does not seem to have the determining influence in this question. Additionally, the highly symmetric structure of the unit cell of the rutile structure leads to fully isotropic properties when polarised light is irradiated.

[0074] Another advantage of using rutile as filler is due to the black appearance of the paper-like structure when irradiated with light thus increasing the contrast between the paper matrix and the security elements.

[0075] As mentioned above, the amount of e.g. rutile effectively necessary to achieve the above effect may depend on other substances possibly present in the matrix. These are substances which themselves have fluorescent effects in the sense that they absorb ultraviolet light and subsequently emit visible light leading to a bright appearance of the matrix. Usually 1 to 2% w/w of rutile are sufficient to provide the requested ultraviolet-dullness.

[0076] Generally, optimal effects are achieved if when irradiating ultraviolet light of about 365nm at an excitation bandwidth of about +/-15nm and excitation power of 15 mW/cm2 in the bandwidth region, using a photomultiplier voltage of 800 V and a measuring slit of 2 mm, on the unprinted paper, the counts per second in the visible range are below 40 between 400 and 450 nm, below 40 to 15 in the range of 450 to 550 nm and below 15 between 550 and 700 nm. This criterion can be used to adjust the content of e.g. rutile-filler.

[0077] Additionally, the desired black appearance of the paper-like structure when irradiated with light thus increasing the contrast between the paper matrix and the security elements can be achieved very efficiently by the incorporation of organic substances commonly known as 'uv-absorbers' into or onto the paper matrix. Such substances can typically be found among the classes of benzophenones, benzotriazenes and benzotriazoles and are, eg., commercialised by Ciba Speciality Chemicals under the trade names 'Tinuvin' and 'Chimassorb'. Furthermore, any other organic substance capable of undergoing the transition known to be responsible for the uv absorbing properties in the above-mentioned classes of uv absorbers (known to the one skilled in the art as 'excited state intramolecular proton transfer', or 'ESIPT') are suitable. Additionally, any other substance showing considerable absorbance in the wavelength regime of interest can be considered suitable, such as common dyes and stains, eg. azo-derivatives or polymethin-derivatives.

Other components of the paper-matrix:

[0078] The paper-matrix may contain other additives like e.g. binder, colorants, resins, surfactants, detergents, anti-foaming agents, etc which may be necessary in the production process of for particular properties of the paper matrix. These additional components are however minor components. Their possible influence on the general appearance of the paper matrix when irradiated with ultraviolet light or other light used for the excitation of the dye incorporated in the security elements has been discussed above.

Paper production process:

[0079] If the security article shall be a paper or paper-like article, it can be produced according to standard paper production technology. However, if dyed fibres have to be incorporated, these fibres should be added to the pulp just prior to starting the actual paper production process, i.e. after the milling process, in order to minimise introduction of defects into the security elements. Also possible is the incorporation of security elements in the form of threads according to the present invention by using a process as described in EP 59056.

Examples:

Example 1: Dying of polypropylene-fibres

[0080] 50 litres of toluene (xylene also possible but slightly less effective) and 25g of brightener (Uvitex OB-One, available through Ciba Speciality Chemicals or as 4,4'-Bis(2-benzxazolyl)-stilbene available from Aldrich, No. 36,859-8) are heated to 45 degrees Celsius, then 5 kg of polypropylene-fibres (polypropylene-fibres, REO Flock&Faser, length: 3 mm, 17 dtex) are being added and the mixture is left at 45 degrees Celsius for 24 h. The fibres can then be taken out of the bath and do not have to be rinsed prior to their incorporation into a paper or paper-like structure.

[0081] Generally, it is observed that the dying process should be carried out in case of polypropylene-fibres above 40 degrees Celsius, i.e. typically in arranged between 40 to 50 degrees Celsius. Usually rinsing does not seem to be necessary.

Example 2: Dying of lyocell/viscose fibres

[0082] 100 litres of water, 500 ml of brightener (Blankophor P, liquid) and 3.7 kg of fibres (Lenzing Lyocell, length: 2.5 mm, 17 dtex; or length: 4 mm, 6.7 dtex) are being mixed and heated up to 90 degrees Celsius. The mixture is stirred and kept at this temperature for 30 minutes, the fibres are then taken out and allowed to drip off the solution. The fibres are then added to 100 litres of water at 90 degrees Celsius and stirred for 15 minutes. Again the fibres are taken out and allowed to drip off the water. This rinsing procedure is repeated at least once. Subsequently, the fibres are being centrifuged and dried at about 50 degrees Celsius. If some coating is present on the surface of such fibres it can be removed by washing it away in hot water prior to the dying process. Possible avivage is eliminated in the present process by carrying out the dying process in water and preferably at elevated temperature.

Example 3: Dying of lyocell/viscose fibres

[0083] 100 litres of water, 10g of dye (Pergasolgelb 8GA) and 3.7 kg of fibres (Lenzing Lyocell, length: 2.5 mm, 17 dtex; or length: 4 mm, 6.7 dtex) are being mixed and heated up to 90 degrees Celsius. The mixture is stirred and kept at this temperature for 30 minutes. Subsequently the colorant is fixed on the fibres by adding 1 kg NaCl to the solution and stirring. The fibres are then added to 100 litres of water at 90 degrees Celsius and stirred for 15 minutes. Again the fibres are taken out and allowed to drip off the water. Subsequently, the fibres are being centrifuged and dried at about 50 degrees Celsius.

[0084] Concerning examples 2 and 3 the dying process improves for temperatures above 80 degrees Celsius and should be carried out at 90 to 95 degrees Celsius. The rinsing process should also be carried out at elevated temperature of at least 80 to 90 degrees Celsius, and in the case of the brightener should be repeated at least twice.

Example 4: Dying of polypropylene-fibres with POPOP

[0085] 20 mg of POPOP (1,4-Bis(5-phenyl-2-oxazolyl)-benzene, Fluka 15150) are dissolved in 5 ml chloroform. 10 mg polypropylene fibres (REO Flock&Faser) are added. The mixture is kept for 2 h at a temperature of 80 °C. The fibres are subsequently removed from the solution, washed with chloroform and dried at ambient temperature. The obtained fibres show the described effect with medium contrast in fluorescence.

Example 5: Dying of uniaxially oriented polypropylene films with Uvitex OB ONE

[0086] Uniaxially oriented poly(propylene) sheets (Nowofol) are kept for 2 h in a saturated solution of Uvitex OB ONE (Aldrich 368590) in chloroform for 2 h. The sheets are subsequently removed, washed with chloroform and dried at ambient. The obtained blend films exhibit the described effect with high contrast in fluorescence.

Example 6: Production of Poly(propylene)films with Uvitex OB ONE by melt-processing techniques

[0087] Poly(propylene) (i-PP Fina 3374, pellets) is blended with 0.05% w/w Uvitex OB ONE (Aldrich 368590) in a twin-screw extruder at a temperature of 180 °C. The polymer/dye blend is extruded and melt-processed into a foil. Subsequent uniaxial tensile deformation of stripes of this film at 130 °C yields a product with the described effect with high contrast in fluorescence.

[0088] The quality of the dyed security elements according to example is 1 to 12 shall be summarised as follows:

Example No	Matrix	Dye(s)	Effect	Production method	Quality
1	PP fibres	Uvitex OB One	PL	Diffusion dying	++
2	Viscose fibres	Blankophor P	PL	Direct dying	++
3	Viscose fibres	Pergasolgelb 8GA	PL/Abs	Direct dying	++
4	PP fibres	POPOP	PL	Diffusion dying	++
5	PP film uniaxially	Uvitex OB ONE	PL	Diffusion dying	+++
6	PP	Uvitex OB ONE	PL	Melt processing	+++

[0089] The fibres according to examples 1 to 4 can be incorporated into paper using standard paper production technique. Three particular examples shall be given:

Example 13:

[0090] 1600 kg of fibre (cotton-fibre) are mixed with 20 m3 of water. 28 kg of silicate (SiO2, Zeolex, Martifin-Werke), 14 kg of titanium dioxide (anatase, Titanweiss A1002), 0.4 kg of colorant (Gelb Ocker), 5 kg of titanium dioxide (rutile, Bayertitan RU) and mixed with 3 kg carboxymethylcellusose (Tylose R 1500). This mixtures is milled through several cycles to achieve an average length of fibre of 0.7 to 1.1 mm at a milling degree of 55 to 65 SR. Only now the dyed fibres are added and the pulp is filled up with water to a solid content of approximately 0.5% to 1%. This pulp is then used in a standard paper production process using a cylinder mould machine or a foudrinier technique. The paper produced has a basis weight of approx. 60 to 120 g/m^2. The paper shows pronounced bright/dark effect of the incorporated fibres.

Example 14:

[0091] 20 m^3 of water, 12 kg of starch, 12 kg of titanium dioxide (rutile, Bayertitan RU), 1000 kg of cellulose fibres (chemical wood pulp), 250 kg of cotton fibres and 30 kg of silicate (SiO2, Zeolex, Martifin-Werke) are mixed. Subsequently, 25 l of aluminasulphate-solution as well as 200 1 of caoline-solution are added and the mixture is milled in several cycles to a milling degree of approx. 25 - 45 SR. Only now the dyed fibres are added and the pulp is filled up with water to a solid content of approximately 0.5% to 1%. This pulp is then used in a standard paper production process using a cylinder mould machine or a foudrinier technique. The paper produced has a basis weight of 30 up to 320 g/m^2, preferably of 60 to 120 g/m^2. The paper shows pronounced bright/dark effect of the incorporated fibres.

Example 15:

[0092] A pulp according to one of the example is 13 or 14 or mixtures of these examples is used in a paper production process involving 2 cylinders. One of the cylinder is running with a pulp without dyed fibres while the other one contains dyed fibres. The two webs individually produced by the two cylinders are joined immediately behind the cylinder to form a laminate, one side of which shows the polarisation effects according to the invention, while the other side does not.

Example 16

[0093] A pulp according to one of the examples 13 or 14 or mixtures of these examples is used in a paper production process involving 3 cylinders. The three webs individually produced by the three cylinders are joined or couched immediately behind the cylinder to form a laminate, the top and the bottom side shows the polarisation effects according to the invention, while the centre ply does not.

Example 17

[0094] On a laminating machine, two or three or more layers of produced paper according to one of the examples 13 to 16 are laminated or pasted together. These separate webs, individually produced are joined and pasted or glued together to get an individual laminate of paper or board with a basis weight range of approx. 80 - 700 g/m^2. The top and the bottom layer show the polarisation effects according to the invention, while the centre ply does not.

Example 18

[0095] The Paper and board qualities of example 15 - 16 - 17 can also be created whilst one of the middle layer shows the polarisation effects according to the invention, and not the top or bottom layer. This can be a special hidden security feature.

LIST OF REFERENCE NUMERALS

[0096]

1 fluorescent fibre
2 straight segment of 1
3 cross-section of 2
4 security document
5 portions of 1 leading to a visible effect
6 upper surface of 4

7 lower surface of 4
8 portions of 1 buried in 4
9 anisotropic cross-section
10 short principal axis of 9
11 long principal axis of 9
12 anisotropic fluorescent fibre

Claims

1. Photoluminescent fibre (12) having an anisotropic cross-section, for the incorporation into the matrix of a security article (4),
characterised in that
the short principal axis (10) is between 5-20 μm, and **in that** the long principal axis (11) is between 50 - 150 μm long.

2. Photoluminescent fibre (12) according to claim 1, **characterised in that** it shows a linearly polarised photoluminescence and/or linearly polarised absorption and **in that** it is **characterised by** a dichroic ratio of 2 or more in absorption and/or emission, preferably of 5 or more in absorption and/or emission, and even more preferably by dichroic ratio of 10 or more in absorption and/or emission.

3. Photoluminescent fibre (12) according to one of the preceding claims, **characterised in that** the ratio of the lengths of the short principal axis (10) to the long principal axis (11) of the anisotropic cross-section (9) is in the range of 1: 5 to 1:25, preferably in the range of 1:8 to 1:15.

4. Photoluminescent fibre (12) according to one of the preceding claims, **characterised in that** the anisotropic cross-section (9) is of substantially oval, polygonal, rectangular, triangular or lens-type shape.

5. Photoluminescent fibre (12) according to one of the preceding claims, **characterised in that** the short principal axis (10) is between 10-15 μm long, and **in that** the long principal axis (11) is between 75-125 μm long.

6. Photoluminescent fibre (12) according to one of the preceding claims, **characterised in** a length below 10 mm, preferably in the range of 1 to 5 mm, most preferably around 3 mm or 3.5 mm.

7. Photoluminescent fibre (12) according to one of the preceding claims, **characterised in that** it can be excited to photoluminesce through exposure to electromagnetic irradiation of a wavelength between 200 and 500 nm, giving rise to emission in the visible range.

8. Photoluminescent fibre (12) according to one of the preceding claims, **characterised in that** it is a synthetic-fibre selected from the group of polyethylene-fibres, polypropylene-fibres, aramide-fibres, polyamide-fibres, polyacrylonitrile-fibres or that it is a natural raw material based fibre selected from the group of wood-fibres, cotton-fibres, grass-fibres, cellulose-fibres, viscose-fibres, lyocell-fibres, rayon-fibres.

9. Photoluminescent fibre (12) according to one of the preceding claims, **characterised in that** it is made of a polymer carrier, preferably made of polyethylene, polypropylene, polycarbonate, polyvinyl alcohol, or aramide dyed with a photoluminescent dye.

10. Photoluminescent fibre (12) according to one of the claims 1 to 7, **characterised in that** said security segment is made of a cellulose-based carrier dyed with a photoluminescent dye.

11. Photoluminescent fibre (12) according to claim 10, **characterised in that** said security segment is made of a viscose-fibre, or a lyocell-fibre with a length of 0.5 to 25 mm, preferably of 1.0 to 5 mm at 1 to 40 dtex, preferably at 5 to 20 dtex.

12. Security article (4), **characterised in that** a photoluminescent fibre (12) according to one of the preceding claims is at least partially embedded in the security article (4).

13. Security article (4) according to claim 12, **characterised in that** the photoluminescent fibre (12) is at least partially embedded in a paper or paper-like structure composed of 30 to 99 percent in dry weight fibres and 70 to 1 percent in dry weight filler and optionally additives, complementing to 100 percent in total.

14. Security article (4) according to claim 12 or 13, **characterised in that** the paper or paper-like structure is substantially free of brightener and/or additives which itself have fluorescent properties in particular which itself show linearly polarised photoluminescence and/or linearly polarised absorption.

15. Security article (4) according to claim 14, **characterised in that** the paper or paper-like structure is substantially free of stilbene-based brightener and/or additives.

16. Security article (4) according to one of the claims 13 to 15, **characterised in that** the filler has high scattering properties and/or high absorption properties in the spectral range used for irradiation and/or detection.

17. Security article (4) according to claim 16, **characterised in that** the filler contains or is substantially composed of titanium dioxide in its anatase-modification or composed of zinc oxide or particularly of titanium dioxide in its rutile-modification, and that preferentially 0.5 to 5%, preferably 1 to 2 % of the filler is titanium dioxide in its rutile-modification.

18. Security article (4) according to claim 16, **characterised in that** the absorption properties in the filler at least partially arise due to one or more organic substances or dyes, wherein these organic substances are preferentially chosen in the group of azo-derivatives, benzophenones, benzotriazoles, polymethin-derivatives or benzotriazenes or mixtures thereof.

19. Security article (4) according to one of the preceding claims, **characterised in that** the paper or paper-like structure is composed of 70 to 97 percent in dry weight paper-fibres and 30 to 3 percent in dry weight filler and optionally additives, complementing to 100 percent in total.

20. Use of the photoluminescent fibre (12) according to one of the claims 1 to 10 for objects the forgery of which shall be made difficult or impossible or for objects the authenticity and/or validity of which shall be marked or for objects the identification of which shall be enabled and/or facilitated.

21. Use of the photoluminescent fibre (12) according to one of the claims 1 to 10 or the security article (4) according to one of the claims 12 - 19 for an object selected from the group consisting of banknotes, checks, stocks, bonds, identification cards, passports, drivers licenses, tickets, stamps, bank cards and credit cards.

22. Process for the production of a security article comprising a photoluminescent fibre (12) according to claims 1-11, **characterised in that** at least one fibre with anisotropic cross-section is dyed with a photoluminescent dye, preferentially prior or after its structural internal orientation, and is then embedded in a paper-like matrix.

23. Process according to claim 22, **characterised in that** the fibres are added to the pulp just prior to the actual paper production process.

24. Process according to claim 22, **characterized in that** the fibres are added at the wet end of the paper machine such that the fibres are embedded in the uppermost layer of the paper web such that the fibres show a strong visual effect, or that the fibres are only added to one of two layers of paper which are laminated on the wet end of the paper machine.

25. Process according to claim 24, **characterized in that** the fibres are added on a selected segment or track of the web forming a region of high concentration of said fibres.

Patentansprüche

1. Photolumineszierende Faser (12) mit einem anisotropen Querschnitt, zur Einbettung in die Matrix eines Sicherheitsgegenstands (4),
dadurch gekennzeichnet, dass
die kurze Hauptachse (10) zwischen 5 und 20 μm beträgt und dass die lange Hauptachse (11) zwischen 50 und 150 μm lang ist.

2. Photolumineszierende Faser (12) nach Anspruch 1, **dadurch gekennzeichnet, dass** sie eine linear polarisierte Photolumineszenz und/oder linear polarisierte Absorption zeigt und dass sie **gekennzeichnet ist durch** ein dichroitisches Verhältnis von 2 oder mehr in Absorption und/oder Emission, bevorzugt von 5 oder mehr in Absorption und/

oder Emission und insbesondere bevorzugt durch ein dichroitisches Verhältnis von 10 oder mehr in Absorption und/oder Emission.

3. Photolumineszierende Faser (12) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Verhältnis der Längen der kurzen Hauptachse (10) zu der langen Hauptachse (11) des anisotropen Querschnitts (9) im Bereich von 1:5 bis 1:25, vorzugsweise im Bereich von 1:8 bis 1:15, liegt.

4. Photolumineszierende Faser (12) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der anisotrope Querschnitt (9) eine im Wesentlichen ovale, polygonale, rechteckige, dreieckige oder linsenartige Form aufweist.

5. Photolumineszierende Faser (12) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die kurze Hauptachse (10) zwischen 10 und 15 μm lang ist und dass die lange Hauptachse (11) zwischen 75 und 125 μm lang ist.

6. Photolumineszierende Faser (12) nach einem der vorhergehenden Ansprüche, **gekennzeichnet durch** eine Länge von weniger als 10 mm, bevorzugt im Bereich von 1 bis 5 mm, insbesondere bevorzugt um 3 mm oder 3,5 mm.

7. Photolumineszierende Faser (12) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** sie zur Photolumineszenz angeregt wird, indem sie elektromagnetischer Strahlung einer Wellenlänge zwischen 200 und 500 nm ausgesetzt wird, was zur Emission im sichtbaren Bereich führt.

8. Photolumineszierende Faser (12) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** es sich bei ihr um eine Kunstfaser handelt, die aus der Gruppe aus Polyethylenfasern, Polypropylenfasern, Aramidfasern, Polyamidfasern, Polyacrylnitrilfasern ausgewählt ist, oder dass es sich bei ihr um eine natürliche Faser auf Rohmaterial basierend handelt, die aus der Gruppe aus Holzfasern, Baumwollfasern, Grasfasern, Zellulosefasern, Viskosefasern, Lyocellfasern, Rayonfasern ausgewählt ist.

9. Photolumineszierende Faser (12) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** sie aus einem Polymerträger hergestellt ist, vorzugsweise hergestellt aus Polyethylen, Polypropylen, Polycarbonat, Polyvinylalkohol oder aus mit einem photolumineszenten Farbstoff gefärbtem Aramid.

10. Photolumineszierende Faser (12) nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** das Sicherheitssegment aus einem mit einem photolumineszenten Farbstoff gefärbten Träger auf Zellulosebasis hergestellt ist.

11. Photolumineszierende Faser (12) nach Anspruch 10, **dadurch gekennzeichnet, dass** das Sicherheitssegment aus einer Viskosefaser oder einer Lyocellfaser mit einer Länge von 0,5 bis 25 mm, bevorzugt von 1,0 bis 5 mm bei 1 bis 40 dtex, bevorzugt bei 5 bis 20 dtex, hergestellt ist.

12. Sicherheitsgegenstand (4), **dadurch gekennzeichnet, dass** eine photolumineszierende Faser (12) nach einem der vorhergehenden Ansprüche zumindest teilweise in dem Sicherheitsgegenstand (4) eingebettet ist.

13. Sicherheitsgegenstand (4) nach Anspruch 12, **dadurch gekennzeichnet, dass** die photolumineszierende Faser (12) zumindest teilweise in einem Papier oder einer papierartigen Struktur eingebettet ist, das bzw. die sich aus 30 bis 99 Gew.-% bezogen auf das Fasertrockengewicht und 70 bis 1 Gew.-% bezogen auf das Füllstofftrockengewicht und wahlweise Zusatzstoffen zusammensetzt, die sich auf insgesamt 100% ergänzen.

14. Sicherheitsgegenstand (4) nach Anspruch 12 oder 13, **dadurch gekennzeichnet, dass** das Papier oder die papierartige Struktur im Wesentlichen frei von Aufhellern und/oder Zusatzstoffen ist, die selbst fluoreszierende Eigenschaften aufweisen, insbesondere die selbst linear polarisierte Photolumineszenz und/oder linear polarisierte Absorption aufweisen.

15. Sicherheitsgegenstand (4) nach Anspruch 14, **dadurch gekennzeichnet, dass** das Papier oder die papierartige Struktur im Wesentlichen frei von Aufhellern und/oder Zusatzstoffen auf Stilbenbasis ist.

16. Sicherheitsgegenstand (4) nach einem der Ansprüche 13 bis 15, **dadurch gekennzeichnet, dass** der Füllstoff hochstreuende Eigenschaften und/oder hohe Absorptionseigenschaften in dem Spektralbereich, der zur Bestrahlung und/oder Erfassung verwendet wird, aufweist.

17. Sicherheitsgegenstand (4) nach Anspruch 16, **dadurch gekennzeichnet, dass** der Füllstoff Titandioxid in seiner Anatas-Modifikation enthält oder sich im Wesentlichen daraus zusammensetzt, oder sich aus Zinkoxid oder insbesondere aus Titandioxid in seiner Rutil-Modifikation zusammensetzt, und dass vorzugsweise 0,5 bis 5%, vorzugsweise 1 bis 2%, des Füllstoffs Titandioxid in seiner Rutil-Modifikation ist.

18. Sicherheitsgegenstand (4) nach Anspruch 16, **dadurch gekennzeichnet, dass** die Absorptionseigenschaften in dem Füllstoff zumindest teilweise aufgrund von einer oder mehreren organischen Substanzen oder Farbstoffen auftreten, wobei diese organischen Substanzen vorzugsweise aus der Gruppe aus Azoderivaten, Benzophenonen, Benzotriazolen, Polymethinderivaten oder Benzotriazenen oder Mischungen daraus ausgewählt sind.

19. Sicherheitsgegenstand (4) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** sich das Papier oder die papierartige Struktur aus 70 bis 97 Gew.-% bezogen auf das Papierfasertrockengewicht und 30 bis 3 Gew.-% bezogen auf das Füllstofftrockengewicht und wahlweise Zusatzstoffen zusammensetzt, die sich auf insgesamt 100% ergänzen.

20. Verwendung der photolumineszenten Faser (12) nach einem der Ansprüche 1 bis 10 für Objekte, deren Fälschung erschwert oder unmöglich gemacht werden soll, oder für Objekte, deren Echtheit und/oder Gültigkeit markiert sein soll, oder für Objekte, deren Identifizierung ermöglicht und/oder erleichtert werden soll.

21. Verwendung der photolumineszenten Faser (12) nach einem der Ansprüche 1 bis 10 oder Sicherheitsgegenstand (4) nach einem der Ansprüche 12-19 für ein Objekt, das aus der Gruppe bestehend aus Banknoten, Schecks, Aktien, Obligationen, Identifizierungsausweise, Pässe, Führerscheine, Fahrkarten, Briefmarken, Bankkarten und Kreditkarten ausgewählt ist.

22. Prozess für die Herstellung eines Sicherheitsgegenstands, umfassend eine photolumineszente Faser (12) nach Ansprüchen 1 bis 11, **dadurch gekennzeichnet, dass** mindestens eine Faser mit anisotropem Querschnitt mit einem photolumineszenten Farbstoff gefärbt wird, vorzugsweise vor oder nach seiner strukturellen internen Orientierung, und anschließend in einer papierartigen Matrix eingebettet wird.

23. Prozess nach Anspruch 22, **dadurch gekennzeichnet, dass** die Fasern gerade vor dem eigentlichen Papierherstellungsprozess zu dem Zellstoff hinzugefügt werden.

24. Prozess nach Anspruch 22, **dadurch gekennzeichnet, dass** die Fasern am nassen Ende der Papiermaschine hinzugefügt werden, derart, dass die Fasern in der obersten Schicht der Papierbahn derart eingebettet sind, dass die Fasern einen starken optischen Effekt zeigen, oder dass die Fasern nur zu einer von zwei Papierschichten, die an dem nassen Ende der Papiermaschine laminiert werden, hinzugefügt werden.

25. Prozess nach Anspruch 24, **dadurch gekennzeichnet, dass** die Fasern auf einem ausgewählten Segment oder Weg der Bahn hinzugefügt werden, wodurch ein Bereich mit einer hohen Konzentration der Fasern ausgebildet wird.

Revendications

1. Fibre photoluminescente (12) ayant une section transversale anisotrope, destinée à être incorporée à la matrice d'un article de sécurité (4),
caractérisée en ce que
l'axe principal court (10) a une longueur comprise entre 5 et 20 μm, et **en ce que** l'axe principal long (11) a une longueur comprise entre 50 et 150 μm.

2. Fibre photoluminescente (12) selon la revendication 1, **caractérisée en ce qu'**elle présente une photoluminescence polarisée linéairement et/ou une absorption polarisée linéairement et **en ce qu'**elle est **caractérisée par** un rapport dichroique de 2 ou plus en absorption et/ou en émission, de préférence de 5 ou plus en absorption et/ou en émission, et mieux encore, par un rapport dichroique de 10 ou plus en absorption et/ou en émission.

3. Fibre photoluminescente (12) selon l'une des revendications précédentes, **caractérisée en ce que** le rapport des longueurs de l'axe principal court (10) à l'axe principal long (11) de la section transversale anisotrope (9) est dans la gamme de 1:5 à 1:25 et de préférence, dans la gamme de 1:8 à 1:15.

4. Fibre photoluminescente (12) selon l'une des revendications précédentes, **caractérisée en ce que** la section transversale anisotrope (9) est de forme sensiblement ovale, polygonale, rectangulaire, triangulaire ou lenticulaire.

5. Fibre photoluminescente (12) selon l'une des revendications précédentes, **caractérisée en ce que** l'axe principal court (10) a une longueur comprise entre 10 et 15 μm et **en ce que** l'axe principal long (11) a une longueur comprise entre 75 et 125 μm.

6. Fibre photoluminescente (12) selon l'une des revendications précédentes, **caractérisée par** une longueur inférieure à 10 mm, de préférence dans la gamme de 1 à 5 mm, et mieux encore, voisine de 3 mm ou de 3,5 mm.

7. Fibre photoluminescente (12) selon l'une des revendications précédentes, **caractérisée en ce qu'**elle peut être excitée en photoluminescence par exposition à un rayonnement électromagnétique d'une longueur d'onde comprise entre 200 et 500 nm, donnant lieu à une émission dans la gamme visible.

8. Fibre photoluminescente (12) selon l'une des revendications précédentes, **caractérisée en ce qu'**il s'agit d'une fibre synthétique sélectionnée dans le groupe de fibres de polyéthylène, de fibres de polypropylène, de fibres d'aramide, de fibres de polyamide, de fibres de polyacrylonitrile ou **en ce qu'**il s'agit d'un matériau brut naturel à base de fibres sélectionnées dans le groupe de fibres de bois, de fibres de coton, de fibres d'herbes, de fibres de cellulose, de fibres de viscose, de fibres lyocell, de fibres de rayonne.

9. Fibre photoluminescente (12) selon l'une des revendications précédentes, **caractérisée en ce qu'**elle est faite d'un support polymère, de préférence constitué de polyéthylène, de polypropylène, de polycarbonate, d'alcool polyvinylique ou d'aramide coloré par un colorant photoluminescent.

10. Fibre photoluminescente (12) selon l'une des revendications 1 à 7, **caractérisée en ce que** ledit segment de sécurité est constitué d'un support à base de cellulose coloré par un colorant photoluminescent.

11. Fibre photoluminescente (12) selon la revendication 10, **caractérisée en ce que** ledit segment de sécurité est constitué d'une fibre de viscose, d'une fibre lyocell ayant une longueur de 0,5 à 25 mm, et de préférence, de 1,0 à 5 mm à 1 à 40 dtex, et de préférence à 5 à 20 dTex.

12. Article de sécurité (4), **caractérisé en ce qu'**une fibre photoluminescente (12) selon l'une des revendications précédentes est au moins partiellement incorporée à l'article de sécurité (4).

13. Article de sécurité (4) selon la revendication 12, **caractérisé en ce que** la fibre photoluminescente (12) est au moins partiellement incorporée à un papier ou à une structure de type papier composé de 30 à 99 pourcent en poids sec de fibres et de 70 à 1 pourcent en poids sec d'une charge et facultativement, d'additifs, pour compléter un total de 100 pourcent.

14. Article de sécurité (4) selon la revendication 12 ou 13, **caractérisé en ce que** le papier ou la structure de type papier est sensiblement exempt d'azurant optique et/ou d'additifs qui ont en eux-mêmes des propriétés fluorescentes, et qui présentent notamment en eux-mêmes une photoluminescence polarisée linéairement et/ou une absorption polarisée linéairement.

15. Article de sécurité (4) selon la revendication 14, **caractérisé en ce que** le papier ou la structure de type papier est sensiblement exempt d'azurant optique à base de stilbène et/ou d'additifs à base de stilbène.

16. Article de sécurité (4) selon les revendications 13 à 15, **caractérisé en ce que** la charge a des propriétés de forte diffusion et/ou des propriétés de forte absorption dans la gamme spectrale utilisée pour l'irradiation et/ou la détection.

17. Article de sécurité (4) selon la revendication 16, **caractérisé en ce que** la charge contient ou est sensiblement composée de dioxyde de titane dans sa variante anatase ou est composée d'oxyde de zinc ou plus particulièrement, de dioxyde de titane dans sa variante rutile, et **en ce que** préférentiellement 0,5 à 5 %, et de préférence, 1 à 2 % de la charge est constituée de dioxyde de titane dans sa variante rutile.

18. Article de sécurité (4) selon la revendication 16, **caractérisé en ce que** les propriétés d'absorption de la charge résultent au moins partiellement d'une ou plusieurs substances ou colorants organiques, dans lequel ces substances organiques sont préférentiellement choisies dans le groupe des dérivés azoiques, des benzophénones, des ben-

zotriazoles, des dérivés de polyméthine ou des benzotriazènes ou de mélanges de ceux-ci.

19. Article de sécurité (4) selon l'une des revendications précédentes, **caractérisé en ce que** le papier ou la structure de type papier est composé de 70 à 97 pourcent en poids sec de fibres de papier et de 30 à 3 pourcent en poids sec d'une charge et facultativement d'additifs, pour compléter un total de 100 pourcent.

20. Utilisation de la fibre photoluminescente (12) selon l'une des revendications 1 à 10 pour des objets dont la falsification sera rendue difficile ou impossible ou pour des objets dont l'authenticité et/ou la validité sera marquée ou pour des objets dont l'identification sera permise et/ou facilitée.

21. Utilisation de la fibre photoluminescente (12) selon l'une des revendications 1 à 10 ou de l'article de sécurité (4) selon l'une des revendications 12 à 19 pour un objet sélectionné dans le groupe constitué de billets de banque, de chèques, de titres, d'obligations, de cartes d'identité, de passeports, de permis de conduire, de tickets, de timbres, de cartes bancaires et de cartes de crédit.

22. Procédé pour la production d'un article de sécurité comprenant une fibre photoluminescente (12) selon les revendications 1 à 11, **caractérisé en ce qu'**au moins une fibre ayant une section transversale anisotrope est colorée par un colorant photoluminescent, de préférence avant ou après son orientation structurelle interne, puis est incorporée à une matrice de type papier.

23. Procédé selon la revendication 22, **caractérisé en ce que** les fibres sont ajoutées à la pâte à papier immédiatement avant le processus de production proprement dit du papier.

24. Procédé selon la revendication 22, **caractérisé en ce que** les fibres sont ajoutées sur l'extrémité humide de la machine à papier de façon à ce que les fibres soient incorporées à la couche supérieure de la bande de papier et que les fibres présentent un fort effet visuel, ou **en ce que** les fibres ne sont ajoutées qu'à l'une de deux couches de papier qui sont stratifiées sur l'extrémité humide de la machine à papier.

25. Procédé selon la revendication 24, **caractérisé en ce que** les fibres sont ajoutées sur un segment ou une piste sélectionnée de la bande en formant une région à forte concentration desdites fibres.

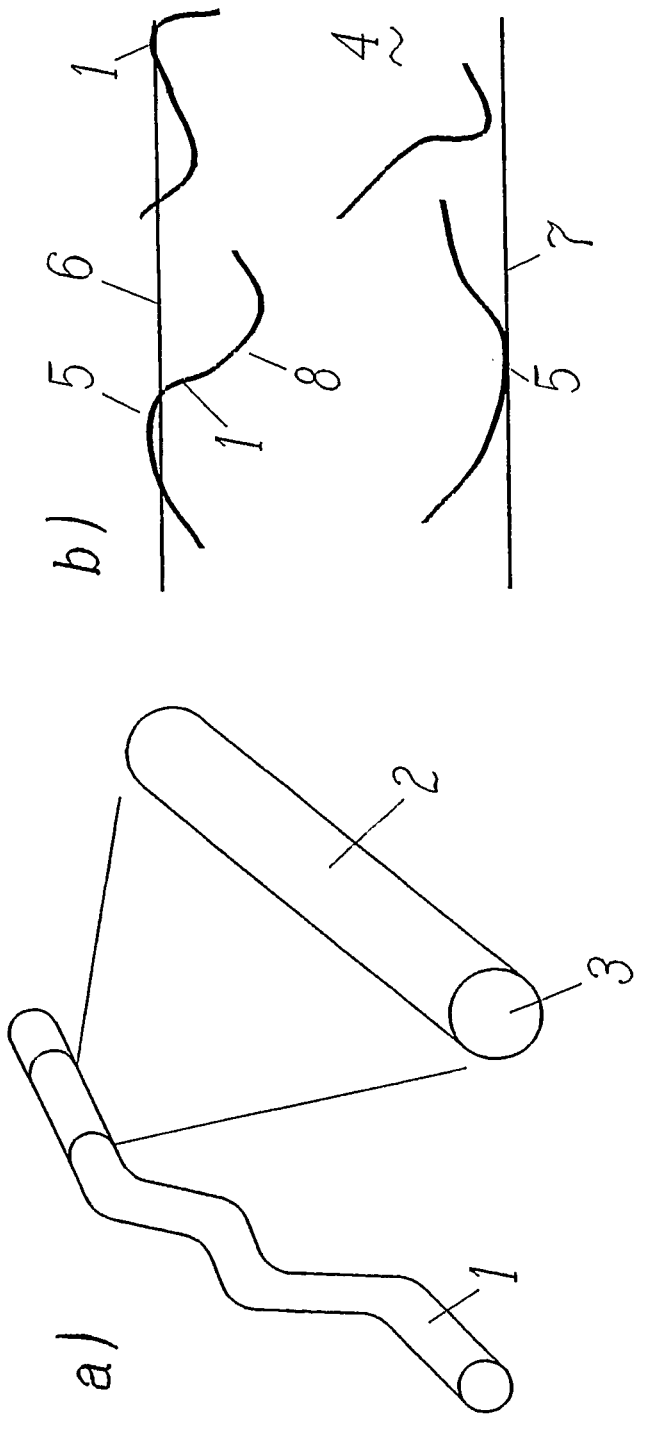


Fig. 1

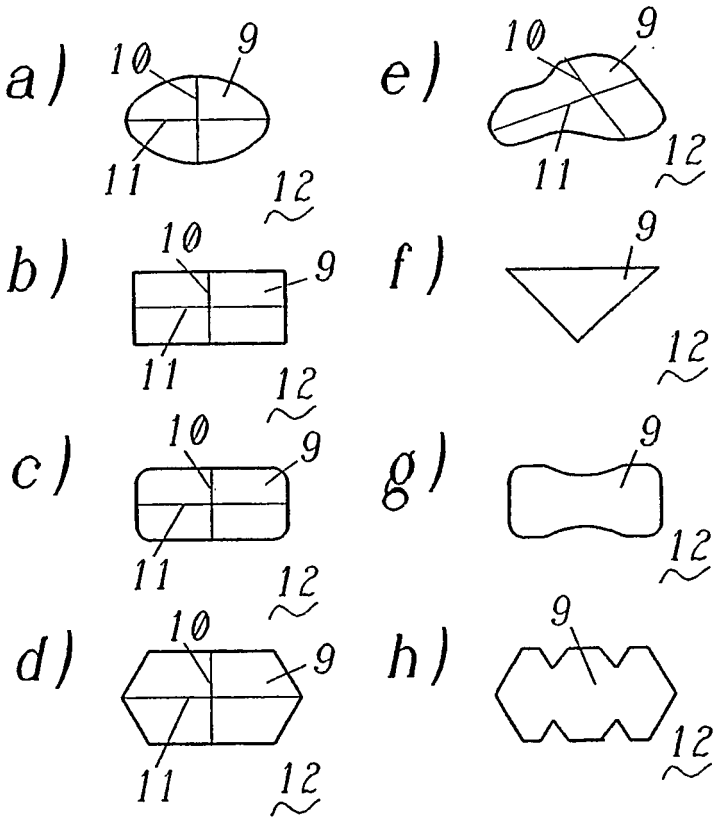

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Fig. 2

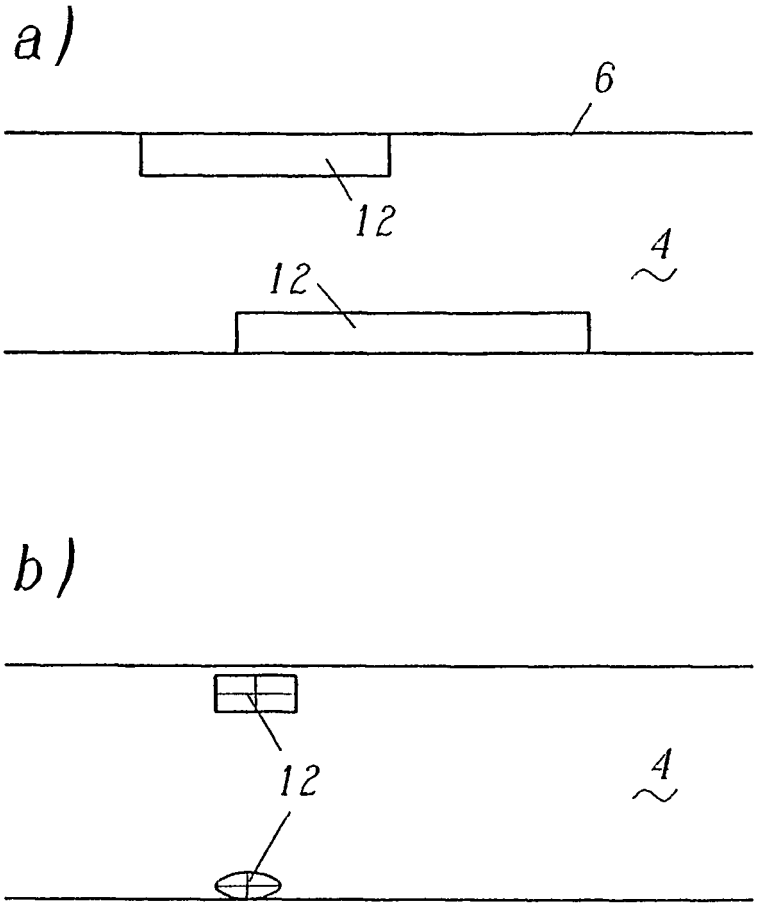


Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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