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(54) **Security paper provided with a security feature exhibiting luminescence**

(57) A security paper (10), comprising a substrate surface delimited by sides, is provided with a security feature (12a-12d) which exhibits luminescence. The security feature comprises at least one luminescent plastic fibre (20) consisting of a plastic and at least one luminescent compound, the plastic fibre having maximum

transverse dimensions in the range from 2-50 micrometres such that it is not visible to the naked eye both in reflective light and in transmitted light, and the plastic fibre (20) extends between at least two sides (19a, 19b) of the security paper, and the luminescent plastic fibre (20) does not have any visually perceptible emission in the visible region under daylight conditions.

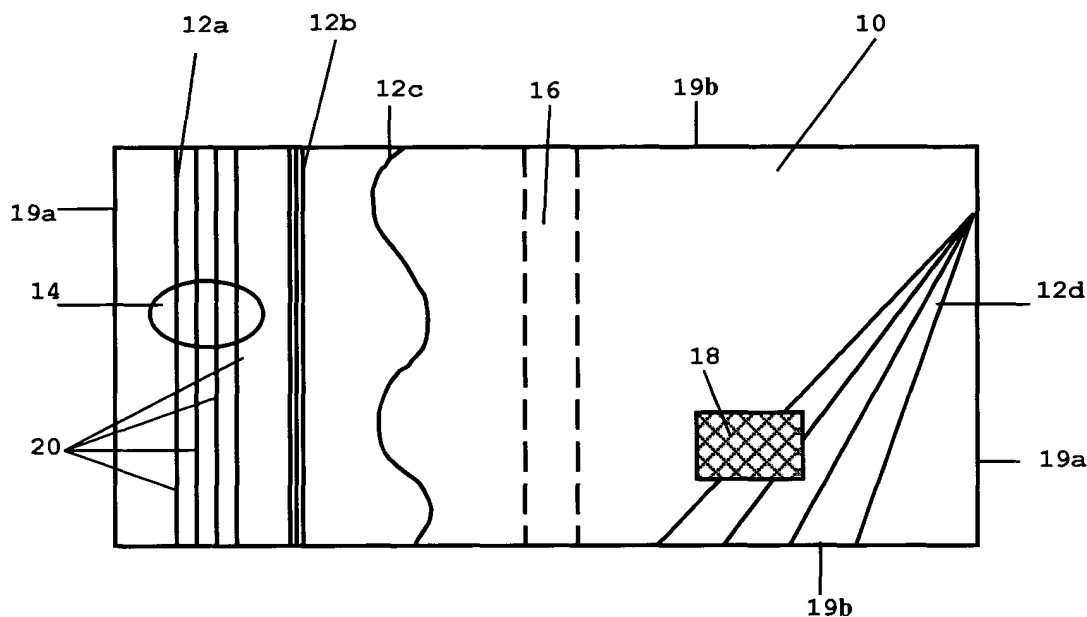


FIG. 1

Description

[0001] The invention relates to security paper, comprising a substrate surface which is delimited by sides and is at least provided with a security feature which exhibits luminescence.

[0002] Security paper of this type is known, for example, from European Patent 66854. This known security paper comprises fibres or threads of cellulose acetate, which contain a luminescent substance in a uniform distribution, embedded in the paper mass; the luminescent substance is a lanthanide chelate showing narrow-band luminescence. The examples describe two variant embodiments; in a first embodiment, a spun fibre is twisted and then cut into short pieces of fibre with a length of approximately 3 mm. These pieces of fibre are added to the paper pulp during production of the security paper, and are thus randomly distributed in the final security paper. In a second embodiment, a plurality of fibres are woven together to form a thread with a width of 0.5 mm. During the production of security paper in a two-layer papermaking machine, this thread is guided from a reel between two layers of a page or sheet which is being formed, and is thereby surrounded by the paper mass. The authenticity of the document in question can be checked via observation of luminescence from the luminescent compounds, or measurement of specific luminescence properties.

[0003] It has recently been proposed in WO 01/48311 to arrange fibres of this type in strips with a width of 5-30 mm in the paper. This offers the option of using the strips to create a code.

[0004] WO 00/19016 discloses a security paper which comprises at least one security element comprising at least one photoluminescent segment which is characterized by linearly polarized photoluminescence and/or linearly polarized absorption. The security element may take various forms, such as fibres, threads, films and strips. In the examples, 1 mm wide strips with a very low thickness of two micrometres are embedded in paper; after the paper has been printed, it is established that these strips are not visible to the naked eye under normal illumination, either in reflection or in transmission. In another example, short fibres with a diameter of between 30 and 400 micrometres and a length of approximately 1 to 10 mm which are distributed randomly in the paper are used; after the security paper has been printed, it is established that the fibres, under daylight conditions, were not readily perceptible either in reflection or in transmission. The photoluminescence is, however, immediately apparent to the naked eye under UV light.

[0005] The low thickness of the strips which is required to ensure that the strips are not visible under normal daylight conditions, which is aided by the printing of the paper, however, constitutes a drawback for both machine production of security paper and for the freedom of choice of the position(s) for subsequent printing. The

requirement that they should not be visible also restricts the substrate materials which can be used. Similar drawbacks also apply to the short fibres.

[0006] A number of useful characteristics of luminescent compounds include: excitation and emission wavelengths (UV, visible, IR), emission intensity, optical bandwidth and the lifetime of the excited state and the shape of the decay curve. The mean lifetime of an excited state of luminescent compounds is of the order of $< 10^{-6}$ s. A lifetime of this type is referred to as fluorescence. If there is delayed emission, for example in inorganic luminophores comprising transition metals, this is described as phosphorescence. Delayed emission of this type can be measured, and sometimes also visually perceived, while excitation is no longer present.

[0007] In the present description, the term luminescence is used for emission via both phosphorescence and fluorescence. In the specialist field, however, the term fluorescence is also used as a collective term for these types of emissions.

[0008] The use of luminescent compounds in security documents to safeguard the latter was proposed as early as the 1920s (cf. for example DE-C 449133 and DE-C 497037). By way of example, luminescent compounds make it possible to process security features which are not directly perceptible in security documents. Moreover, the features cannot be directly copied, even using modern colour reproduction systems. In documents produced from security paper, luminescence may be encountered not only in the fibres and threads described above, but also in security threads, films, OVDs (optically variable devices), printing inks and throughout the entire mass from which the substrate in question is produced.

[0009] By way of example, a document may be partially printed with fluorescent and/or phosphorescent inks which are invisible under normal light but emit when subject to UV irradiation, with the result that the visible printed image of the document then looks completely different. In modern generations of Euro notes, excitation with UV light also clearly reveals how luminescent inks have been used in the printed image.

[0010] It is also known to add luminescent compounds to the overall substrate mass used for a security document (in this case the paper mass), so that a specific emission, distributed more or less homogeneously over the entire substrate, can be measured. Emissions of this type are generally outside the visible region and in this case the luminescent compositions used often have very distinct and specific spectral characteristics.

[0011] Luminescent compounds with an emission in the visible region, the excitation often taking place in the near UV, are often used for a cashier's feature. All that is then needed for excitation is exposure by a simple and inexpensive UV light source, such as black light, and by LEDs which emit in the UV region. Another possible option is formed by visible emission produced after excitation with light with a longer wavelength; for exam-

ple emission of green light after excitation in the IR (anti-Stokes emission). A normal IR light source (i.e. not a high-power IR laser) has the advantage over a short-wave UV light source that the IR radiation produced is not harmful to the eyes, whereas short-wave UV radiation is harmful to the eyes.

[0012] In the case of a security feature which must also or exclusively be machine-detectable, it is often opted to use emissions in a region which is not visible, often in the IR.

[0013] It is technically possible for luminescent compounds or compositions and organic polymers to be processed together, in such a manner that the polymer fibres and/or fibres can be used to spin composite threads which then contain a luminophore in the polymer matrix, as proposed, for example, in EP 66854 and DE 19802588. A composite thread of this type may have good luminescent properties, but the individual emissions of the threads of which it is composed cannot generally be distinguished easily by visual means. If the individual emissions are in a narrow band, the different emissions can be distinguished separately via measurements.

[0014] The presence of composite luminescent threads with a width of from 0.5 mm in security paper is visible to the naked eye by the public, either in transmitted light or in reflected light or in both, as is the case with metallized or unmetallized security threads. This can also apply to the wide strips of 5-30 mm in accordance with WO 01/48311 if the fibre density selected is too high (cf. '311 p4, 14). In WO 00/19016, the thickness of the strips or the length of the fibres and the type of starting material are evidently selected in such a manner that these strips and fibres are not visible or are scarcely visible. However, this method imposes considerable limitations on the production options.

[0015] It is an object of the present invention to provide security paper with at least one security feature exhibiting luminescence which is not directly visible to the public but is visible if the correct illumination conditions are used, while the person observing the luminescence cannot easily be misled by the randomness of the overall luminescent appearance.

[0016] A further object of the invention is to provide a security paper having at least one security feature exhibiting luminescence in which the ease of handling of the security feature is high, so that the security paper is easy to produce.

[0017] Yet another object is to provide a security paper having at least one security feature exhibiting luminescence, in which the choice of starting materials with a view to making the security feature not visible under daylight conditions is subject to few if any restrictions.

[0018] According to the invention, this object is achieved by virtue of the fact that the security feature comprises a luminescent plastic fibre consisting of a plastic and at least one luminescent compound, the maximum transverse dimensions of the plastic fibre be-

ing in the range from 2-50 micrometres, such that at normal reading distance in daylight conditions, the plastic fibre is not visible to the naked eye both in reflection and in transmission, and the plastic fibre extends between at least two sides of the security paper, and the luminescent plastic fibre is not subject to any excitation by daylight which causes emission perceptible to the naked eye under daylight conditions.

[0019] The plastic fibre, which comprises a luminescent compound, according to the invention has a maximum transverse dimension below the detection limit for the naked eye at normal reading distance (which is generally considered as standard to be 30-35 cm), in other words is lower than the resolution of the naked eye. The minimum transverse dimension depends, inter alia, on the required fibre strength, the emission level of the luminescent compound and the concentration of the latter. The transverse dimension of the plastic fibre is advantageously more than 10 micrometres, more preferably more than 20 micrometres, so that a security paper with a security feature comprising a plastic fibre can be produced easily and reliably. Also, the demands imposed on the dimensions of the plastic fibre imposes no further restriction on the choice of starting materials. Therefore, the plastic fibre does not form a public mark for determining the authenticity of the document with the naked eye overall without special aids. In the invention, the plastic fibre is at a defined position, with at least its two ends at the sides of the security paper, and on this basis a cashier or the like can determine the authenticity relatively easily. The luminescent plastic fibre does not have any emission which is visible to the naked eye under daylight conditions for verification, for example because the fluorescence intensity is generally completely absent in the intensity of daylight and/or since daylight has no intensity or insufficient intensity in the excitation region in question. In addition, the luminescence can be shielded from the visible region by suppression or masking, as will be explained below. It is also possible to use compounds which are excited outside the visible region (440-700 nm) and/or which luminance exclusively outside the visible region. The fact that a fibre, despite such a small cross section, does become visible under the correct illumination conditions is attributable to the scatter of the emission light to all sides, with the result that the original dimensions of the thread no longer form any visible restrictions. On account of the absence of emission which is visible under daylight conditions and on account of the small cross section, the presence of the luminescent plastic fibre in the security paper according to the invention is not perceptible without auxiliary means.

[0020] The luminescent plastic fibre may be a plastic fibre to which a coating of a luminescent component has subsequently been applied. The luminescent plastic fibre may also be spun directly from a polymer starting material containing the luminescent compound, so that the luminescent compound is present in the plastic ma-

trix of the fibre. A combination of these options is also possible. If desired, a plurality of plastic fibres can be woven together to form a composite thread, provided that the maximum transverse dimensions of 50 micrometres are not exceeded.

[0021] The luminescent plastic fibre may exhibit emissions in the UV and/or visible and/or IR regions; the emissions may be both Stokes and anti-Stokes. As well as luminescent properties, the plastic fibre may also have magnetic properties. It will be understood that these magnetic properties may be of both the "soft" and the "hard" type. The cross section of the threads may vary from circular or oval to polygonal, such as for example square or hexagonal. In the context of the requirement that the feature must not be directly visible, the largest dimension must not exceed 50 micrometres.

[0022] The security feature proposed here differs clearly from the standard (metallized) security threads which are nowadays used as a public mark in security documents. Security threads of this type consist of a strip, generally with a width of more than 0.4 mm, of a plastic film, on which a metal layer is often deposited. Threads of this type are clearly perceptible to the naked eye in transmitted light. The metal used is often aluminium, on account of the fact that a security thread made from aluminium embedded in the paper mass is less visible in reflected light. Security threads provided with micro-printing, whether negative or positive, have a width of the order of magnitude of 0.7 mm or more. There is also a considerable tendency to increase the width of these threads further in security documents, up to at least 4 mm. If the security thread is partially visible in windows at the surface, it can be detected even better at these locations.

[0023] The plastic used for the fibres is advantageously selected from polyester, polyether, polyamide, aramide, polyimide, polycarbonate, polyacetate, polybutyrate, polylactate, polyvinyl chloride, cellulose acetate or mixtures thereof, including derivatives of the above polymers.

[0024] The luminescent compounds which are used in the security paper according to the invention are not subject to any particular restrictions. The luminescence of the luminescent compounds per se is advantageously in the spectral range from 250-2500 nm; excitation by daylight resulting in emission which is visible under daylight conditions should be avoided. Excitation of the luminescent compound may, depending on the type, be brought about by irradiation with light with a shorter and/or longer wavelength than the peak of the emission light, with the aid of an alternating electric field, mechanical forces (in this case deformation), as well as a combination of the excitation options mentioned. A plastic fibre may have (visually) different emissions at different excitation wavelengths; the emissions may differ in intensity and/or wavelength and/or decay.

[0025] The text which follows provides a non-exhaustive list of luminescent compounds and their use as se-

curity features which can also be used in the invention.

[0026] A difficulty in measuring luminescent features in/on a security document is the threshold value to be set for the emission signal. It has recently been proposed therefore to take the entire normalized decay curve of the emission over the course of time as measurement scale (WO 01/88846). A decay curve of this type has a characteristic shape, and this shape does not change as a result of soiling and/or ageing of the luminescent feature.

[0027] WO 98/39163 describes how it is possible to use compounds which can be made to emit both via excitation with (short-wave) light and by an alternating electric field (electroluminescence).

[0028] It is also known in security documents to use luminescent compounds for which the emissions and/or excitations that are to be measured are preferably not in the visible region (EP 52624, 53124, 53125, 53148 and 53183, DE 198 04 032, 198 04 024, 198 04 021, 198 04 012, 198 03 997). This latter series of German patent applications use rare earths, such as holmium and thulium doped in a specific host lattice, the host lattice absorbing in the visible region and partially transmitting in the IR. The transmission should be high in the region of the emissions of the said compounds. One of the characteristics of a number of the patent publications mentioned above is that the excitation and emission characteristics of fluorescent compounds can be influenced in the presence of absorption compounds, with the result that the original character of the emission and excitation of (generally) the rare earth ion can be changed.

[0029] DE 101 11 116 describes the use of at least one chromophore with a (3d)² configuration, doped in a specific host lattice, as authenticity feature.

[0030] EP 52624 has disclosed compounds which are characterized by the absence of emissions in the visible region; there is a high absorption of light which is emitted by a halogen lamp or a (pulsed) xenon lamp. The absence of visible emission and the high absorption are caused by the specific host lattice in which a lanthanide is present as fluorescent group. Visible emissions are extinguished by the host lattice, whereas IR emissions remain. One requirement is that the host lattice must be optically (partly) transparent for the desired IR emissions.

[0031] EP 53148 has disclosed the use of quasi-resonant fluorescence of rare earths in a specific lattice as security feature. Any excitations and emissions which occur outside this "resonant" region are suppressed. One advantage mentioned for this method is that the emission signal is difficult to measure on fluorimeters which were commercially available at the time, since the fluorescence which occurs disappears in the excitation light.

[0032] EP 53183 discloses compounds which do not have excitation and emission characteristics in the visible region. The excitation and emission wavelengths

are exclusively in the UV and the IR. Where it is still possible for emissions or excitations in the visible region to occur, these are masked by extra additions to the fluorescent compound or via masking properties of the host lattice.

[0033] The masking compounds effectively keep excitations and/or emission out of the visible region. In this way, it is also possible to extend the number of luminescent compounds that can be used, since the emissions from a single luminescent compound can be modified in a number of ways, each having their own different and characteristic spectral properties, as is known, for example, from DE 3020652.

[0034] Semiconducting luminescent nanostructures (dimensions in the nanometre range, $1 \text{ nm} = 10^{-9} \text{ m}$) have also been described over about the last fifteen years. These nanocrystals, also known as quantum dots (QDs), have the very characteristic property whereby the emission wavelengths of specific nanocrystal materials are dependent on the size of the nanocrystal. Only one emission peak per particle size is found. The emission peaks are narrow and symmetrical. The emission light is therefore "naturally" much more monochromatic than that of many other luminophores, such as the inorganic lanthanide compositions mentioned above.

[0035] One type of nanocrystal material may have completely different emission peaks, and the following relationship applies: the larger the nanocrystal, the lower the energy (= the longer the wavelength) of the emitted light. By contrast, the conventional luminescent materials have a clearly defined excitation spectrum, with the result that the compound can generally only be excited in a limited region. Nanocrystals can often be excited at virtually any wavelength which is lower than the emission wavelength; the emission wavelength is independent of the excitation wavelength.

[0036] Under the correct conditions, this nanocrystal material may also exhibit electroluminescence; by way of example, light-emitting diodes have been made using nanocrystals of the material CdSe (Colvin et al, Nature 370, 354 (1994) and Dabbousi et al, Appl. Phys. Lett. 66, 1316 (1995)).

[0037] If the semiconducting nanocrystals are covered with another inorganic material, such that a wide band gap is formed between this coating and the material (for example ZnS or CdS coating on CdSe nanocrystals), these coated nanocrystals have very good quantum yields (> 50%) at room temperature (Eychmüller et al., Chem. Phys. Lett. 208, 59 (1993), Hines et al, J.Phys. Chem. 100, 468 (1996) and Peng et al, J.Am. Chem.Soc. 119, 7019 (1997)). The surface treatment also causes the photostability of certain systems to increase considerably. (Peng et al, J.Am. Chem.Soc. 119, 7019 (1997)).

[0038] The nanostructures whereof the surfaces are only passivated with organic long-chain surfactants have a quantum yield rising to 10%, with a longer fluorescence lifetime.

[0039] A combination of just three types of material, varying in size from 2.1 - 6 nm, can cover an extraordinarily wide emission range, specifically from 400-2000 nm (Bruchez et al, Science 281, 2013 1998)); there are also very narrow-band emissions. This is not readily conceivable with just three conventional fluorescent compounds. The composition of nanomaterials of this type and the usability of emitting nanomaterials in security features are known from a number of patent applications (WO 99/26299, 00/17103, 00/17655, 00/17656). WO 00/18591 and WO 00/207988 describe other uses.

[0040] Another class of emitting compounds which are used in security features is formed by compounds (compositions) which have an increased luminescence under defined conditions. US 5,448,582 has disclosed a luminescence system which has a nearly thresholdless laser behaviour, consisting of an optically excited dye-methanol solution which also contains colloidal TiO_2 or Al_2O_3 ruby nanoparticles. A high pumping energy generates a bichromatic spectrum with lower optical bandwidths than at a lower energy input. In a system of this type, it is also possible to use semiconducting nanocrystals, and in some embodiments the emitting phase, the increasing phase and the scattering phase may comprise a single phase. US 6,259,506 also describes a specific embodiment of a security feature in which increased emission may also play a role.

[0041] WO 00/71363 also mentions luminescent compounds which are enclosed in molecular sieves (zeolites). These compounds enclosed in this way have increased emissions if the excitation intensity exceeds a defined threshold value, and at the same time the emission peak acquires a narrower band. The structure of the molecular sieve acts as an optical resonance space; the emission light ultimately emerges through small defects in the spaces. These characteristics offer the possibility of designing security features in such a manner that within one feature a uniform emission occurs below the said excitation threshold, whereas above this threshold emission discontinuities can be noted within the same feature, specifically when part of the luminescent compound in the feature is within a resonance space and another part is not.

[0042] EP 1 182 048 also describes a material which gives rise to increased fluorescence.

[0043] According to a preferred embodiment, the luminescent plastic fibre comprises one or more luminescent compounds which are colourless under daylight conditions. According to another preferred embodiment, the luminescent plastic fibre comprises pigments of a colour identical to that of the substrate in which the fibre is embedded.

[0044] It is preferable for the plastic fibre used in the invention to be continuous, since this facilitates production of the security paper according to the invention. The occurrence of a break in the fibre in the security paper as a result of use does not cause a problem, since any

such break does not affect the luminescence properties, and therefore it is still readily possible to verify the authenticity of the paper. Magnetic detection, if applicable, is also no problem if a fibre is broken. This contrasts with verification by conductivity measurements on metallized security threads, where a break causes major problems with detection.

[0045] It is preferable for the fibre to be colourless in the visible region or to be of a colour corresponding to that of the substrate in which it is embedded, and it is advantageous for the fibre to have a refractive index which corresponds to a considerable extent to that of the substrate. Both preferred properties contribute to reducing the visibility of the fibre in the paper to the naked eye.

[0046] The length of the threads in the proposed security feature is partially determined by the dimensions of the security document in which it is enclosed. The length of the fibres used in the invention is many times (at least ten times) greater than that of the standard security fibres.

[0047] If the security paper according to the invention has a surface with at least two parallel sides, it is preferable for the plastic fibre to extend between parallel sides, more preferably along a straight line. A plastic fibre with a rectilinear orientation can be recognised as authentic more easily than a plastic fibre with a random orientation between two sides of the security paper. A plastic fibre whereof the shape comprises a repeating pattern in its longitudinal direction is also easily recognisable. Examples of this type of profile of the plastic fibre(s) include a sinusoid, sawtooth, block shape, etc.

[0048] In a further preferred embodiment, the actual orientation of the plastic fibre, i.e. the profile in the security paper, is stored in a memory, for example an IC, which is provided in the security paper. The fibre orientation may also be stored outside the security paper, in an external memory or database. The orientation will be slightly different for every fibre and different in every document. A more or less random profile of this type can also be used as an individual feature of the document and stored in some way in an external database or in the document itself.

[0049] In yet another embodiment, the security paper comprises a plurality of parallel luminescent plastic fibres located at a distance from one another. Since the plastic fibres are located at a distance from one another, their emissions can be perceived and/or measured separately. The plastic fibres may exhibit an identical emission at a defined excitation wavelength. The fibres may exhibit identical emissions in the visible region at a defined excitation wavelength but have different emission spectra outside the visible region. When excited with a specific wavelength, the fibres may differ in terms of their emission wavelength. The fibres can be excited and emit at the same wavelengths. The decay curve may in this case differ (cf. US 6,402,986).

[0050] More preferably, the security paper comprises

a plurality of plastic fibres which are located at a distance from one another and are arranged in groups, which groups define a code. In addition to the individual emissions of the separate plastic fibres, the code forms an additional security feature which if desired can be stored in an external or internal memory. It is advantageous for a group of this type to have a width, as seen in the direction transverse to the longitudinal direction of the fibres, in the range from 2 to 50 mm. The orientation of a plurality of fibres can be stored as a code in an internal or external memory. The code will advantageously be encrypted, in which case it can be read via suitable encryption and decryption techniques and compared with the profile of the fibres in question which is actually present.

[0051] The plastic fibre advantageously also comprises an additional security feature, in particular a magnetically detectable compound and/or a compound which can be detected with the aid of microwaves.

[0052] According to a further embodiment, the security paper is composed of a plurality of layers of paper, in which case the security feature is accommodated between two adjacent layers.

[0053] In yet another embodiment, the emission wavelengths of the luminescent plastic fibres in the visible region correspond to the national colours of a country, for example in the order of the national flag.

[0054] A preferred position of the plastic fibre in a security paper provided with a watermark is the region of the watermark, in order to optimise the visibility of the luminescence of the luminescent fibre threads. The luminescence will be differently perceptible in the lighter parts of the watermark than in its darker parts. With a technique as proposed in FR 2 804 448, it is possible to arrange very light parts in a document with the aid of a watermark. The luminescence of a fibre is more clearly perceptible in light parts of this type than in the dark parts. The variation in the luminescence intensity of an embedded fibre can, in view of the above, form an additional check on the presence of a watermark in a security document, in particular if the luminescent fibres are introduced between the individual layers of a multi-layer paper.

[0055] The security paper according to the invention can be used in security documents. Security documents of this type include, for example, bank notes, other documents of value which represent a specific monetary value, such as cheques and credit cards, travel tickets, such as aircraft tickets, admission tickets, but also identity documents, such as driving licences and passports. A preferred application is a bank note.

[0056] The invention also relates to a method for producing security paper with a security feature that exhibits its luminescence, comprising the steps of arranging at least one luminescent plastic fibre consisting of a plastic and a luminescent compound, which luminescent plastic fibre under daylight conditions is not subject to any excitation causing emission perceptible to the naked

eye under daylight conditions, with maximum transverse dimensions in the range from 2-50 micrometres such that during use (at normal reading distance) under daylight conditions the plastic fibre is not visible to the naked eye both in reflection and in transmission, in a substrate matrix, such that the plastic fibre extends between at least two sides of the security paper.

[0057] As has been noted above, it is possible to spin plastic fibres, in which case luminescent and if desired substances which can be detected, for example magnetically, are incorporated in the plastic matrix during spinning. Plastic fibres may also be provided with luminescent and if desired magnetic properties after they have been spun. It is possible to form a thread of fibres from a bundle of fibres with identical luminescence properties. It is also possible to put together a heterogeneous bundle in which the individual fibres in a bundle have non-identical excitation, emission and if desired magnetic properties. A thread consisting of a bundle of individual threads with the same or different luminescent and/or magnetic properties will, depending on the diameter of the fibres, comprise at least two up to several hundred ($n \times 100$) individual fibres. The bundle is then worked into security paper in such a manner that the individual fibres from the bundle are embedded in the substrate of security paper isolated from one another. For the distribution of the fibres, it is important to take account of the subsequent use of the security paper with security feature. By way of example, fibres with an exclusively visually perceptible luminescence are preferably not embedded in a document or paper of which a large part will subsequently be printed in such a manner that as a result the luminescence of the fibres will not be readily visually perceptible. If the fibres have luminescences which are outside the absorption range of the printing inks used and/or if the emissions are very bright, the fibres can also be incorporated in the sections which are subsequently to be printed; the luminescences can then be perceived/measured using auxiliary means which are suitable for this purpose.

[0058] As has been explained above, the one or more luminescent fibres are advantageously arranged between two parallel sides of the security paper.

[0059] For individual fibres, which are positioned at a distance from one another and preferably parallel to one another, from a bundle of fibres to be incorporated in the paper in such a way that the fibres can be individually perceived clearly in a document, a bundle of fibres is passed through a distribution device before the fibres are incorporated in the paper mass. A distribution device may also comprise a plurality of optionally identical distributor regions of this type. By varying the shape of the different distributor regions, it is possible to ensure that a greater or lesser number of fibres per unit length perpendicular to the main fibre direction are present in a specific region of the document. It is in this way possible, for example, to vary the luminescence intensity for each subregion of the document. This offers the option of

forming a desired pattern or a specific code with the aid of the fibres. In another variant, in which the plastic fibre comprises an additional security feature, the luminescence may be identical, but the additional security feature different, so that the code is generated by the variation in the additional security feature. Sheets of security paper will usually be produced from a web of paper in which the luminescent plastic fibres run in the longitudinal direction by cutting.

[0060] The invention will be explained in more detail below with reference to the drawing, in which:

Fig. 1 shows a security document in the form of a bank note with a number of known security features and the security feature according to the invention; and

Fig. 2 diagrammatically depicts an embodiment of the method according to the invention.

[0061] Fig. 1 shows a security document 10 in the form of a bank note. It should be expressly noted that the various parts of the bank note 10 are not to scale, in order to improve the clarity of the drawing. The bank note 10 comprises security features 12 according to the invention in four regions, denoted by 12a, 12b, 12c and 12d. In addition, the bank note 10 includes a number of customary features, such as a watermark 14, a security thread 16 and an optically active element in the form of a foil 18. The bank note 10 is in the shape of a rectangle with two pairs of parallel sides 19a and 19b. Security feature 12a comprises a group of four parallel luminescent plastic fibres 20 which are positioned at a certain distance from one another and extend between the long sides 19b of the bank note 10. The fibres of the security feature 12a are partially located in the watermark 14. Feature 12b comprises a group of three parallel luminescent plastic fibres which are located at a shorter distance from one another than the plastic fibres of the feature 12a. They likewise run parallel to the short sides 19a of the bank note. The width of feature 12a is greater than that of feature 12b. Together, the features 12a and 12b can form a code. The luminescent fibres in the feature 12a have the same emission in the visible region, for example orange. The luminescent fibres in the feature 12b have different emissions, for example red, white and blue, the colours of the flag of the Netherlands, from left to right. Feature 12c comprises a single luminescent plastic fibre which extends over a twisty path, i.e. a non-rectilinear path, between the long sides 19b of the bank note 10. Security feature 12d comprises four luminescent plastic fibres which extend divergently from a common point on a short side 12b of the bank note 10 to an adjacent long side 19b. All the plastic fibres have a round cross section with a diameter of 20 micrometres.

[0062] Fig. 2 diagrammatically depicts the embedding of luminescent polymer fibres 20 in a two-layer paper

38 comprising layer 34a and 36. In general, when a vat wire method is used for producing two-layer paper, one layer is thicker than the other, although this is not imperative. The watermark (region 14) is arranged in the thicker layer. The fibres 20 (only one of which is visible in this side view) are distributed from a bundle of fibres, denoted by reference numeral 30, with the aid of a distribution device 32 and arranged on the inner side of layers 34 and 36. For the layer 36, this means that this embedding takes place on the felt side of the paper layer 36, i.e. on the side on which the watermark 14 is not primarily formed. As an alternative to a mechanical distribution device 32, the separate fibres may also be positioned with the aid of directed jets of a gaseous medium, such as air.

[0063] The distribution device 32 itself, or the guides for the separate fibres, can be arranged such that they can move transversely with respect to the longitudinal direction of the paper layers, so that the shape of the fibres in the longitudinal direction can be given a controlled, preferably repeating pattern (for example a sinusoidal pattern) by displacement of the distribution device or its guides.

[0064] In the case of production of a single-layer paper, the polymer fibres can be introduced in a way which is known from the introduction of security threads into this type of paper on a Fourdrinier or vat machine.

[0065] Examples of the production of fibres of this type per se are described, inter alia, in DE 19802588.

[0066] A plastic fibre according to the invention can be made by mixing a colourless pigment with a melt of, for example, polymeric cellulose acetate or a derivative thereof, forcing the melt through a spinning head and then stretching the spun fibres to produce the desired diameter.

[0067] If insoluble pigments are used, the pigment loading in the final fibre will be between 1 and 10% (m/m). This loading depends on the final diameter of the fibre and the luminescence intensity of the pigment to be used. The mean particle size of insoluble pigments is preferably less than 20 µm, more particularly less than 5 µm.

[0068] Pigments which are eminently suitable to be worked into the luminescent plastic fibres are generally based on inorganic luminophores, in particular on account of the thermal stability and light - fastness of such pigments. Examples include the pigments available from Honeywell Speciality Chemicals Seelze GmbH such as CD 128, CD 144, CD 145, CD 110, CD 135, CD 105 and CD 106. Other companies, such as Nemoto (Japan), supply similar pigments. The emissions of the above pigments are sometimes based on those of lanthanides in a host lattice and for other compounds on the luminescences of transition metals in a specific lattice. Nanomaterials generally have a lower emission intensity and are consequently less suitable for visual assessment. However, these materials are suitable for measurement.

Claims

1. Security paper, comprising a substrate surface delimited by sides and at least provided with a security feature which exhibits luminescence, **characterized in that** the security feature (12) comprises at least one luminescent plastic fibre (20) consisting of a plastic and at least one luminescent compound, the maximum transverse dimensions of the plastic fibre being in the range from 2-50 micrometres, such that at normal reading distance in daylight conditions, the plastic fibre is not visible to the naked eye both in reflection and in transmission, and the plastic fibre extends between at least two sides (19a, 19b) of the security paper (38), and the luminescent plastic fibre (20) is not subject to any excitation by daylight which causes emission perceptible to the naked eye under daylight conditions.
2. Security paper according to claim 1, **characterized in that** the plastic fibre (20) is continuous.
3. Security paper according to one of the preceding claims, **characterized in that** the plastic fibre (20) is colourless in the visible region.
4. Security paper according to one of the preceding claims, **characterized in that** the plastic fibre (20) has a refractive index corresponding to that of the surrounding substrate.
5. Security paper according to one of the preceding claims, **characterized in that** the colour of the plastic fibre (20) corresponds to that of the surrounding substrate.
6. Security paper according to one of the preceding claims, **characterized in that** the light-scattering behaviour of the plastic fibre (20) corresponds to that of the surrounding substrate.
7. Security paper according to one of the preceding claims, the surface of which has at least two parallel sides, **characterized in that** the plastic fibre (20) extends between two parallel sides (19a, 19b).
8. Security paper according to claim 7, **characterized in that** the plastic fibre (20) extends along a straight line between parallel sides (19a, 19b).
9. Security paper according to claim 7, **characterized in that** the plastic fibre (20) has a random non-rectilinear orientation.
10. Security paper according to one of the preceding claims 1-7, **characterized in that** the shape of the plastic fibre in its longitudinal direction comprises a

repeating pattern.

11. Security paper according to one of claims 7-9, **characterized in that** the orientation of the plastic fibre (20) is stored in a memory, preferably in the security paper. 5
12. Security paper according to one of the preceding claims, **characterized in that** the security paper comprises a plurality of parallel plastic fibres (20) which are located at a distance from one another and are arranged in groups (12a, 12b), which groups define a code. 10
13. Security paper according to claim 12, **characterized in that** a group has a width, as seen in the direction transverse to the longitudinal direction of the fibres, in the range from 2 to 50 mm. 15
14. Security paper according to one of the preceding claims, **characterized in that** the plastic fibre (20) also comprises an additional, further security feature, in particular a magnetically detectable compound. 20
15. Security paper according to one of the preceding claims, **characterized in that** the paper is composed of a plurality of layers of paper, with the security feature accommodated between two adjacent layers (34, 36). 25
16. Security paper according to one of the preceding claims, **characterized in that** the emission wavelengths of the luminescent plastic fibres in the visible region correspond to the national colours of a country. 30
17. Security paper according to one of the preceding claims, **characterized in that** the luminescent plastic fibre (20) is provided in a region having a watermark (14). 35
18. Security document, in particular a banknote (10), produced from security paper according to one of the preceding claims. 40
19. Method for producing security paper with a security feature that exhibits luminescence, comprising the steps of arranging at least one luminescent plastic fibre (20) consisting of a plastic and a luminescent compound, which luminescent plastic fibre under daylight conditions is not subject to any excitation causing emission perceptible to the naked eye under daylight conditions, with maximum transverse dimensions in the range from 2-50 micrometres such that during use under daylight conditions the plastic fibre is not visible to the naked eye both in reflection and in transmission, in a substrate matrix, 45

such that the plastic fibre (20) extends between at least two sides (19a, 19b) of the security paper.

20. Method according to claim 19, **characterized in that** the luminescent fibre (20) is arranged between two parallel sides of the security paper.
21. Method according to claim 19 or 20, **characterized in that** a plurality of luminescent fibres are arranged parallel to and at a distance from one another in the substrate material by means of a distribution device (32).
22. Method according to one of the preceding claims 19-21, **characterized in that** the luminescent fibre is accommodated between two layers (34, 36) of the substrate of the security paper.
23. Method according to one of the preceding claims 19-22, **characterized in that** the plastic fibre (20) also comprises an additional, further security feature, in particular a magnetically detectable compound.

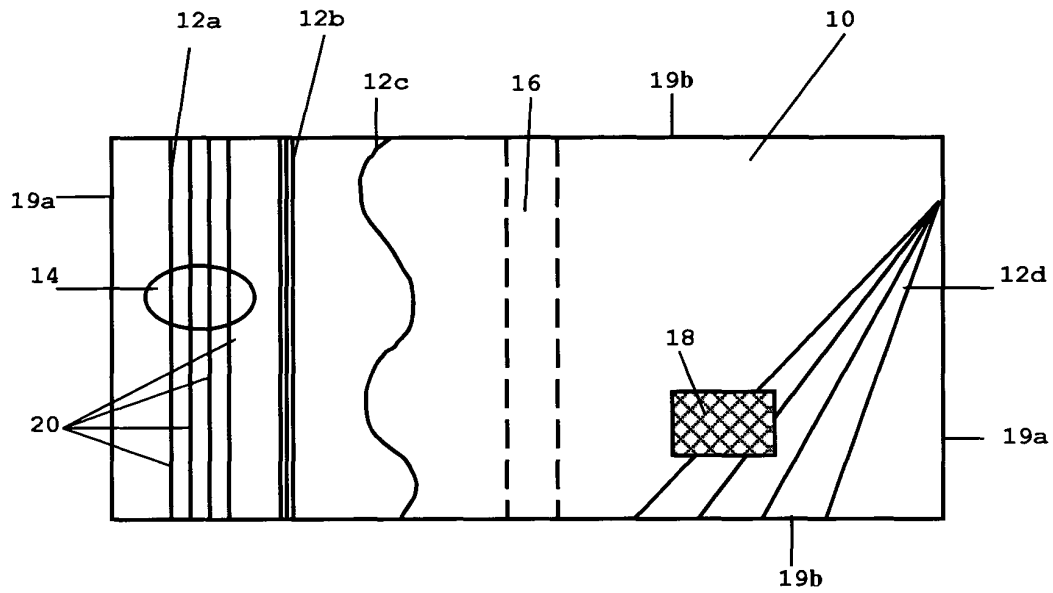


FIG. 1

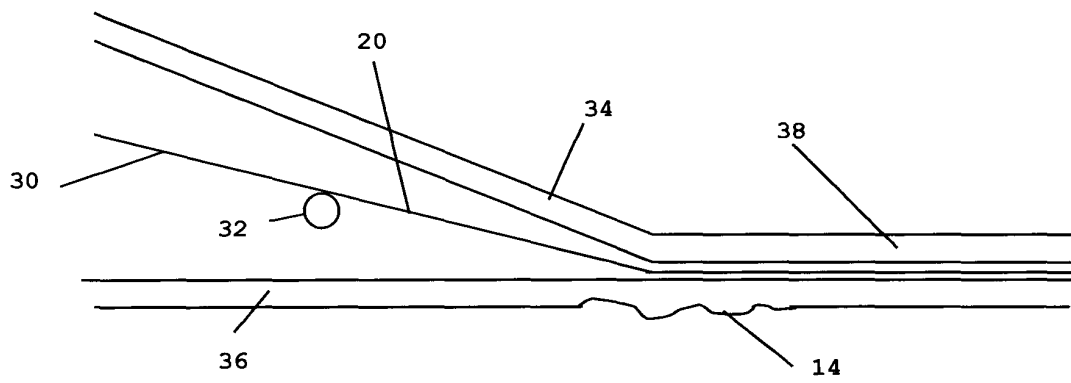


FIG. 2