(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 July 2004 (01.07.2004)

PCT

(10) International Publication Number
WO 2004/055798 A1

(51) International Patent Classification[7]: G11B 7/24, 7/26

(21) International Application Number: PCT/IB2003/005286

(22) International Filing Date: 19 November 2003 (19.11.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1022205 18 December 2002 (18.12.2002) NL

(71) Applicant *(for all designated States except US)*: **KONINKLIJKE PHILIPS ELECTRONICS N.V.** [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BUSCH, Christopher** [DE/NL]; c/o Prof . Holstlaan 6, NL-5656 AA Eindhoven (NL). **VAN DER LEE, Alexander, M.** [NL/NL]; c/o Prof . Holstlaan 6, NL-5656 AA Eindhoven (NL). **WILDERBEEK, Johannes, T., A.** [NL/NL]; c/o Prof . Holstlaan 6, NL-5656 AA Eindhoven (NL).

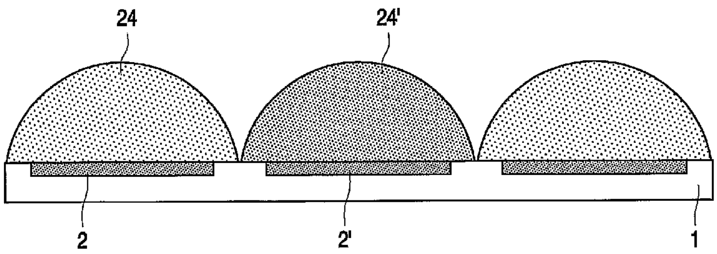
(74) Agent: **DEGUELLE, Wilhelmus, H., G.**; Philips Intellectual Property & Standards, Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

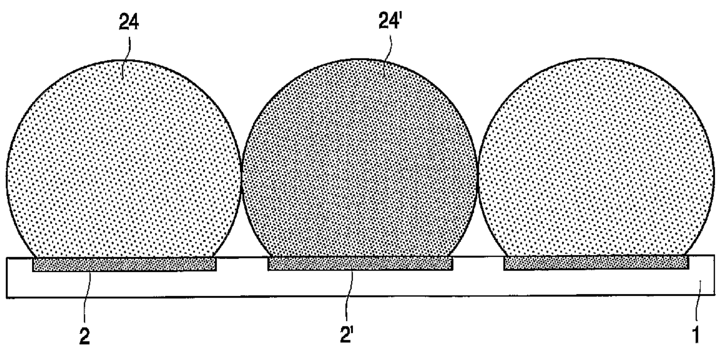
(84) Designated States *(regional)*: ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE,

[Continued on next page]

(54) Title: STORAGE MEDIUM FOR THE OPTICAL STORAGE AND RETRIEVAL OF INFORMATION



A



B

(57) Abstract: The invention relates to a storage medium for the storage and retrieval of information, comprising: a substrate (1), an active layer (2) for retention of data, the active layer employing bit-position encoding for the storage and retrieval of information, and a plurality of micro-optical elements (24, 24', ...) for receiving illumination from an external source of illumination. According to the invention, the micro-optical elements (24, 24', ...) are provided according to a pre-determined pattern of bit positions, preferably at each of the possible bit positions. Preferably, the micro-optical elements comprise lenses, preferably hemispherical or stigmatic lenses. The invention also relates to a method of manufacturing the storage medium. According to the invention, the storage medium has a relatively high data density.

WO 2004/055798 A1

SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Storage medium for the optical storage and retrieval of information

The invention relates to a storage medium for the optical storage and retrieval of information.

In addition, the invention relates to a method of manufacturing a storage medium for the optical storage and retrieval of information and to a record carrier having information written thereon.

The information age has led to an explosion of information available to users. (Personal) computers are omnipresent and connected via a worldwide network of computer networks. The decreasing costs of storing data, and the increasing storage capacities of the same small device footprint, have been key enablers of this revolution. While current storage needs are being met, storage technologies continue to improve in order to keep pace with the rapidly increasing demand.

Media for optical storage of the kind mentioned in the opening paragraph are well known in the art. However, both magnetic and conventional optical data storage technologies, where individual bits are stored as distinct magnetic or optical changes on the surface of a recording medium, are approaching physical limits beyond which individual bits may be too small and/or too difficult to store and/or to distinguish. Inter-pixel or inter-symbol interference is a phenomenon in which intensity at one particular pixel contaminates data at nearby pixels. Physically, this interference arises from the band-limit of the (optical) channel, originating from optical diffraction or from time-varying aberrations in the lens system.

The invention has for its object to provide a storage medium with a higher data density. According to the invention, a medium for optical storage of the kind mentioned in the opening paragraph for this purpose comprises:

a substrate,

an active layer for retention of data,

the active layer employing bit-position encoding for the storage and retrieval of information, and

a plurality of micro-optical elements for receiving illumination from an external source of illumination, the micro-optical elements being provided according to a pre-determined pattern of bit positions.

An active layer in the present description and claims is understood to be a layer in which information can be stored (coded) and changed.

In a conventional one-dimensional (optical) storage medium a single bit row is written along a spiral. In general, the track pitch is chosen large enough to reduce thermal cross talk between neighboring tracks to acceptable levels. In addition, a recording dye layer is or, alternatively, inorganic phase change layers are distributed homogeneously across the medium.

By providing a plurality of micro-optical elements, wherein the micro-optical elements are provided according to the pre-determined pattern of bit positions, the track density on the storage medium can be significantly improved. The inventors have had the insight to provide above every possible bit position a micro-optical element, for instance a so-called nano-lens, resulting in a significant gain in optical resolution of the storage medium. By embedding micro-optical elements (nano-optics) in the storage medium close to or on top of the active layer, cross-talk between bit positions is largely reduced. When information is stored (recorded or coded) in the storage medium, the spot size of the storage means, preferably, is such that only the active layer at the desired bit position is activated or de-activated and that the adjacent bit positions are (practically) not affected by the storing means.

US patent 5,910,940 describes a storage medium employing an optical layer provided with cylindrical micro-lenses embedded in the storage medium in close proximity of the active layer. In the known (one-dimensional) optical storage medium, a single bit row is written along a spiral employing the bit-length encoding as encoding concept. In the so-called near-field optical recording as described in the known storage medium, the cylindrical micro-lenses stretch along the track direction.

When a pre-determined pattern comprising a plurality of micro-optical elements are provided according to a pre-determined pattern of bit positions, the preferred encoding concept is bit-position encoding.

Preferably, the micro-optical elements are provided at each of the possible bit positions. This has the additional advantage that the optical constraints are the same for every possible bit position. Patterning the micro-optical elements largely facilitates the manufacturing of the storage medium according to the invention.

A preferred embodiment of the storage medium according to the invention is characterized in that the micro-optical elements are made from a material with a relatively high refractive index and that the micro-optical elements are embedded in a cover layer, the cover layer being made of a material with a relatively low refractive index. The higher the difference in refractive index between the cover layer and the micro-optical elements, the higher the gain in optical resolution. Preferably, the refractive index n_{cl} of the cover layer is $n_{cl} \leq 1.5$ and the refractive index n_{me} of the micro-optical elements is $n_{me} > 1.5$. Preferably, the refractive index of the micro-optical elements is $n_{me} \geq 1.75$. High gains in optical resolution are possible by choosing high refractive index materials for the micro-optical elements and/or low index material for the cover layer.

Preferably, the micro-optical elements comprise lenses (e.g. nano-lenses). Preferably, each of the possible bit positions in the active layer is provided with an individual lens. Preferably, the curvature of the lenses is hemispherical or stigmatic. For micro-optical elements based on hemispherical lenses, the achieved gain in optical resolution is proportional to the ratio of the refractive index of the lens material as compared to the refractive index of the cover layer material. For micro-optical elements based on stigmatic lenses, an even higher gain is possible than with a hemispherical lens set-up, in this case, the optical resolution being proportional to the square of the ratio between the respective refractive indexes.

A preferred embodiment of the storage medium according to the invention is characterized in that the pre-determined pattern comprises a two-dimensional strip of micro-optical elements. In the known (one-dimensional) optical storage medium, a single bit row is written along a spiral employing bit-length encoding as encoding concept. When a pre-determined pattern comprising a two-dimensional strip of bit positions is used, bit-position encoding is employed. Preferably, a strip is aligned horizontally and consists of a number of rows and columns. Preferably, code words do not cross boundaries of a strip.

A preferred embodiment of the storage medium according to the invention is characterized in that the pre-determined pattern comprises an at least partial quasi-hexagonal or quasi-square pattern. With a quasi-hexagonal or quasi-square pattern is meant a pattern of micro-optical elements that may be ideally arranged hexagonally or square, respectively. However, small position distortions from the ideal pattern may be present. The number of nearest neighbors is six for the hexagonal pattern whereas it is four for a square pattern. The bit error rate is smaller for the quasi-hexagonal and quasi-square pattern as compared to the known storage medium. The higher packing density of the quasi-hexagonal pattern provides a higher storing efficiency than the quasi-square pattern. The quasi-hexagonal or quasi-square patterns are very suitably employed in a storage medium comprising a two-dimensional strip of bit positions.

The invention has for its further object to provide a method of manufacturing a storage medium for the optical storage and retrieval of information providing alignment of the micro-optical elements with the pre-determined pattern of bit positions. According to an embodiment of the invention, a method of manufacturing a storage medium for the optical storage and retrieval of information comprises the following steps. A hydrophilic wetting material is deposited on a substrate provided with an active layer for retention of data. The hydrophilic wetting material is provided on the substrate according to a pre-determined pattern. As a next step, a hydrophilic optical layer material is deposited on the patterned hydrophilic wetting material. Subsequently, the hydrophilic optical layer material is fixated, forming a micro-optical element according to the pre-determined pattern. By applying a hydrophilic optical layer material on a patterned hydrophilic wetting material, the surface tension properties are influenced in a favorable manner, such that droplets of optical layer material are formed on the hydrophilic wetting material. These droplets of hydrophilic optical layer material can be fixated to form the micro-optical elements. The method according to the invention is efficient, low-cost and high-yield and is very well suited for manufacturing.

A preferred embodiment of the method of manufacturing a storage medium according to the invention is characterized in that the hydrophilic wetting material is deposited on a pressing tool provided with protrusions according to the pre-determined pattern. Preferably, the optical layer is deposited by means of spin coating or dip coating. Due to the characteristic properties of the wetting material, the droplets are be formed only on top of the patches of hydrophilic wetting material

According to an alternative embodiment of the invention, a method of manufacturing a storage medium for the optical storage and retrieval of information comprises the following steps. A hydrophobic (wetting) material is deposited on a substrate provided with an active layer for retention of data. The hydrophobic (wetting) material is provided according to a pre-determined pattern. As a next step, a hydrophobic optical layer material is deposited on the patterned hydrophobic (wetting) material. Subsequently, the hydrophobic optical layer material is fixated, forming a micro-optical element according to the pre-determined pattern. By applying a hydrophobic optical layer material on a patterned hydrophobic (wetting) material, respectively, the surface tension properties are influenced in a favorable manner, such that droplets of optical layer material are formed on the hydrophobic (wetting) material, respectively. These droplets of hydrophobic optical layer material can be fixated to form the micro-optical elements. The method according to the invention is efficient, low-cost and high-yield and is very well suited for manufacturing.

A preferred embodiment of the method of manufacturing a storage medium according to the invention is characterized in that the hydrophobic (wetting) material is deposited on a pressing tool provided with protrusions according to the pre-determined pattern, and in that the hydrophobic optical layer material is deposited on the hydrophobic wetting material by positioning the pressing tool on the substrate. By employing a pressing tool, the micro-optical elements are provided on the storage medium according to a pattern which can be determined beforehand such that recording or storing (coding) information in the active layer is possible only at pre-determined positions.

Preferably, the micro-optical elements comprise lenses. Preferably, the curvature of the lenses is hemispherical or stigmatic. The surface tension properties during and after the deposition of the hydrophilic optical layer material on the patterned hydrophilic wetting material and the hydrophilic properties of the active layer largely determine the shape of the lenses. The method of manufacturing according to the invention is particularly suitable for providing stigmatic lens layout on the storage medium. Such lens shapes are difficult to produce by conventional methods.

A favorable embodiment of the method of manufacturing a storage medium according to the invention is characterized in that the storage medium is covered by a transparent cover layer. Such a cover layer largely has a protective purpose.

The storage medium according to the invention can be a record carrier having information written thereon, e.g. an optical disc, a CD, a CD-Rom, a CD-R, a CD-RW, and a DVD, BD, optical memory cards, and similar products.

Preferably, a record carrier having information written thereon, is coded in an active layer and that micro-optical elements are embedded in the record carrier, said micro-optical elements being provided by a method of manufacturing. Preferably, the record carrier is an optical disc.

Other advantageous embodiments and further developments are defined in the dependent claims.

The invention will now be explained in more detail with reference to a number of embodiments and accompanying drawing figures in which:

Fig. 1A shows a storage medium for optical storage and retrieval of information according to the invention;

Fig. 1B shows a detail of the storage medium of Figure 1A;

Fig. 2A shows a side view of an embodiment of the storage medium according to the invention,

Fig. 2B shows a side view of an alternative embodiment of the storage medium according to the invention,

Figs. 3A-3F show steps of the method of manufacturing a storage medium according to a preferred embodiment of the invention, and

Fig. 4 shows the geometry and direction of the surface tensions for a droplet of hydrophilic optical layer material forming the micro-optical elements.

The Figures are purely diagrammatic and not drawn true to scale. Some dimensions are particularly strongly exaggerated for reasons of clarity. Equivalent components have been given the same reference numerals as much as possible in the Figures.

Figure 1A shows very schematically a storing medium for optical storage and retrieval of information according to the invention. In Figure 1A a substrate 1 is provided by a strip or track in the form of a spiral of possible bit positions. Upon storing and retrieving of information the spiral is followed by the storage or retrieval means, respectively. Figure 1B shows very schematically a detail of the storing medium of Figure 1A. A pre-determined pattern 4 of micro-optical elements 24, 24', ... is shown. So-called guard bands 3 are shown between the strips or tracks of micro-optical elements 24, 24', ...; the direction in which information is stored and retrieved from a strip of micro-optical elements 24, 24', ... is indicated by a bold arrow. In the example of Figure 1B, the pattern 4 of micro-optical elements 24, 24', ... is a quasi-hexagonal pattern for which the number of nearest neighbors is six. In an alternative embodiment, the pattern of micro-optical elements is a quasi-square pattern for which the number of nearest neighbors is four. It is well known that hexagonal patterns provide the highest packing fraction. In particular, the packing fraction for the hexagonal pattern is approximately 15% higher than that of a square pattern with the same distance between nearest-neighbor micro-optical elements. In addition, other patterns can be employed. Periodic two-dimensional patterns can be built up using triangles with arbitrary angles as basic building blocks. In addition, patterns with parallelograms and hexagons can be used.

When a pre-determined pattern of micro-optical elements comprising a two-dimensional strip of bit positions as shown in Figure 1A and 1B is employed, information is stored and retrieved in the storage medium employing bit-position encoding. Reliable readout at such a high packing density of the information bits is only possible by the synchronized detection and processing of signals from several rows of micro-optical elements. This can e.g. be done by using an array of light spots that simultaneously detects (or writes) the two-dimensional (2D) encoded information, thereby dramatically increasing the data rate. Using the obtained 2D signal information, the large signal energy present in inter-symbol interference (which in standard optical recording largely is considered as part of the noise) can be coherently used in the reconstruction of the original 2D bit patterns. So-called two-dimensional coding enhances the speed of data coding and decoding. The location of the micro-optical elements is known to a high accuracy beforehand.

Figure 2A shows a side view of an embodiment of the storage medium according to the invention. In the example of Figure 2A, the micro-optical elements 24, 24', ... comprise hemispherical lenses. The hemispherical lenses are deposited on the substrate 1 provided with an active layer 2.

Preferably, the[0] active layer 2 is a recording dye layer (typical for a WORM medium). Preferably, these layers are deposited by conventional techniques such as spin coating, embossing, molding, (photo)lithography, micro-contact printing or vapor deposition. Organic dye layers can be easily patterned. Alternatively, inorganic phase change layers may also be used as re-writable medium. Preferably, the latter layers are deposited by sputtering. Patterning organic dyes is preferred as compared to patterning re-writable rare earth recording layers.

Preferably, the cover layer 18 is made of a material with a relatively low refractive index, and the micro-optical elements 24, 24', ... have a relatively high refractive index. Preferably, the refractive index n_s of the cover layer 18 is $n_{cv} \leq 1.5$ and the refractive index n_{mo} of the micro-optical elements 24, 24', ... is $n_{mo} \geq 1.5$. Preferably, the refractive index n_{mo} of the micro-optical elements 24, 24', ... is $n_{mo} \geq 1.75$. For micro-optical elements based on hemispherical lenses, the achieved gain in optical resolution is proportional to the ratio of the refractive index of the lens material as compared to the refractive index of the substrate material. By way of example, if the refractive index of the cover layer n_{cl}=1.5 (e.g.

polycarbonate) and the refractive index of the hemispherical lens n_{me}=2, an optical resolution increase of 1.33, or equivalently an effective numerical aperture of NA=1.13, is obtained.

Figure 2B shows a side view of an embodiment of the storage medium according to the invention. In the example of Figure 2B, the micro-optical elements 24, 24', ... comprise stigmatic lenses, giving even higher optical resolutions than with the hemispherical lenses, the optical resolution being proportional to the square of the ratio between the respective refractive indexes. By way of example, if the refractive index of the cover layer material n_{cl}=1.5 (e.g. polycarbonate) and the refractive index of the hemispherical lens n_{me}=2, an optical resolution increase of 1.78, or equivalently an effective numerical aperture NA=1.51, is obtained. Higher gains in optical resolution are possible by choosing higher refractive index materials for the micro-optical elements and/or lower index materials for the cover layer (e.g. fluorinated polymers $n \approx 1.3$).

Figure 3A-3F show steps of the method of manufacturing a storage medium according to a preferred embodiment of the invention. Figure 3A shows diagrammatically a cover layer 18 provided with an active layer 2 for retention of data and a pressing tool 10 provided with protrusions 11, 11', ... according to a pre-determined pattern 4. A hydrophilic wetting material 13 is deposited on the pressing tool 10.

Suitable materials for the hydrophilic wetting material can be recruited from the class of materials that are conventionally used for wetting and non-wetting purposes as are known to persons skilled in the art, such as thiols, protein derivatives, long-chain fatty acid derivatives, silane derivatives, or other surfactant-like molecules, clusters, complexes, or aggregates, all optionally provided with functional head, and/or tail and/or side groups. The mentioned material classes are solely included as non-limitative examples.

The pressing tool 10 is lowered (according to arrow in Figure 3A) and brought into contact with the substrate (see Figure 3B). The hydrophilic wetting material 13 is transferred on the surface of (the active layer 2 on) the substrate 1. In Figure 3C the pressing tool 10 is removed from the substrate (according to arrow in Figure 3C) leaving on the surface of (the active layer 2 on) the substrate 1 the hydrophilic wetting material 13 at a plurality of locations according to the pre-determined pattern 4. In practice, the wetting layer is a molecular monolayer with a thickness substantially smaller than that of the other layers.

As a next step of the method of manufacturing a storage medium, a hydrophilic optical layer material 23 is deposited on the hydrophilic wetting material 13 (see Figure 3D). In this manner, the droplets of hydrophilic wetting material forming the micro-optical elements 24, 24', ... (also see Figure 4) are provided according to the pre-determined pattern 4. Preferred deposition methods are spin coating or dip coating. Other suitable deposition techniques are embossing, molding, (photo)lithography, micro-contact printing or vapor deposition.

In Figure 3E the hydrophilic optical layer material is fixated, forming a plurality of micro-optical elements 24, 24', ... according to the pre-determined pattern 4. Preferred fixating methods are radiation (e.g. UV-light, visible light) or thermal energy (e.g. thermally initiated polymerization). Photo-initiators, photo-sensitizers and/or thermal initiators, along with other additives (e.g. inhibitors, stabilizers, nucleating agents (so-called clarifying agents) can be added to the optical layer material before enclosure in the pressing tool.

In an alternative embodiment of the invention, a hydrophobic (wetting) material is used in stead of a hydrophilic wetting material and a hydrophobic optical layer material in stead of a hydrophilic optical layer is deposited on the patterned hydrophobic (wetting) material.

The micro-optical elements manufactured according to the method according to the invention are, optionally, covered with a transparent cover layer consisting of a low refractive index material ($n \approx 1.3$) (see Figure 3F). Preferably, (amorphous) fluorinated polymers are employed.

The optical elements are restricted in size by the lattice parameter d_c. If a system with a blue laser (λ=405nm) and a NA=0.85 is used, a typical parameter is $d_c \approx 140$ nm. The result is a significantly higher bit density for the storage medium according to the invention as compared to the known storage media. Compared to the so-called Blu-ray Disc standard, the physical bit density is increased roughly by a factor or two. By employing a recording medium with the array of micro-optical elements, writing cross-talk between bit positions is significantly reduced.

The pressing tools used for the manufacturing process as described here are obtained by standard methods commonly used for the preparation of stamps for micro-contact printing. By way of example, a soft polydimethylsiloxane (PDMS) stamp is cast from a preformed mold. This allows the exact replication of the designated recording areas both in size, depth and position. Preferably, the widths of the protrusions 11, 11', ... are approximately 100-300 nm which can be readily made using this replication process.

The concept of the surface tension determining the shape of a droplet is given by Young's equation:

$$\gamma_{SV} = \gamma_{LS} + \gamma_{LV} \cos(\theta),$$

where γ_{SV} is the solid-vapor interfacial tension, γ_{LS} and γ_{LV} those of liquid-solid and liquid vapor, respectively. Figure 4 shows the geometry and direction of the surface tensions for a droplet of hydrophilic optical layer material forming the micro-optical elements 24 on the active layer 2 on the substrate (not shown in Figure 4). In order to form a stigmatic (hemispheric) lens, the solid-vapor tension of the interfaces has to be smaller (equal) to the liquid-solid interfaces term. In that case, the effective force tries to minimize the surface of the optical layer material, resulting in the correct shape. It has to be kept in mind though, that the actual situation is more difficult than indicated by the simple formula because the extra interface between the wetting layer 13 and the active layer 2.

Preferably, a transparent high refractive index material is used for the micro-optical elements (nano-lenses). By a proper choice of materials, the shape of the droplet can be determined. Also, additional means such as electro-wetting concepts might be used to further control the effect. Suitable materials for the hydrophilic optical layer material are predominantly polar high refractive index materials. Optionally, mixtures of one or more different reactive (e.g. monomers) and one of more inert materials may be employed as to adjust the wetting and refractive index properties of the mixture and of the fixated optical layer material. Non-limitative examples of monomers resulting in high refractive index polymers are high index polymers are pentabromophenyl acrylate (n_{om}≈1.7), pentabromophenyl methacrylate (n_{om}=1.71), 2-vinylnaphtalene (n_{om}=1.68), 2-naphtyl methacrylate (n_{om}=1.64), N-vinylphtalimide (n_{om}=1.62), and pentachlorophenyl acrylate (n_{om}≈1.6).

Preferably, a two-dimensional strip of micro-optical elements 24, 24', ... in the form of a spiral is provided on the substrate by the method of manufacturing a storage medium (see Figure 1A and 1B).

The scope of the invention is not limited to the embodiments. The invention is embodied in each new characteristic and each combination of characteristics. Any reference sign do not limit the scope of the claims. The word "comprising" does not exclude the presence of other elements or steps than those listed in a claim. Use of the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

CLAIMS:

1. A storage medium for the storage and retrieval of information, the storage medium comprising:

a substrate,

an active layer for retention of data,

the active layer employing bit-position encoding for the storage and retrieval of information, and

a plurality of micro-optical elements for receiving illumination from an external source of illumination, the micro-optical elements being provided according to a pre-determined pattern of bit positions.

2. A storage medium as claimed in claim 1, characterized in that the micro-optical elements are provided at each of the possible bit positions.

3. A storage medium as claimed in claim 1 or 2, characterized in that the micro-optical elements comprise lenses.

4. A storage medium as claimed in claim 3, characterized in that the curvature of the lenses is hemispherical or stigmatic.

5. A storage medium as claimed in claim 1 or 2, characterized in that the micro-optical elements are made from a material with a relatively high refractive index and that the micro-optical elements are embedded in a cover layer, the cover layer being made of a material with a relatively low refractive index.

6. A storage medium as claimed in claim 5, characterized in that the refractive index n_{cl} of the cover layer is $n_{cl} \leq 1.5$ and the refractive index n_{me} of the micro-optical elements is $n_{me} > 1.5$.

7. A storage medium as claimed in claim 1 or 2, characterized in that the pre-determined pattern comprises a two-dimensional strip of micro-optical elements.

8. A storage medium as claimed in claim 1 or 2, characterized in that the pre-determined pattern comprises an at least partial quasi-hexagonal or quasi-square pattern.

9. A method of manufacturing a storage medium for the optical storage and retrieval of information, the method comprising the following steps:

a hydrophilic wetting material is deposited on a substrate provided with an active layer for retention of data, the hydrophilic wetting material being provided according to a pre-determined pattern,

a hydrophilic optical layer material is deposited on the patterned hydrophilic wetting material,

the hydrophilic optical layer material is fixated, forming a micro-optical element according to the pre-determined pattern.

10. A method of manufacturing a storage medium for the optical storage and retrieval of information, the method comprising the following steps:

a hydrophobic wetting material is deposited on a substrate provided with an active layer for retention of data, the hydrophobic wetting material being provided according to a pre-determined pattern,

a hydrophobic optical layer material is deposited on the patterned hydrophobic wetting material,

the hydrophobic optical layer material is fixated, forming a micro-optical element according to the pre-determined pattern.

11. A method of manufacturing a storage medium as claimed in claim 9 of 10, characterized in that

the wetting material is deposited on a pressing tool provided with protrusions according to the pre-determined pattern.

12. A method of manufacturing a storage medium as claimed in claim 9 or 10, characterized in that the micro-optical elements comprise lenses.

13. A method of manufacturing a storage medium as claimed in claim 12 characterized in that the curvature of the lenses is hemispherical or stigmatic.

14. A method of manufacturing a storage medium as claimed in claim 9 or 10, characterized in that the storage medium is covered by a transparent cover layer.

15. A method of manufacturing a storage medium as claimed in claim 14, characterized in that the cover layer is made of a material with a relatively low refractive index, and the micro-optical elements have a relatively high refractive index.

16. A method of manufacturing a storage medium as claimed in claim 14, characterized in that the refractive index n_{cl} of the cover layer is $n_{cl} \leq 1.5$ and the refractive index n_{mo} of the micro-optical elements is $n_{mo} > 1.5$.

17. A method of manufacturing a storage medium as claimed in claim 9 or 10, characterized in that a two-dimensional strip of micro-optical elements in the form of a spiral is provided on the substrate.

18. A record carrier having information written thereon, characterized in that the information is coded in an active layer and that micro-optical elements are embedded in the record carrier, said micro-optical elements being provided by a method of manufacturing as claimed in claim 9 or 10.

19. A record carrier as claimed in claim 18, characterized in that the record carrier is an optical disc.

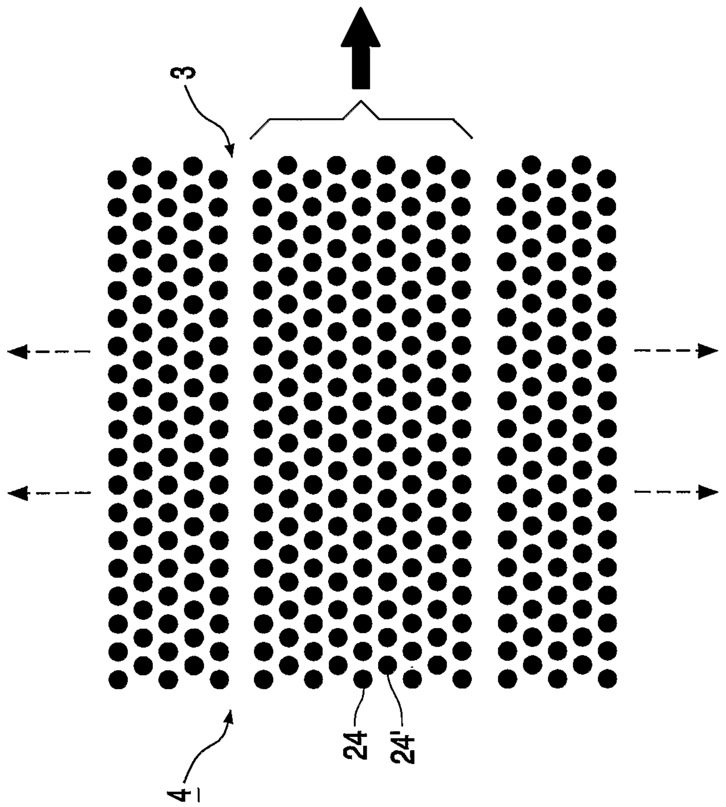


FIG. 1B

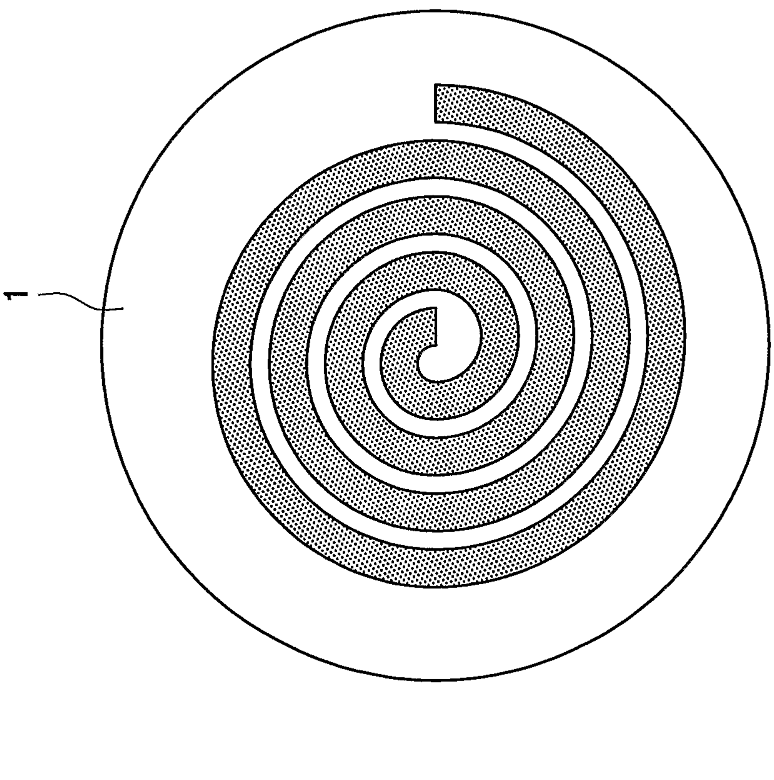


FIG. 1A

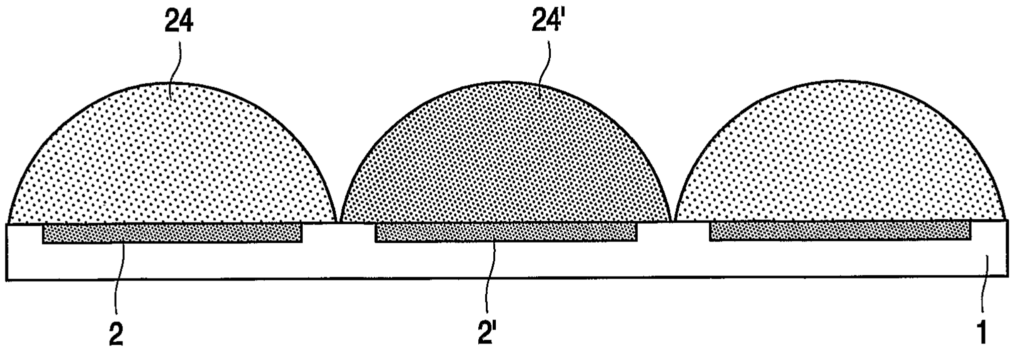


FIG. 2A

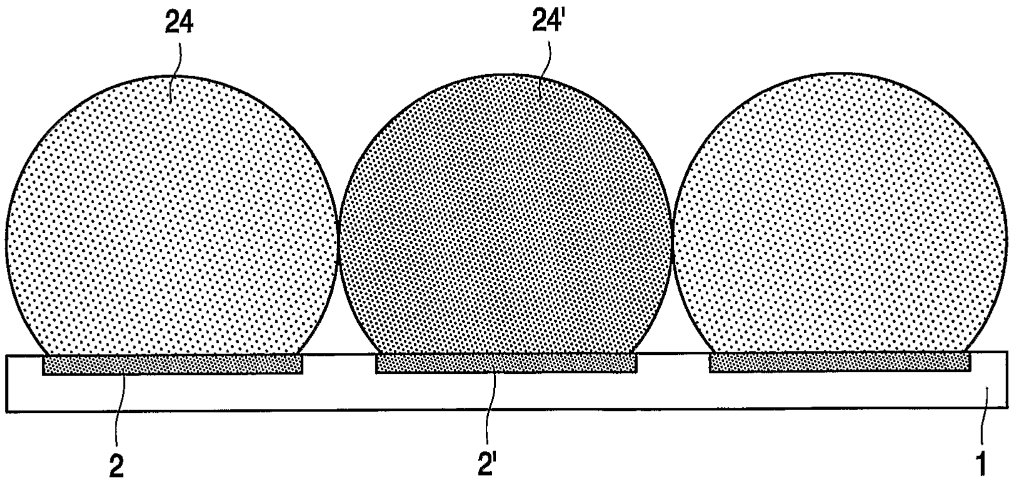


FIG. 2B

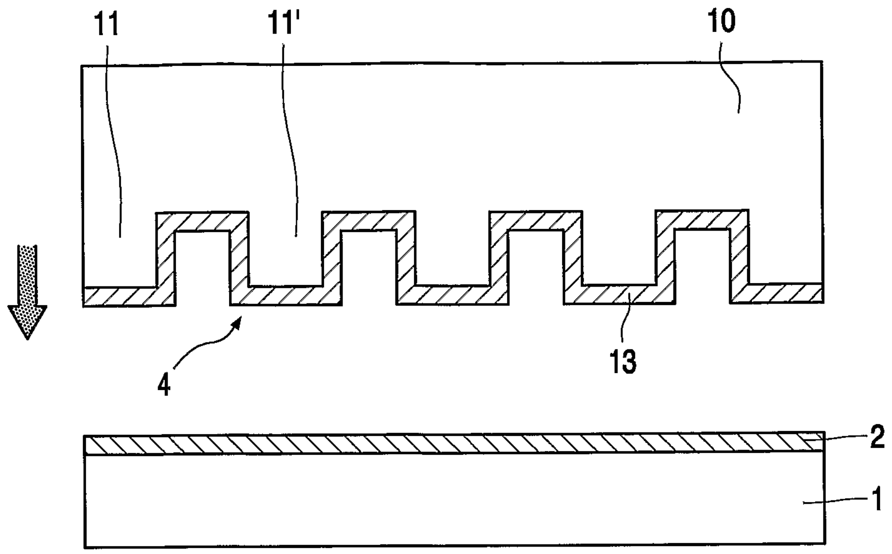


FIG. 3A

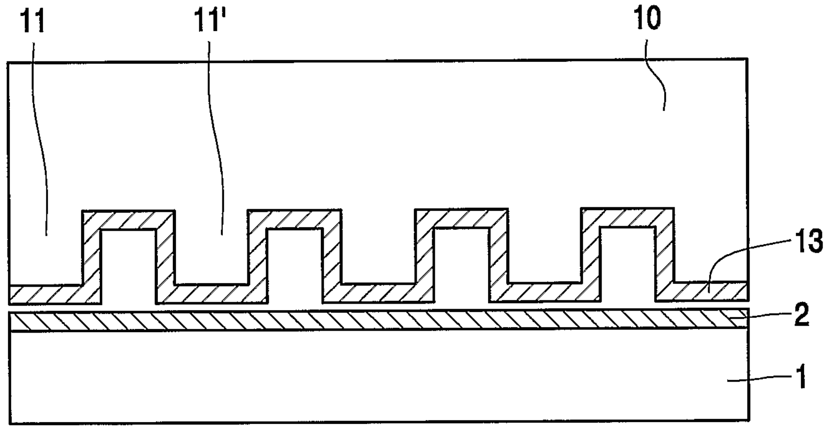


FIG. 3B

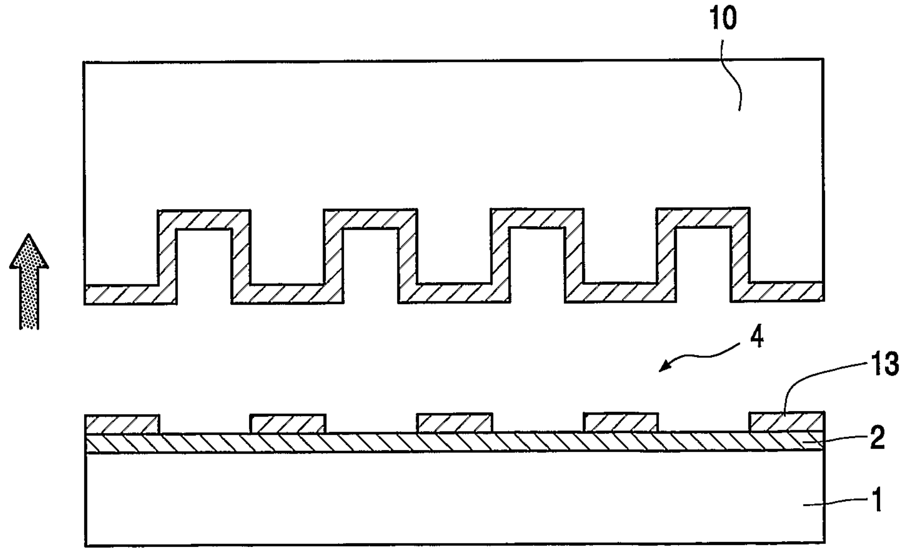


FIG. 3C

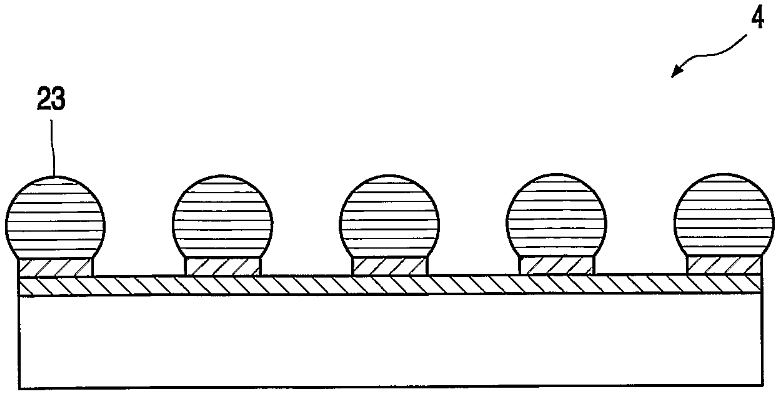


FIG. 3D

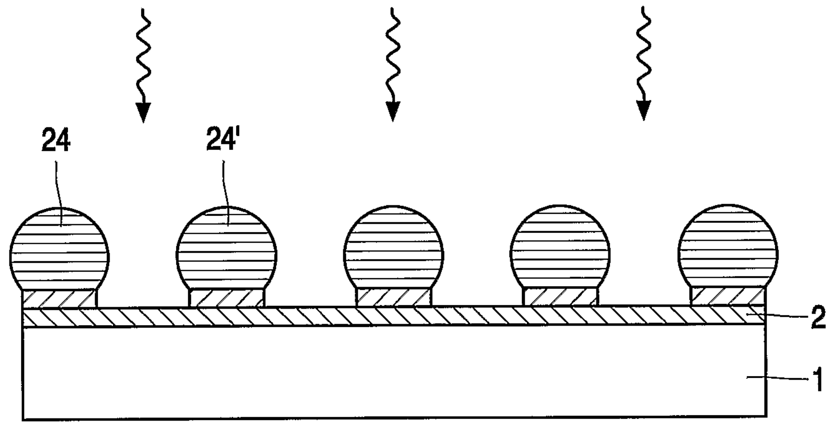


FIG. 3E

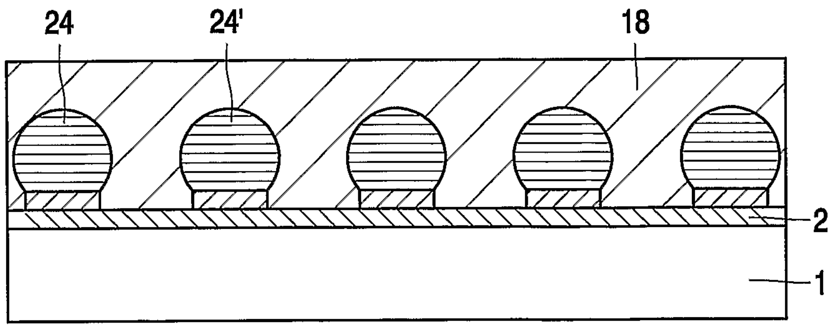


FIG. 3F

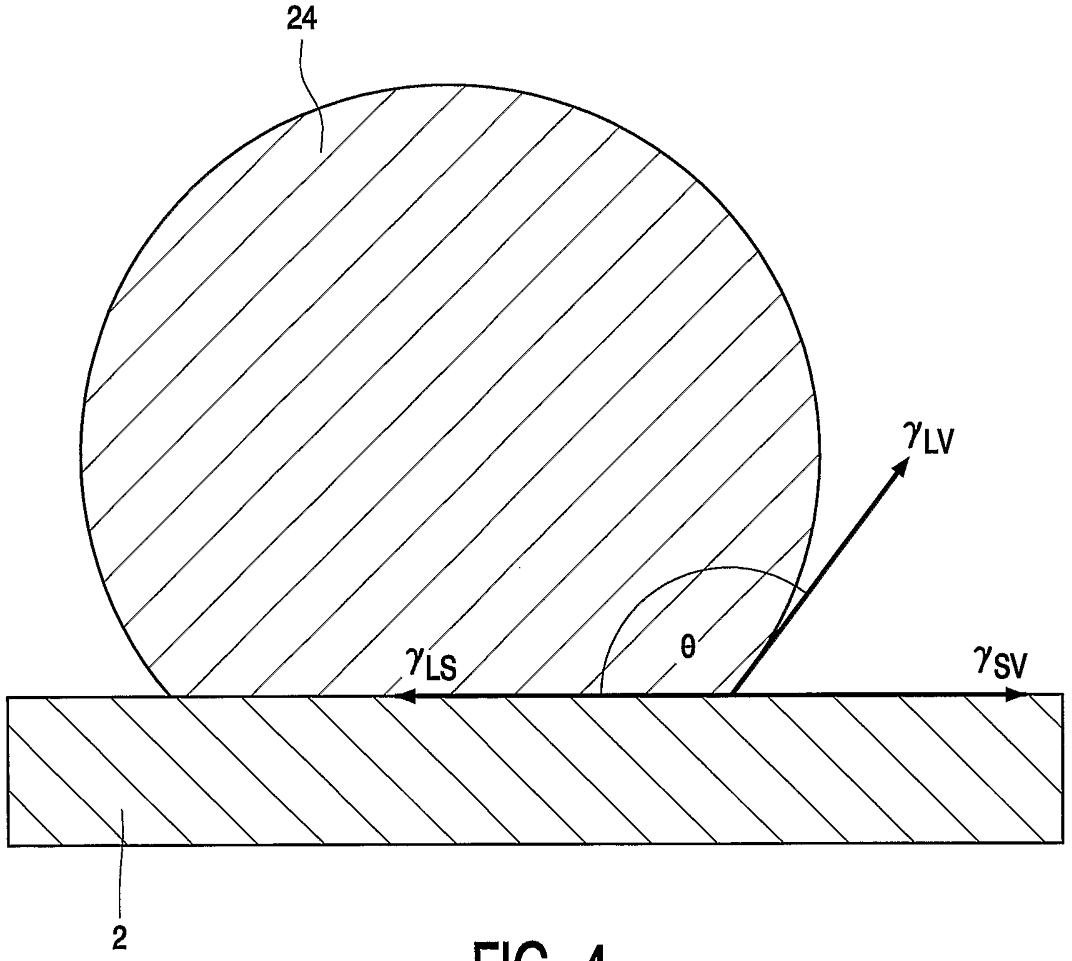


FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 03/05286

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11B7/24 G11B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G11B G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 91/11804 A (DYNO PARTICLES AS) 8 August 1991 (1991-08-08) page 20 - page 21; figure 11 page 19, line 15 - line 15 page 9, line 9 - line 11 page 10, line 16 - line 26 -----	1-8 9-19
Y	WO 01/62400 A (KIBAR OSMAN ; ESENER SADIK (US); HARTMANN DANIEL (US); UNIV CALIFORNIA) 30 August 2001 (2001-08-30) page 18 - page 21; figure 1 page 30 - page 53 page 7 - page 8 page 12, line 27 - page 13, line 30 ----- -/--	9-19

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 May 2004	11/06/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Holubov, C

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 03/05286

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 064 615 A (GUDESEN HANS GUDE) 16 May 2000 (2000-05-16)	1-3,5-8
A	column 3, line 42 - column 4, line 10; figure 1D column 8, line 10 - line 23 column 4, line 52 - line 60; figure 5	9,10,18
X	WO 97/01171 A (GUDESEN HANS GUDE ; NAERINGSRUD THORMOD (NO); NILSEN ROLV MOELL (NO);) 9 January 1997 (1997-01-09)	1-3,7,8
A	abstract	9,10,18
X	WO 97/04448 A (GUDESEN HANS GUDE ; NORDAL PER ERIK (NO); OPTICOM AS (NO)) 6 February 1997 (1997-02-06) abstract	1,3
A	page 6, line 3 - line 16	2
A	WO 99/26240 A (POLAROID CORP) 27 May 1999 (1999-05-27) page 18; figures 18-20b abstract	1,9,10,18
A	WO 97/33275 A (GUDESEN HANS GUDE ; OPTICOM AS (NO)) 12 September 1997 (1997-09-12) page 1, line 28 - page 3, line 21	1,9,10,18
A	US 2002/145807 A1 (NISHIKAWA TAKAO) 10 October 2002 (2002-10-10) abstract paragraph '0034! paragraph '0042! paragraph '0058!; figure 6	9-16
A	WILBUR J L ET AL: "Microcontact printing of self-assembled monolayers: applications in microfabrication" NANOTECHNOLOGY (UK), NANOTECHNOLOGY, DEC. 1996, IOP PUBLISHING, UK, vol. 7, no. 4, 1996, pages 452-457, XP002281473 ISSN: 0957-4484 abstract page 455, column 1	9-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 03/05286

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 9111804	A	08-08-1991	NO	900443	A	01-08-1991
			AT	107068	T	15-06-1994
			AU	7142191	A	21-08-1991
			DE	69102421	D1	14-07-1994
			DE	69102421	T2	29-09-1994
			DK	513062	T3	14-11-1994
			EP	0513062	A1	19-11-1992
			ES	2057861	T3	16-10-1994
			JP	5506530	T	22-09-1993
			LV	11390	A	20-06-1996
			LV	11390	B	20-10-1996
			WO	9111804	A1	08-08-1991
			US	5384764	A	24-01-1995
WO 0162400	A	30-08-2001	AU	3991101	A	03-09-2001
			WO	0162400	A2	30-08-2001
			US	2002027300	A1	07-03-2002
US 6064615	A	16-05-2000	AU	1213897	A	28-07-1997
			EP	0882290	A1	09-12-1998
			NO	982964	A	25-06-1998
			WO	9724715	A1	10-07-1997
WO 9701171	A	09-01-1997	NO	952542	A	27-12-1996
			AT	252269	T	15-11-2003
			AU	702006	B2	11-02-1999
			AU	6321296	A	22-01-1997
			BR	9608964	A	29-06-1999
			CA	2222085	A1	09-01-1997
			CN	1192819	A ,C	09-09-1998
			DE	69630381	D1	20-11-2003
			EP	0834174	A1	08-04-1998
			JP	10510653	T	13-10-1998
			JP	3120286	B2	25-12-2000
			WO	9701171	A1	09-01-1997
			RU	2146397	C1	10-03-2000
			US	6052354	A	18-04-2000
WO 9704448	A	06-02-1997	NO	952855	A	20-01-1997
			AU	698622	B2	05-11-1998
			AU	6634096	A	18-02-1997
			CA	2223638	A1	06-02-1997
			CN	1191034	A	19-08-1998
			EP	0839372	A1	06-05-1998
			JP	11500252	T	06-01-1999
			WO	9704448	A1	06-02-1997
			US	6005817	A	21-12-1999
WO 9926240	A	27-05-1999	US	5910940	A	08-06-1999
			DE	69803604	D1	14-03-2002
			DE	69803604	T2	17-10-2002
			EP	1032937	A1	06-09-2000
			JP	2001523876	T	27-11-2001
			WO	9926240	A1	27-05-1999
			US	6094413	A	25-07-2000
			US	6249507	B1	19-06-2001
			US	6115348	A	05-09-2000

INTERNATIONAL SEARCH REPORT

Information on patent family members

ational Application No

PCT/IB 03/05286

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9733275	A	12-09-1997	NO	960957 A	08-09-1997
			AU	2047197 A	22-09-1997
			WO	9733275 A1	12-09-1997
			US	6418092 B1	09-07-2002
US 2002145807	A1	10-10-2002	JP	2002196106 A	10-07-2002