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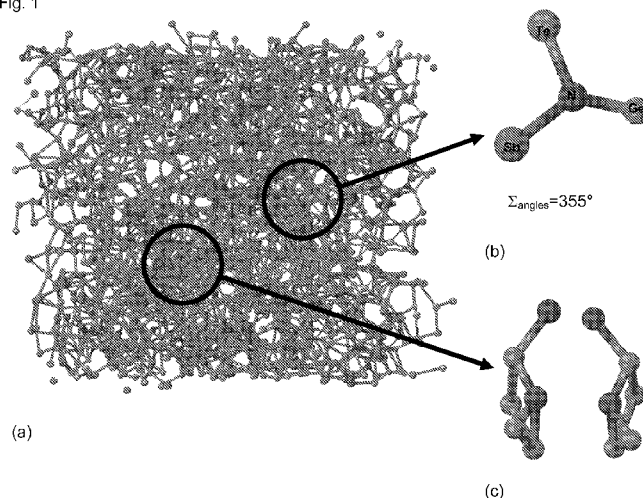
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Fig. 1



(57) Abstract: According to the present invention there is provided a chalcogenide phase change material which can be converted between first and second states, wherein the material comprises a chiral species and wherein at least a portion of the material comprises the chiral species in the form of an enantiomeric excess. Methods of producing and analysing said material, as well as optical recording media and phase change memory devices comprising said material, are also provided.

CHALCOGENIDE PHASE CHANGE MATERIALS AND THEIR USEField of the Invention

- 5 The present invention relates to chalcogenide phase change materials and their use. The materials may find particular use in phase change memory applications, including optical recording media and phase change memory devices.

Background to the Invention

10

Phase change materials may be capable of being reversibly switched between a plurality of states which differ in at least one property that is detectable. For example, a phase change material may be converted between states having different optical reflectivities and/or different electrical resistivities.

15

Chalcogenide phase change materials have been employed in optical recording media, for example rewritable optical discs. Here, a germanium-antimony-tellurium (Ge-Sb-Te; GST) material may be used as the phase change material. GST materials can exist in amorphous and crystalline states having different optical
20 reflectivities. Consequently, data may be recorded by switching the material between an amorphous state and a crystalline state using a laser, thereby changing the reflectivity of the material.

25

Chalcogenide materials such as GST are also utilised in phase change memory (PCM) devices. In addition to having different optical reflectivities, the amorphous state and the crystalline state of GST materials have relatively high and low electrical resistivities respectively. Thus, when incorporated into a phase change memory device, a GST material can be converted between a higher electrical resistance amorphous state and a lower electrical resistance crystalline state by
30 applying a switching current pulse. Data can therefore be recorded by exploiting the difference in resistivity. The crystalline and amorphous states are commonly referred to as SET and RESET states and may be associated with conventional binary bits.

– 2 –

GST materials can consume high currents for the phase transition from the crystalline state to the amorphous state. This high consumption of current has been attributed to the low electrical resistivity of the crystalline state. It has been found that the resistivity of the crystalline state may be increased by including one or more dopants such as nitrogen in the material. The structure of nitrogen-doped GST (N-GST) is described in more detail by, for example, Borisenko *et al* (Chem. Mater., (2009), 21 (21), 5244-5251).

Summary of the Invention

The present invention is based at least in part on a discovery that chalcogenide phase change materials may contain one or more chiral species which can be used to record data in the materials. In particular, data corresponding to the presence or absence of an enantiomeric excess of a chiral species may be recorded in the material.

By way of illustration, and without limitation, an enantiomeric excess may be formed in the material by converting the material from a first state to a second state in the presence of circularly polarised light. If left circularly polarised light is used, then an excess of the left enantiomer may be obtained in the irradiated portion of the material. Similarly, if right circularly polarised light is used, an excess of the right enantiomer may be obtained. In the absence of any circularly polarised light, a racemic form may be obtained. In this way, bits of data corresponding to the left excess, right excess and racemic forms of a chiral species may be recorded in the material. Data may be recorded and retrieved independently from other bits of data that are recorded in the same volume of the material. Consequently, the information storage density of the phase change material may be enhanced.

Accordingly, in a first aspect of the present invention there is provided a chalcogenide phase change material which can be converted between first and second states, wherein the material comprises a chiral species and wherein at least a portion of the material comprises the chiral species in the form of an enantiomeric excess.

– 3 –

In another aspect, the invention provides a method of producing a phase change material, which comprises providing a chalcogenide phase change material which can be converted between first and second states and which comprises a chiral species; and forming an enantiomeric excess of the chiral species in at least a portion of the material.

According to a further aspect of the invention, there is provided a method of analysing a chalcogenide phase change material, wherein the material can be converted between first and second states and comprises a chiral species, and wherein the method comprises detecting the presence or absence of an enantiomeric excess of the chiral species in at least a portion of the material.

In a further aspect, the invention provides an optical recording medium comprising a chalcogenide phase change material which can be converted between first and second states, wherein the material comprises a chiral species and wherein at least a portion of the material comprises the chiral species in the form of an enantiomeric excess.

The invention also provides a phase change memory device comprising a chalcogenide phase change material which can be converted between first and second states, wherein the material comprises a chiral species and wherein at least a portion of the material comprises the chiral species in the form of an enantiomeric excess.

Description of Various Embodiments

The present invention involves the use of a chalcogenide phase change material which can be converted between a first state and a second state.

In an embodiment, the first state is a crystalline state and the second state is an amorphous state. The term "crystalline" as used herein refers to a state in which the phase change material has a more ordered structure or arrangement of atoms, whereas the term "amorphous" refers to a state in which the phase change material has a less ordered structure or arrangement of atoms. It will be appreciated that

– 4 –

the material may be converted between different states of local order across the entire spectrum between completely amorphous and completely crystalline states.

- 5 In an embodiment, the first and second states have different optical reflectivities and/or different electrical resistivities. In an embodiment, the first state is a crystalline state and the second state is an amorphous state, wherein the first and second states have different optical reflectivities and/or different electrical resistivities.
- 10 The chalcogenide material may comprise one or more chalcogen elements, *e.g.* selected from O, S, Se, Te and Po, and one or more electropositive elements, *e.g.* selected from N, Si, Ni, Ga, Ge, As, Ag, In, Sn, Sb, Au, Pb and Bi. The chalcogenide material may be in the form of a binary, ternary, or quaternary alloy.
- 15 Non-limiting examples of chalcogenide materials include Ge-Sb-Te (GST), As-Sb-Te, As-Ge-Sb-Te, Sn-Sb-Te, In-Sb-Te, Ag-In-Sb-Te, Ge-Te, In-Se, Sb-Te, Ga-Sb, In-Sb, As-Te, Al-Te, Ge-Sb-Te, Te-Ge-As, In-Sb-Te, Te-Sn-Se, Ge-Se-Ga, Bi-Se-Sb, Ga-Se-Te, Sn-Sb-Te, In-Sb-Ge, Te-Ge-Sb-S, Te-Ge-Sn-O, Te-Ge-Sn-Au, Pd-Te-Ge-Sn, In-Se-Ti-Co, Ge-Sb-Te-Pd, Ge-Sb-Te-Co, Sb-Te-Bi-Se, Ag-In-Sb-Te, 20 Ge-Sb-Se-Te, Ge-Sn-Sb-Te, Ge-Te-Sn-Ni, Ge-Te-Sn-Pd and Ge-Te-Sn-Pt. It will be appreciated that the hyphenated chemical composition notation used herein indicates the elements included in a particular mixture or compound, and is intended to represent all stoichiometries involving the indicated elements. Moreover, where chalcogenide compounds having particular stoichiometries are 25 specified, the chalcogenide compound may include the same combination of elements having other stoichiometries.

In an embodiment, the phase change material comprises Ge, Sb and Te.

- 30 The phase change material may comprise one or more dopants. In an embodiment, the one or more dopants are selected from Ag, Au, B, C, N, O, Al, Si, P, S, Ga, Se, In, Sn, I, Pb and Bi. In an embodiment, the material comprises one or more dopants, at least one of which is N.

– 5 –

In an embodiment, the phase change material is a chalcogenide material comprising Ge, Sb, Te and one or more dopants. In an embodiment, the one or more dopants are selected from Ag, Au, B, C, N, O, Al, Si, P, S, Ga, Se, In, Sn, I, Pb and Bi. In an embodiment, the material comprises one or more dopants, at least one of which is N.

In an embodiment, the material comprises Ge, Te and Sb in the following amounts (in atomic percent): from about 5% to about 60% Ge; from about 20% to about 70% Te; and from about 5% to about 30% of one or more dopants; with the remainder being Sb (e.g. from about 5% to about 60% Sb). In an embodiment, the atomic percentage of Ge in the material is from about 15% to about 50%, e.g. from about 17% to about 44%, e.g. about 22%. In an embodiment, the atomic percentage of Sb in the material is from about 15% to about 50%, e.g. from about 17% to about 44%, e.g. about 22%. In an embodiment, the atomic percentage of Te in the material is from about 23% to about 56%, e.g. from about 48% to about 56%, e.g. about 55%. In another embodiment, Ge, Sb and Te are present in atomic percentages of about 22%, about 22% and about 55% respectively.

In a particular embodiment, the phase change material comprises a chalcogenide compound of the formula $\text{Ge}_2\text{Sb}_2\text{Te}_5\text{X}_n$, wherein X represents one or more dopants and n is from about 0.1 to about 2. In an embodiment, X represents one or more dopants selected from Ag, Au, B, C, N, O, Al, Si, P, S, Ga, Se, In, Sn, I, Pb and Bi. In a particular embodiment, X is N. In an embodiment, n is from about 1 to about 2, e.g. about 1 or about 2.

The phase change material may be produced in accordance with various techniques known in the art. For instance, the phase change material may be produced by vapour deposition on a suitable substrate. Suitable deposition techniques include physical vapour deposition (PVD), chemical vapour deposition (CVD). Physical vapour deposition techniques include sputtering, evaporation and ionized deposition techniques.

In an embodiment, the phase change material is formed as a layer of material. In an embodiment, the layer has a thickness ranging from about 100 to about 500 nm,

– 6 –

e.g. from about 200 to about 300 nm.

In a particular embodiment, the phase change material is formed as a layer on a substrate. The substrate may be a silicon substrate or another bulk substrate
5 including a layer of semiconductor material. For example, the substrate may be selected from silicon wafers, silicon-on-insulator substrates, silicon-on-sapphire substrates, epitaxial layers of silicon on a base semiconductor foundation, and other semiconductor or optoelectronics materials, such as silicon-germanium, germanium, gallium arsenide, or indium phosphide. The material of the substrate
10 may be doped or undoped. The phase change material may also be formed on another material overlying the substrate, depending on the intended application of the phase change material.

The phase change material comprises a chiral species. In an embodiment, the
15 phase change material comprises a plurality of chiral species. A chiral species may be a chiral molecule or complex, or a chiral fragment, *i.e.* a molecular fragment which can exist in a plurality of non-superimposable forms.

In an embodiment, the material comprises a dopant which forms one or more chiral
20 species in the material. In a particular embodiment, the material is doped with nitrogen such that one or more chiral species are formed in the material.

In an embodiment, the material comprises a chiral species containing a nitrogen atom, wherein the nitrogen atom is bound to three different moieties in a
25 substantially non-planar geometry and comprises a lone pair of electrons. In an embodiment, the nitrogen atom is bound to Ge, Sb and Te in a non-planar geometry. In an embodiment, the sum of the bond angles about the nitrogen atom is less than 360°, e.g. from about 320° to about 355°. In an embodiment, the sum of the bond angles about the nitrogen atom is about 355°.

30 In an embodiment, the material comprises a chiral fragment which can exist in the material in a plurality of non-superimposable forms. For example, a nitrogen-doped chalcogenide material containing Ge may contain a cluster of nitrogen and germanium atoms which can exist in at least two non-superimposable forms.

– 7 –

According to the present invention, data corresponding to the presence or absence of an enantiomeric excess may be recorded in at least a portion of the material. Thus, the material may comprise at least one portion comprising a chiral species which is in the form of an enantiomeric excess. The configuration of an enantiomer may be designated using conventional (*e.g.* *D/L* or *+/-*) terminology.

In an embodiment, at least a portion of the material comprises a chiral species which is present in an enantiomeric excess of at least 60%, *e.g.* at least 65%, *e.g.* at least 70%, *e.g.* at least 75%, *e.g.* at least 80%, *e.g.* at least 85%, *e.g.* at least 90%, *e.g.* at least 95%, *e.g.* at least 99%.

In an embodiment, the material comprises one or more further portions in which the chiral species is present in an excess of a different enantiomer and/or in which an enantiomeric excess of the chiral species is absent. Data corresponding to the absence of an enantiomeric excess may be recorded by forming the chiral species in a racemic form.

In an embodiment, the chiral species is produced in an enantiomeric excess during conversion of the phase change material from the first state to the second state. In particular, an enantiomeric excess may be formed by irradiating at least a portion the material with polarised light, *e.g.* circularly polarised light, during the conversion of the material from the first state to the second state.

For example, where the material is converted from a crystalline state to an amorphous state, application of a pulse of left circularly polarised light to the material during amorphisation may induce formation of an amorphous state having an excess of left chiral species. Similarly, application of right circularly polarised light during amorphisation may induce formation of an amorphous state having an excess of right chiral species. Where amorphisation is performed in the absence of circularly polarised light, a racemic amorphous phase may be formed. In this way, bits of data corresponding to the left excess, right excess and racemic forms of the chiral species may be recorded in the material.

– 8 –

In an embodiment, at least a portion of the material is irradiated with circularly polarised laser light. Circularly polarised light may be generated using techniques known in the art, for example using a Babinet-Soleil prism. In an embodiment, the circularly polarised light has a wavelength of from about 400 to about 750 nm and a power of from about 10 to about 25 mW. In an embodiment, the portion of the material is irradiated with laser light having a wavelength of about 680 nm and a power of about 16 mW. In an embodiment, the material is irradiated with circularly polarised light for a period of from about 10 to about 500 ns, *e.g.* from about 100 to about 300 ns.

Where polarised light is used to effect the formation of an enantiomeric excess, irradiation of the material with the polarised light may be sufficient to convert the material from the first state to the second state. Alternatively, the material may be further treated in order to effect the conversion of the material from the first state to the second state. Typically, conversion of the material from the first state to the second state will be achieved by appropriate heating and, where necessary, cooling of the material. For instance, laser light can be directed to the phase change material, a current may be driven through the phase change material, or a current may be fed through a resistive heater adjacent the phase change material.

The presence or absence of an enantiomeric excess in the material may be determined in accordance with techniques known in the art. For instance, spectroscopic techniques such as circular dichroism spectroscopy may be used in order to determine whether an enantiomeric excess or a racemic form of the chiral species is present. A circular dichroism spectrum may be obtained in which the absorption of the material is plotted against the wavelength of the circularly polarised light.

In an embodiment, data are read by irradiating at least a portion of the material with circularly polarised light and determining the circular dichroism of the irradiated portion. For example, circularly polarised laser light having a wavelength of from about 500 to about 750 nm, *e.g.* from about 640 to about 650 nm, may be used in order to detect the presence or absence of an enantiomeric excess.

– 9 –

The phase change materials of the present invention may be used in various phase change memory applications.

- In particular, the materials may be useful in optical recording media. Accordingly,
- 5 there is provided an optical recording medium comprising a chalcogenide phase change material which can be converted between first and second states, wherein the material comprises a chiral species and wherein at least a portion of the material comprises the chiral species in the form of an enantiomeric excess.
- 10 In an embodiment, the optical storage medium is in the form of an optical disc. The disc may be, for example, a write once disc or a rewritable disc. Optical discs may be manufactured in accordance with techniques known in the art.
- In an embodiment, the optical disc comprises a plurality of layers, at least one of
- 15 which contains a phase change material according to the present invention. The optical disc may also comprise one or more layers, for example selected from recording layers, reflecting layers, transparent layers, spacer layers, dielectric layers, protecting layers and outer covering layers.
- 20 In an embodiment, the optical disc has a diameter of about 10 to about 500 mm. In an embodiment, the optical disc has a diameter of about 120 mm. In an embodiment, the optical disc has a thickness of from about 0.5 to about 5 mm, *e.g.* from about 0.6 to about 1.2 mm.
- 25 Especially where the phase change material is used in an optical disc, the first and second states of the phase change material preferably differ in at least one optical property, for example selected from optical reflectivity, optical transmissivity, optical absorption and optical refraction. In this way, further bits of data corresponding to a difference in an optical property between the first and second states may also be
- 30 recorded in the phase change material. In a particular embodiment, the first and second states have different optical reflectivities.

The phase change materials may also be employed in phase change memory devices.

– 10 –

Accordingly, there is also provided a phase change memory device comprising a chalcogenide phase change material which can be converted between first and second states, wherein the material comprises a chiral species and wherein at least a portion of the material comprises the chiral species in the form of an enantiomeric excess. The device may be manufactured in accordance with techniques known in the art.

In an embodiment, the phase change material is in electrical contact with first and second electrodes. In an embodiment, the phase change material is interposed between the first and second electrode.

Suitable electrode materials are known in the art. For example, the first and second electrodes may comprise a conductive material containing one or more of nitrogen, carbon, titanium, tungsten, molybdenum and tantalum. Exemplary electrode materials include aluminium, aluminium-copper, aluminium-copper-silicon, tungsten silicide, copper, tungsten titanium, titanium nitride, tantalum nitride, molybdenum nitride, niobium nitride, titanium silicon nitride, titanium aluminium nitride, titanium boron nitride, zirconium silicon nitride, tungsten silicon nitride, tungsten boron nitride, silicon aluminium nitride, molybdenum silicon nitride, molybdenum aluminium nitride, tantalum silicon nitride, tantalum aluminium nitride, titanium oxide nitride, titanium aluminium oxide nitride, tungsten oxide nitride and tantalum oxide nitride.

In order to convert the phase change material from the first state to the second state, a current may be applied to heat up a contact region between the phase change material and one of the electrodes. In the case of a chalcogenide material such as GST, application of a high current pulse may cause the material to be heated to a temperature above its melting point, causing at least a portion of the phase change material to convert from its crystalline state to the amorphous state.

The portion of the phase change material converted from a crystalline state to an amorphous state corresponds to the contact region. The phase change material may remain in the amorphous state until a low current pulse is applied of sufficient duration to convert the phase change material to the crystalline state. In particular, a current density of from approximately 1×10^5 A/cm² to approximately 1×10^7 A/cm²

– 11 –

may be used to switch the phase change material between the amorphous and crystalline states in the contact region. By way of example, the phase change material may be switched from the amorphous state to the crystalline state in an amount of time ranging from approximately 50 ns to approximately 500 ns. The
5 phase change material may, for example, be switched from the crystalline state to the amorphous state in an amount of time ranging from approximately 5 ns to approximately 100 ns.

10 In an embodiment, the device comprises means for forming an enantiomeric excess in at least a portion of the material. For example, the device may comprise means for irradiating the material with a source of polarised light, e.g. circularly polarised light. In an embodiment, the device comprises means for irradiating the material with a source of polarised laser light, e.g. circularly polarised laser light. In an embodiment, the device comprises a source of laser light and a Babinet-Soleil
15 prism.

In an embodiment, the device comprises means for detecting the presence or absence of an enantiomeric excess in at least a portion of the phase change material. In an embodiment, the device comprises means for irradiating the
20 material with circularly polarised light and means for determining the circular dichroism of the material. In an embodiment, the device comprises a source of laser light and a Babinet-Soleil prism.

The device may also comprise means for determining one or more additional
25 properties of the phase change material. Thus, for example, where the first and second states exhibit different electrical resistivities, the device may comprise means for determining the electrical resistivity (or conductivity) of at least a portion of the material. By way of illustration, data may be read by applying a potential below a threshold value such that the resistivity of the phase change material is
30 substantially unchanged. The resistivity of the material, and thus the associated data value, can then be determined.

The following non-limiting Examples illustrate the present invention.

– 12 –

Example 1

Figure 1a depicts the atomic structure of a thin film of nitrogen-doped $\text{Ge}_2\text{Sb}_2\text{Te}_5$ as determined by reverse Monte Carlo refinement based on experimental electron
5 diffraction reduced density functions and density functional theory molecular dynamics simulations.

Figures 1b and 1c are exploded views depicting chiral species located within the atomic structure of Figure 1a. As can be seen from Figure 1b, the material
10 contains a chiral species in which a nitrogen atom is bound to Ge, Sb and Te in a non-planar geometry (in this case the sum of the bond angles is approximately 355°). Moreover, it can be seen from Figure 1c that the material contains non-superimposable fragments of nitrogen and germanium atoms (shown as dark and light atoms respectively).

Example 2

A 100 nm thin film of nitrogen-doped $\text{Ge}_2\text{Sb}_2\text{Te}_5$ is produced on a $\text{SiO}_2/\text{Si}(100)$ substrate using a conventional DC magnetron sputtering method.

Circularly polarised light is produced using a laser and a Babinet-Soleil prism. The light has a wavelength of 680 nm and a power of up to 16 mW. Application of a pulse of left circularly polarised light to the crystalline material induces formation of an amorphous phase with an excess of left chiral species. Similarly, application of
25 right circularly polarised light during amorphisation leads to an excess of right chiral species. The absence of any polarisation in the laser light leads to formation of a racemic amorphous phase. In this way, amorphous left excess (L), amorphous right excess (R) and amorphous racemic (RC) bits are recorded in the material, together with conventional binary (0 and 1) bits corresponding to the crystalline and
30 amorphous states.

The L, R and RC bits of data are read by determining the circular dichroism of the material. Circularly polarised laser light having a wavelength of 643 nm is used and the absorption coefficients determined. The 0 and 1 bits of data are read by

– 13 –

measuring the optical reflectivity of the material.

5 It will be understood that the present invention has been described above purely by way of example, and modification of detail can be made within the scope of the invention. Each feature disclosed in the description, and where appropriate the claims and drawings may be provided independently or in any appropriate combination.

– 14 –

CLAIMS

1. A chalcogenide phase change material which can be converted between first and second states, wherein the material comprises a chiral species and wherein at least
5 a portion of the material comprises the chiral species in the form of an enantiomeric excess.
2. A material according to claim 1, wherein the first state is a crystalline state and the second state is an amorphous state.
10
3. A material according to claim 2, wherein at least said portion of the material is in the second state.
4. A material according to claim any preceding claim, wherein the first and second
15 states have different resistivities and/or reflectivities.
5. A material according to any preceding claim, wherein the material comprises Ge, Sb and Te.
- 20 6. A material according to any preceding claim, wherein the material comprises a dopant.
7. A material according to claim 6, wherein the dopant forms one or more chiral species in the material.
25
8. A material according to claim 6 or claim 7, wherein the material comprises a compound of the formula $\text{Ge}_2\text{Sb}_2\text{Te}_5\text{X}_n$, wherein X represents one or more dopants selected from Ag, Au, B, C, N, O, Al, Si, P, S, Ga, Se, In, Sn, I, Pb and Bi; and n is from about 0.1 to about 2.
30
9. A material according to claim 8, wherein X is N.
10. A material according to any preceding claim, wherein the chiral species is

– 15 –

present in said portion in an enantiomeric excess of at least 95%.

11. A material according to any preceding claim, wherein the material comprises a further portion in which the chiral species is present in a racemic form or in the form of an excess of a different enantiomer.

12. A method of producing a phase change material, which comprises providing a chalcogenide phase change material which can be converted between first and second states and which comprises a chiral species; and forming an enantiomeric excess of the chiral species in at least a portion of the material.

13. A method according to claim 12, wherein the method comprises converting at least a portion of the material from the first state to the second state under conditions such that the chiral species is formed in an enantiomeric excess in at least said portion.

14. A method according to claim 12 or claim 13, wherein the method comprises irradiating at least said portion of the material with circularly polarised light.

15. A method according to any of claims 12 to 14, wherein the chiral species is formed in an enantiomeric excess of at least 95%.

16. A method according to any of claims 12 to 15, wherein the method further comprises forming a racemic form or an excess of a different enantiomer of the chiral species in a further portion of the material.

17. A method according to any of claims 12 to 16, wherein the material is as defined in any of claims 2 to 9.

18. A method of analysing a chalcogenide phase change material, wherein the material can be converted between first and second states and comprises a chiral species, and wherein the method comprises detecting the presence or absence of an enantiomeric excess of the chiral species in at least a portion of the material.

– 16 –

19. A method according to claim 18, wherein the presence or absence of an enantiomeric excess is detected by determining the circular dichroism of at least said portion of the material.

5 20. A method according to claim 18 or claim 19, wherein the material is as defined in any of claims 2 to 11.

21. A method according to any of claims 18 to 20, wherein the first and second states have different optical reflectivities and/or electrical resistivities and wherein the
10 method further comprises determining the optical reflectivity and/or the electrical resistivity of at least a portion of the material.

22. An optical recording medium comprising a chalcogenide phase change material which can be converted between first and second states, wherein the material comprises
15 a chiral species and wherein at least a portion of the material comprises the chiral species in the form of an enantiomeric excess.

23. A medium according to claim 22, wherein the medium is in the form of an optical disc.
20

24. A medium according to claim 22 or claim 23, wherein the phase change material is as defined in any of claims 2 to 11.

25. A phase change memory device comprising a chalcogenide phase change material which can be converted between first and second states, wherein the material
25 comprises a chiral species and wherein at least a portion of the material comprises the chiral species in the form of an enantiomeric excess.

26. A device according to claim 25, wherein the phase change material is in
30 electrical contact with first and second electrodes.

27. A device according to claim 25 or claim 26, wherein the phase change material is as defined in any of claims 2 to 11.

– 17 –

28. Use of a phase change material of any of claims 1 to 11, as a recording medium.

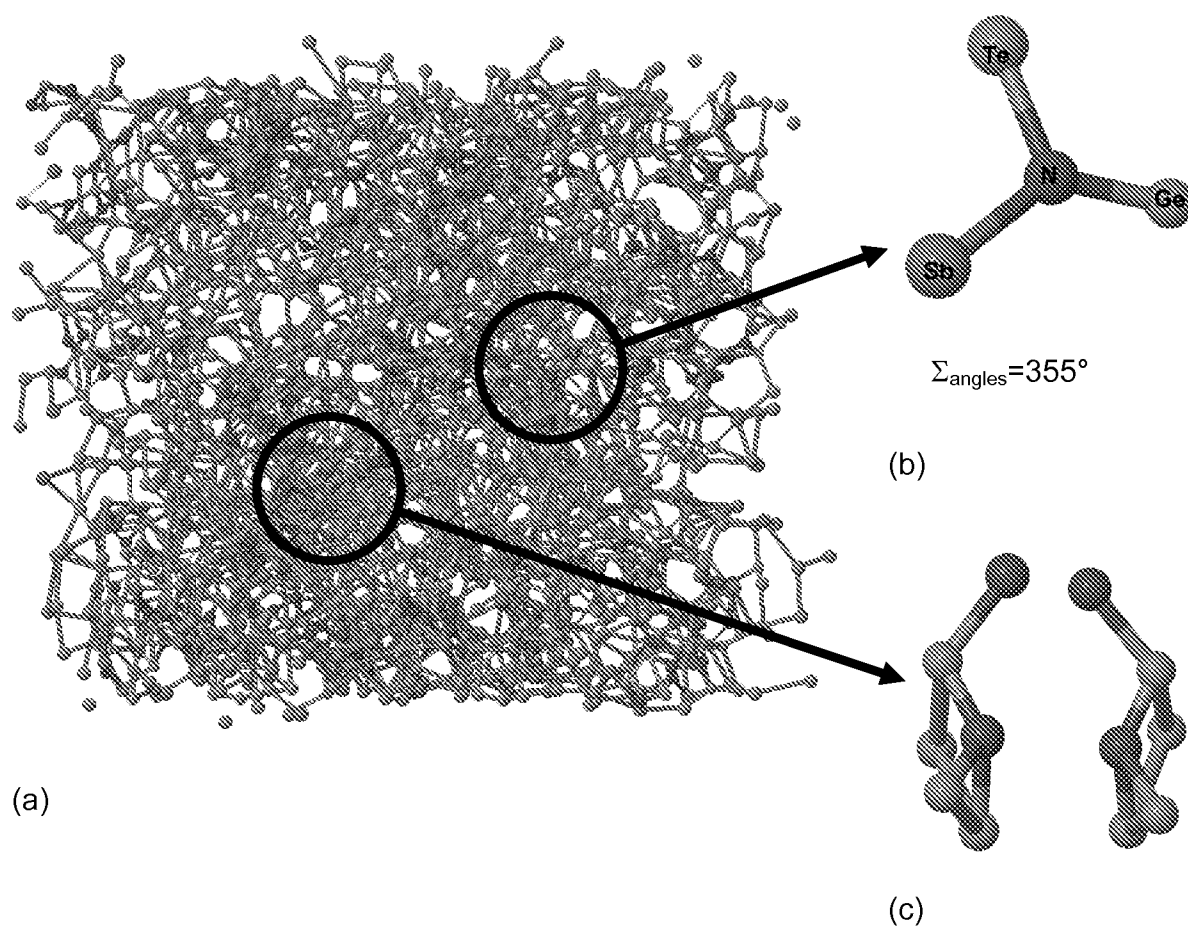


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2011/050555

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01L45/00 G11B7/243 G11C13/00 G11B7/0045
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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)

H01L G11B G11C

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)

EP0-Internal, WPI Data, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	MEISTER S ET AL: "Synthesis and Characterization of Phase-Change Nanowires", NANO LETTERS, vol. 6, no. 7, 17 June 2006 (2006-06-17), pages 1514-1517, XP55002474, ISSN: 1530-6984, DOI: 10.1021/nl061102b	18
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Y	----- US 7 405 420 B1 (WONG H S PHILIP ET AL) 29 July 2008 (2008-07-29) column 4, line 24 - column 8, line 26; figures 1-5 ----- -/--	21



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

11 July 2011

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2011/050555

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	----- WO 01/45111 A1 (POLIGHT TECHNOLOGIES LTD; ELLIOTT STEPHEN ET AL) 21 June 2001 (2001-06-21) page 7, line 9 - page 8, line 23 page 12, line 1 - page 22, line 3; figures 3-5 -----	1,12,14, 18,19,22

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Information on patent family members

International application No

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