

METHOD OF FABRICATION OF A MAGNETIC STRUCTURE AND MAGNETIC STRUCTURE

FIELD OF INVENTION

5 The present invention relates broadly to a method of fabrication of a magnetic structure and to a magnetic structure.

BACKGROUND

10 There is an ongoing demand for providing devices and methods for magnetic treatment for enhancing sports and physical performance & increase muscle strength as well as for relief from ailments such as chronic aches and pain or injuries or post-surgery recovery or illnesses, and in a manner that is non-intrusive, that is comfortable, and that does not inhibit a person's activities, and for magnetic treatment of perishable objects such as food items or drinks, e.g. for food preservation, wine & beverage enhancement.

15 While several devices and method have been proposed, there remains a need for improvements in the fabrication of magnetic structures to provide magnetic structures of desired properties, e.g. in terms of one or more of the magnetic strength, the size, the thickness, the mechanical properties etc.

Embodiments of the present invention provide a method of fabrication of a magnetic structure and a magnetic structure that seek to address that need.

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SUMMARY

25 In accordance with a first aspect of the present invention there is provided a method of fabricating a magnetic material structure comprising the steps of breaking at least one single piece of magnetic material into a plurality of fragments; inhibiting lateral movement of the plurality of fragments with respect to each other during the breaking of the magnetic material; forming an intermediate structure comprising the fragments of the magnetic material, wherein lateral movement of the plurality of fragments with respect to each other is substantially inhibited in the formed intermediate structure; placing the intermediate structure and a curable material into a container such that the intermediate structure is supported by, and conforms to, a support surface of the container; and curing the curable material while being disposed in the container to form the magnetic material structure.

35 In accordance with a second aspect of the present invention there is provided a magnetic material structure comprising an intermediate structure comprising fragments of at least one single piece of magnetic material, wherein lateral movement of the plurality of fragments with respect to each other is inhibited; and a cured

curable material encapsulating the intermediate structure; wherein the intermediate structure conforms to a support surface of the magnetic material structure.

BRIEF DESCRIPTION OF THE DRAWINGS

- 5 Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Figures 1(a) to (c) illustrate a stage 1 fabrication process according to an example embodiment.

- 10 Figures 2(a) to (d) illustrate an alternative stage 1 fabrication process according to an example embodiment.

Figures 3(a) and (b) illustrate a stage 2 fabrication process according to an example embodiment.

- 15 Figures 4(a) and (b) illustrate an alternative stage 2 fabrication process according to an example embodiment.

Figure 5 shows a flowchart illustrating a method of fabricating a magnetic material structure according to an example embodiment.

DETAILED DESCRIPTION

- 20 Embodiments of the present invention relate to a method of fabrication of a magnetic structure and to a magnetic structure providing improvements in the fabrication of magnetic structures with desired properties, e.g. in terms of one or more of the magnetic strength, the size, the thickness, the mechanical properties etc.

- 25 Figures 1 to 4 show schematic drawings illustrating methods of fabricating a magnetic structure and magnetic structures according to example embodiments, for use in devices and methods for magnetic treatment.

- 30 Figures 1(a) to (c) illustrate a stage 1 fabrication process according to an example embodiment. As shown in Figure 1(a), a fixture element in the form of two adhesive sheet portions 101 is attached onto a single piece 100 of magnetic material. The piece 100 of magnetic material is disposed between the two adhesive sheet portions 101, as shown in Figure 1(a). The adhesive sheet portions 101 are attached along opposing surfaces of the magnetic material. Preferably, the magnetic material is in an unmagnetized state during the stage 1 process steps.

The adhesive sheet portions 101 comprise two separate strips/pieces of elastic adhesive that are each stretched in this embodiment, thereby binding the magnetic material. As a result a compressive force is exerted on the magnetic material. However, it will be appreciated that other types of fixture elements and other methods of applying the fixture elements can be used, as long as lateral movement of the magnetic material fragments 104 (Figure 1(c)) with respect to each other is inhibited. For example, a single elastic adhesive may be stretched and may be wound around the opposing surfaces of the magnetic material.

A pair of co-operating punches 102a, b is used in this embodiment to physically break the piece of magnetic material into a plurality of adjoining magnet fragments, as shown in Figure 1(b). The punches 102a, b each comprise a plurality of protrusions (not resolved in Figure 1(b)) on respective leading surfaces 105a, b. The punches 102a, b are advanced relative to each other so as to move towards the magnetic material and to apply a force onto the magnetic material to break the magnetic material. The punches 102a, b are retracted relative to each other after the piece of magnetic material is broken, forming a plurality 103 of adjoining magnet fragments 104, as shown in Figure 1(c).

It is noted that the relative lateral movement of the punches 102a, b may be effected by lateral movement of only one of the punches, e.g. the upper punch 102a. However it will be appreciated that in different embodiments, the bottom punch 102b and/or both punches 102a, b may be moved to effect the relative lateral movement to apply a force onto the magnetic material to break the magnetic material into the plurality 103 of adjoining magnet fragments 104. Furthermore, while both punches 102a, b have protrusions formed on the respective leading surfaces 105a, b in this example, only one of the punches 102a, b may have protrusions formed thereon, the other having a substantially flat counter or support surface. Further, it will be appreciated that instead of having protrusions on the leading surface, the punch 102a and/or the punch 102b can have other geometries and configurations, as long as the punch can break the magnetic material into the plurality 103 of magnet fragments 104. Also, other techniques for applying horizontal, lateral and/or bending stresses to fragment the magnetic material may be applied in different embodiments.

Therefore, a first intermediate magnetic structure 106 comprising the plurality 103 of adjoining magnet fragments 104 is obtained. Lateral movement of the magnet fragments 104 with respect to each other during the breaking of the magnetic material and in the first intermediate magnetic structure is inhibited by the adhesive sheet portions 101.

The piece of magnetic material is shown to be disk-shaped in this example. It will be appreciated that the piece of magnetic material can be of other shapes, e.g. square, circular, rectangular etc., depending on design requirements.

Figures 2(a) to (d) illustrate an alternative stage 1 fabrication process according to an example embodiment. As shown in Figure 2(a), a fixture element in the form of two adhesive sheet portions 201 is attached onto two or more pieces 203a,b of magnetic material. The piece 203a, b of magnetic material are disposed between the two adhesive sheet portions 201, as shown in Figure 2(a). The adhesive sheet portions 201 are attached along opposing respective surfaces of the pieces 203a, b of magnetic material. Preferably, the magnetic material is in an un-magnetized state during the stage 1 process steps.

The adhesive sheet portions 201 comprise two separate strips/pieces of elastic adhesive that are each stretched in this embodiment, thereby binding the respective pieces 203a, b of magnetic material. As a result a compressive force is exerted on the respective pieces 203a, b of magnetic material. However, it will be appreciated that other types of fixture elements and other methods of applying the fixture elements can be used, as long as lateral movement of the magnetic material fragments 204a, b (Figure 2(c)) with respect to each other is inhibited. For example, a single elastic adhesive may be stretched and may be wound around the opposing surfaces of the magnetic material.

A pair of co-operating punches 202a, b is used in this embodiment to physically break the pieces 203a, b of magnetic material into respective pluralities of adjoining magnet fragments, as shown in Figure 2(b). The punches 202a, b each comprise a plurality of protrusions (not resolved in Figure 2(b)) on respective leading surfaces 207a, b. The punches 202a, b are advanced relative to each other so as to move towards the respective pieces 203a, b of magnetic material and to apply a force onto the pieces 203a, b of magnetic material to break each piece 203a, b of magnetic material. The punches 202a, b are retracted relative to each other after the pieces 203a, b of magnetic material are broken, forming respective broken pieces 205a, b of adjoining magnet fragments 204a, b, as shown in Figure 2(c).

Preferably, the fixture element, here in the form of the two adhesive sheet portions 201 inhibits the lateral movement of fragments within each broken piece 205a, b of adjoining magnet fragments 204a, b, and inhibits lateral movement of the broken pieces 205a, b relative to each other.

It is noted that the relative lateral movement of the punches 202a, b may be effected by lateral movement of only one of the punches, e.g. the upper punch 202a. However it will be appreciated that in different embodiments, the bottom punch 202b and/or both punches 202a, b may be moved to effect the relative lateral movement to apply a force onto the pieces 203a, b of magnetic material to break the pieces 203a, b of magnetic material into the broken pieces 205a, b. Furthermore, while both punches 202a, b have protrusions formed on the respective leading surfaces 207a, b in this example, only one of the punches 202a, b may have protrusions formed thereon, the other having a substantially flat counter or support surface. Further, it will be

appreciated that instead of having protrusions on the leading surface, the punch 202a and/or the punch 202b can have other geometries and configurations, as long as the punch can break the pieces 203a, b of magnetic material into the broken pieces 205a, b. Also, other techniques for applying horizontal, lateral and/or bending stresses to fragment the magnetic material may be applied in different embodiments.

Therefore, a second intermediate magnetic structure 206 comprising the broken pieces 205a, b connected by the fixture element inhibiting lateral movement of the fragments, here in the form of the adhesive sheet portions 201, is obtained. The second intermediate magnetic structure 206 advantageously exhibits an inherent mechanical flexibility due to the interconnecting fixture element portions e.g. between the broken pieces 205a, b of magnetic material. In other words, for a same or similar overall dimension/shape of the second intermediate magnetic structure 206 (Figure 1(c)) and the first intermediate magnetic structure 106, a mechanically flexible design can be provided with substantially the same or similar amount of magnetic material, i.e. with substantially the same or similar magnetic interference strength (after magnetization). This can advantageously improve incorporation into various magnetic devices such as wearable device such as wrist bands or straps, knee bands or straps, shoulder bands or straps, leg bands or straps, and ankle bands or straps, where mechanical flexibility may be desired for avoiding breakage, and/or for conforming to the user's body, which may improve comfort and/or effectiveness of the device.

Optionally, a cutting blade 208 (or other suitable cutting device) is used to cut the second intermediate magnetic structure 206 into a third intermediate magnetic structure 210 comprising the group of separated broken pieces 205a, b of magnetic material, with lateral movement of fragments in each separated broken piece 205a, b continued to be inhibited. The third intermediate magnetic structure 210 can be used for fabrication of magnetic structures with high mechanical flexibility and high flexibility of overall shape and dimensions. This can advantageously improve incorporation into various magnetic devices such as wearable device such as wrist bands or straps, knee bands or straps, shoulder bands or straps, leg bands or straps, and ankle bands or straps, where mechanical flexibility and flexibility in overall shape and dimensions may be desired for avoiding breakage, and/or for conforming to the user's body, which may improve comfort and/or effectiveness of the device.

The pieces 203a, b are shown to be rectangular in this example. It will be appreciated that the pieces 203a, b can be of other shapes, e.g. square, circular, disk-shaped etc., depending on design requirements.

In the above described stage 1 processes, the fixture element, here in the form of the adhesive sheet portions 101, 201, serves to inhibit lateral movement of the magnet fragments by exerting a compressive force to hold the magnet fragments 104, 204a, b in place with respect to each other. Preferably, the magnetic material is in an un-

magnetized state during the stage 1 processes described above, which advantageously avoids any magnetic repulsive forces between the magnet fragments 104, 204a, b. The magnet fragments 104, 204a, b are in practice spaced adjacent to each other with a small separation gap defining a boundary between adjoining magnet fragments 104, 204a, b to produce a magnetic field created by magnetic interference. Further, the adhesive sheet portions 101, 201 are preferably sufficiently deformable such that the adhesive sheet portions 101, 201 are not or not substantially broken when force is applied to break the pieces of magnetic material. The adhesive sheet portions 101, 201 can be, for example, cellophane tape or polyethylene tape. In the above description, adhesive sheet portions 101, 201 are provided on the bottom and top of the pieces of magnetic material, however, it will be appreciated that a single adhesive sheet can be attached along at least one surface of the piece of magnetic material, as long as the plurality of magnet fragments 104, 204a, b can be held securely such that relative lateral movement of the magnet fragments 104, 204a, b is inhibited, thereby maintaining small gaps between the adjoining magnet fragments 104, 204a, b.

By keeping the plurality of magnet fragments 104, 204a, b adjacent to each other with small gaps between adjoining magnet fragments 104, 204a, b, the magnetic interference created by the adjoining magnet fragments 104, 204a, b is intensified.

The magnetic material may comprise, for example, a magnetic plate or may be provided as a magnetic material film coated on a solid substrate. For example, a coated magnetic film on the surface of a solid substrate such as plastics or non-magnetic metals may be used.

The magnetic material can be made of materials comprising, for example, one or more of a group consisting of ferrite, ceramics, samarium cobalt, or neodymium. The intensity of magnetic interference created between the magnet fragments 104, 204a, b depends on several factors and can be generally represented by the following equation:

$$\text{Intensity of magnetic interference} = f(B_1^2, L, g^{-2}, D^{-2}) \quad (1)$$

where

B_1 is the average magnetic flux density of the magnet fragments 104, 204a, b [Gauss];

L is the total length of the boundary between the magnet fragments 104, 204a, b [m];

g is the average gap distance between the magnet fragments 104, 204a, b [m], where $g \neq 0$; and

D is the perpendicular distance from a surface plane of the magnet fragments 104, 204a, b [m], $D \neq 0$.

From the above equation (1), it is observed that at a given perpendicular distance (D) from a surface plane of the magnet fragments 104, 204a, b, the intensity of magnetic interference is proportional to the length of the boundary between the magnet fragments 104, 204a, b (L) and the square of the average magnetic flux density (B_1) of the magnet fragments 104, 204a, b. However, the intensity of magnetic interference is inversely proportional to the square of the average gap distance (g) between the magnet fragments 104, 204a, b.

Referring to equation (1) (and assuming that all other factors, B_1 , L and D are kept constant) it is observed that when the gap distance between adjoining magnet fragments 104, 204a, b is decreased, the intensity of the magnetic interference is increased as the magnetic interference intensity is inversely proportional to the square of the gap distance (g). Therefore, the gap distance between adjoining magnet fragments 104, 204a, b is preferably maintained as small as possible to achieve magnetic interference of a greater intensity.

The separation gaps between the magnet fragments 104, 204a, b can, for example, be in the range of about 0.01mm to about 1.00mm. This advantageously creates a substantially intensified magnetic interference.

Since increasing the intensity of magnetic interference increases the strength of the magnetic field, the size and/or the number of magnets required to achieve a desired magnetic field strength is reduced. This in turn can preferably reduce the total weight and cost of the device.

Figures 3(a) and (b) illustrate a stage 2 fabrication process according to an example embodiment. The stage 2 process is illustrated in Figures 3(a) and (b) with the first intermediate magnetic structure 106 being used. However, the stage 2 fabrication process can be equally applied using the second intermediate magnetic structure 206, or the third intermediate structure 210.

The first intermediate magnetic structure 106 is placed into a mould container 300 and sealed with epoxy resin(s) or other suitable plastic material(s) 302 and allowed to cure, forming a magnetic structure 304 comprising the intermediate magnetic structure 106, the cured epoxy resin(s) or other suitable plastic material(s) 302, and the container 300. The container is preferably made of plastic, e.g. from Polystyrene (PS), Polycarbonates (PC), Polypropylene (PP) or Polyethylene (PE). The curing time can take between about 20 mins to 4 hours. In particular, the first intermediate magnetic structure 106 is placed into the mould container 300 such that the first intermediate structure 106 is supported by a bottom surface 305 of the container 300 and sealed with the epoxy resin(s) or other suitable plastic material(s) 302.

While in the embodiment shown in Figures 3(a) and (b) the bottom surface 305 is substantially flat, it will be appreciated that the bottom surface can have a different shape including, but not limited to, an arc shape or a dome shape. The first

intermediate structure 106, due to a degree of flexibility preferably provided by the fixture element, e.g. in the form of two adhesive sheet portions 101 (Figure 1), advantageously conforms to the shape of the bottom surface 305 under gravitational force and/or under the weight of the epoxy resin(s) or other suitable plastic material(s) 302 during the sealing. This advantageously enables that the intermediate structure being used can be incorporated in the formed magnetic structure 304 in a desired shape (e.g. flat, arc shape, or dome shape), which can achieve a desired magnetic strength and/or shape of the magnetic interference field generated by the magnetic structure 304.

As mentioned above, the stage 2 process can be equally applied using the second intermediate magnetic structure 206, or the third intermediate structure 210 thus forming a magnetic structure comprising the second intermediate magnetic structure 206, the cured epoxy resin(s) other suitable plastic material(s) 302, and the container 300, or comprising the third intermediate magnetic structures 210, the cured epoxy resin(s) other suitable plastic material(s) 302, and the container 300. When the third intermediate structure 210 is used, the separated broken pieces 205a, b are preferably placed at a lateral distance from each other chosen to achieve a desired magnetic strength and/or mechanical property of the formed magnetic material structure 304.

The container 300 is shown to be cylindrical in this example. It will be appreciated that the container can be of other shapes, e.g. cubic or cuboid, depending on design requirements.

Figures 4(a) and (b) illustrate an alternative stage 2 fabrication process according to an example embodiment. The stage 2 process is illustrated in Figures 4(a) and (b) with the first intermediate magnetic structure 106 being used. However, the stage 2 fabrication process can be equally applied using the second intermediate magnetic structure 206, or the third intermediate structure 210.

The first intermediate magnetic structure 106 is placed into a mould container 400 and sealed with an injection molding plastic material(s) 402 and allowed to cure. In this example, the mould container material and the injection molding plastic material(s) are chosen such that the cured material 402 can be removed from the mould container, forming a magnetic structure 404 comprising the intermediate magnetic structure 106 and the cured injection molding plastic material(s) 402. The container is preferably made from a solid material for easy removal of the magnetic structure after curing of the injection molding plastic material(s) 402, e.g. from a metal such as steel. The injection molding plastic material(s) may be Polystyrene (PS), Polycarbonates (PC), Polypropylene (PP) or Polyethylene (PE). The curing time can be within a few seconds. In particular, the first intermediate magnetic structure 106 is placed into the mould container 400 such that the first intermediate structure 106 is supported by a bottom surface 405 of the container 400 and sealed with the injection molding plastic material(s) 402.

While in the embodiment shown in Figures 4(a) and (b) the bottom surface 405 is substantially flat, it will be appreciated that the bottom surface can have a different shape including, but not limited to, an arc shape or a dome shape. The first intermediate structure 106, due to a degree of flexibility preferably provided by the fixture element, e.g. in the form of two adhesive sheet portions 101 (Figure 1), advantageously conforms to the shape of the bottom surface 405, under gravitational force and/or under the weight of the injection molding plastic material(s) 402 during the sealing. This advantageously enables that the intermediate structure being used can be incorporated in the formed magnetic structure 404 in a desired shape (e.g. flat, arc shape, or dome shape), which can achieve a desired magnetic strength and/or shape of the magnetic interference field generated by the magnetic structure 404.

As mentioned above, the stage 2 process can be equally applied using the second intermediate magnetic structure 206, or the third intermediate structure 210, thus forming a magnetic structure comprising the second intermediate magnetic structure 206 and the cured injection molding plastic material(s) 402, or comprising the third intermediate magnetic structure 210, and the cured injection molding plastic material(s) 402. When the third intermediate structure 210 is used, the separated broken pieces 205a, b are preferably placed at a lateral distance from each other chosen to achieve a desired magnetic strength and/or mechanical property of the formed magnetic material structure 404.

The container 400 is shown to be cylindrical in this example. It will be appreciated that the container can be of other shapes, e.g. cubic or cuboid, depending on design requirements.

The magnetic material may be magnetized before, during or after the stage 2 process. If the third intermediate structure 210 is used, the magnetic material may be magnetized during or preferably after the stage 2 process. As will be appreciated by a person skilled in the art, there are two polarities and directions in a magnetic field. One direction is from the North magnetic pole and the other direction is from the South magnetic pole. Based on scientific convention, the compass "north" needle points in the direction of the magnetic flux, that is, in an outward direction from a magnet's North pole end and inward at the magnet's South pole end. . Preferably, the magnetic South polarity is used for sports & physical enhancement, e.g. to increase muscle strength as well as for pain relief, and food preservation. The magnetic North polarity is preferably used for wine & beverage enhancement. The magnetic poles can be differentiated by marking or color differences in the fabricated magnetic structures 304, 404.

The magnetic structures 304, 404 thus fabricated advantageously exhibit preferred mechanical properties governed by the choice of epoxy resin(s),/other suitable plastic material(s), or injection molding plastic material(s). For example, the magnetic structures may be made of a chosen mechanical strength and/or flexibility as desired

for a particular application. In the magnetic structure 304, the mechanical strength and/or flexibility is additionally governed by the material of the mould container 300, which further increases design options by providing additional one or more design parameters. For example, the container material may be chosen to have higher stiffness than the epoxy resin(s) or other plastic material(s) in the cured state, which can advantageously provide a magnetic structure with a relative harder shell and a softer core, which may improve breakage avoidance, shape conforming and/or wearer comfort. In the fabrication of the magnetic structures 304, 404, the shaping and the encapsulating of the intermediate magnetic structure is advantageously performed simultaneously, instead of performing one step for pre-shaping the intermediate magnetic structure into a desired shape, followed by a separate encapsulation step applied to the pre-shaped intermediate magnetic structure.

It is noted that the magnetic structures 304, 404 can be used as single piece structures, or two or more of the magnetic structures 304, and/or 404 may be stacked together to form a combined magnetic structure with increased net magnetic interference strength accordingly.

The thickness of the intermediate magnetic structures 106, 206, 210 may differ in different embodiments, and may be in a range from about 0,01mm to about 2mm, for example about 0,05mm in one embodiment.

The thickness of the magnetic structure 304, 404 can e.g. be in a range from about 0,05 to about 3mm. As mentioned above, two or more magnetic structures 304 and/or 404 may be stacked together to form a combined magnetic structure with increased net magnetic interference strength, and with increased total thickness accordingly.

Figure 5 shows a flowchart 500 illustrating a method of fabricating a magnetic material structure according to an example embodiment. At step 502, at least one single piece of magnetic material is broken into a plurality of fragments. At step 504, lateral movement of the plurality of fragments with respect to each other is inhibited during the breaking of the magnetic material. At step 506, an intermediate structure comprising the fragments of the magnetic material is formed, wherein lateral movement of the plurality of fragments with respect to each other is inhibited in the formed intermediate structure. At step 508, the intermediate structure and a curable material are placed into a container such that the intermediate structure is supported by, and conforms to, a support surface of the container. At step 510, the curable material is cured while being disposed in the container to form the magnetic material structure.

The breaking may comprise breaking two or more interconnected single pieces of magnetic material into interconnected respective pluralities of fragments, and inhibiting the lateral movement comprises inhibiting lateral movement of fragments within each broken piece and inhibiting lateral movement of the pluralities of fragments relative to each other. The intermediate structure may comprise the

interconnected pluralities of fragments. The method may further comprise separating the interconnected pluralities of fragments into a group of separated pluralities of fragments, and wherein the intermediate structure comprises the group of the separated pluralities of fragments. The placing of the intermediate structure may
5 comprise disposing the separated pluralities of fragments at a lateral distance from each other on the support surface of the container, the lateral distance being chosen to achieve a desired magnetic strength and/or mechanical property of the formed magnetic material structure.

The formed magnetic material structure may comprise the container, the intermediate
10 structure and the cured curable material. The curable material and a material of the container may be chosen to achieve a desired mechanical property of the formed magnetic material structure.

The method may further comprise removing the intermediate structure and the cured
15 curable material from the container, and wherein the formed magnetic material structure comprises the intermediate structure and the cured curable material.

The fragments of the magnetic material may be magnetically polarized after the magnetic material structure is formed.

Inhibiting relative movement of the fragments of magnetic material may comprise
20 providing a fixture element on the pieces of magnetic material prior to the breaking of the pieces of magnetic material. The fixture element may comprise at least one adhesive sheet portion attached along at least one surface of the respective pieces of magnetic material. The fixture element may comprise two adhesive sheet portions attached along opposing surfaces of the respective pieces of magnetic material. The adhesive sheet may be an elastic plastic sheet.

25 The shape of the support surface of the container may be flat, arc shaped, or dome shaped.

The support surface may be a bottom surface of the container.

In an example embodiment, a magnetic material structure comprises an intermediate
30 structure comprising fragments of at least one single piece of magnetic material, wherein lateral movement of the plurality of fragments with respect to each other is inhibited; and a cured curable material encapsulating the intermediate structure; wherein the intermediate structure conforms to a support surface of the magnetic material structure.

The intermediate structure may comprise interconnected respective pluralities of
35 fragments from two or more interconnected pieces of magnetic material, wherein lateral movement of the fragments in each plurality of fragments and lateral movement of the pluralities of fragments relative to each other is inhibited. The intermediate structure may comprise the interconnected pluralities of fragments.

The intermediate structure may comprises separated respective pluralities of fragments from two or more pieces of magnetic material, wherein lateral movement of the fragments in each plurality of fragments and lateral movement of the pluralities of fragments relative to each other is inhibited. The separated pluralities of fragments
5 may be disposed at a lateral distance from each other, the lateral distance being chosen to achieve a desired magnetic strength and/or mechanical property of the formed magnetic material structure.

The formed magnetic material structure may further comprise a container surrounding the intermediate structure and the cured curable material. A surface of the container
10 may form the support surface. The curable material and a material of the container may be chosen to achieve a desired mechanical property of the formed magnetic material structure.

The fragments of the magnetic material may be magnetically polarized.

Inhibiting lateral movement of the fragments of magnetic material may be by means
15 of a fixture element. The fixture element may comprise at least one adhesive sheet portion attached along at least one surface of the respective pluralities of fragments. The fixture element may comprise two adhesive sheet portions attached along opposing surfaces of the respective pluralities of fragments. The adhesive sheet may be an elastic plastic sheet.

20 The shape of the support surface may be flat, arc shaped, or dome shaped.

A surface of the intermediate structure may form at least part of the support surface.

The methods of fabrication of a magnetic structure and magnetic structures described above have applications in various devices and methods for magnetic treatment for enhancing sports and physical performance & increase muscle strength as well as for
25 relief from ailments such as chronic aches and pain or injuries or post-surgery recovery or illnesses, and also for food preservation, wine & beverage enhancement. A non-limiting list, by way of example only, includes wearable devices such as wrist bands or straps, knee bands or straps, shoulder bands or straps, leg bands or straps, and ankle bands or straps, and their use for magnetic treatment for relief from
30 ailments such as chronic aches and pain or injuries or post-surgery recovery or illnesses. Other applications include shoe insoles or build-in devices in shoes & sandals, wearable clothing, or hand grip straps for sports rackets. Further examples of devices and method are described e.g. in WO/2015/002615 and WO/2015/084263. The methods of fabrication of a magnetic structure and magnetic structures described
35 above also have applications in various devices and methods for magnetic treatment of perishable objects such as food items or drinks, e.g. for food preservation, wine & beverage enhancement.. Examples of such devices and methods are described e.g. in WO/2006/083232 and WO/2008/030191.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to
5 be illustrative and not restrictive. Also, the invention includes any combination of features, in particular any combination of features in the patent claims, even if the feature or combination of features is not explicitly specified in the patent claims or the present embodiments.

CLAIMS

1. A method of fabricating a magnetic material structure comprising the steps of:
breaking at least one single piece of magnetic material into a plurality of fragments;
inhibiting lateral movement of the plurality of fragments with respect to each other
5 during the breaking of the magnetic material;
forming an intermediate structure comprising the fragments of the magnetic material,
wherein lateral movement of the plurality of fragments with respect to each other is
substantially inhibited in the formed intermediate structure;
placing the intermediate structure and a curable material into a container such that the
10 intermediate structure is supported by, and conforms to, a support surface of the
container; and
curing the curable material while being disposed in the container to form the
magnetic material structure.
- 15 2. The method as claimed in claim 1, wherein the breaking comprises breaking two or
more interconnected single pieces of magnetic material into interconnected respective
pluralities of fragments, and inhibiting the lateral movement comprises inhibiting
lateral movement of fragments within each broken piece and inhibiting lateral
movement of the pluralities of fragments relative to each other.
- 20 3. The method as claimed in claim 2, wherein the intermediate structure comprises
the interconnected pluralities of fragments.
4. The method as claimed in claim 2, further comprising separating the interconnected
pluralities of fragments into a group of separated pluralities of fragments, and
wherein the intermediate structure comprises the group of the separated pluralities of
fragments.
- 25 5. The method as claimed in claim 4, wherein the placing of the intermediate structure
comprises disposing the separated pluralities of fragments at a lateral distance from
each other on the support surface of the container, the lateral distance being chosen to
achieve a desired magnetic strength and/or mechanical property of the formed
magnetic material structure.
- 30 6. The method as claimed in any one of the preceding claims, wherein the formed
magnetic material structure comprises the container, the intermediate structure and
the cured curable material.
7. The method as claimed in claim 6, wherein the curable material and a material of
the container are chosen to achieve a desired mechanical property of the formed
35 magnetic material structure.

8. The method as claimed in any one of claims 1 to 6, further comprising removing the intermediate structure and the cured curable material from the container, and wherein the formed magnetic material structure comprises the intermediate structure and the cured curable material.
- 5 9. The method as claimed in any one of the preceding claims, wherein the fragments of the magnetic material are magnetically polarized after the magnetic material structure is formed.
- 10 10. The method as claimed in any one of the preceding claims, wherein inhibiting lateral movement of the fragments of magnetic material comprises providing a fixture element on the pieces of magnetic material prior to the breaking of the pieces of magnetic material.
11. The method as claimed in claim 10, wherein the fixture element comprises at least one adhesive sheet portion attached along at least one surface of the respective pieces of magnetic material.
- 15 12. The method as claimed in claim 11, wherein the fixture element comprises two adhesive sheet portions attached along opposing surfaces of the respective pieces of magnetic material.
13. The method as claimed in claims 11 or 12, wherein the adhesive sheet is an elastic plastic sheet.
- 20 14. The method as claimed in any one of the preceding claims, wherein the shape of the support surface of the container is flat, arc shaped, or dome shaped.
15. The method as claimed in any one of the preceding claims, wherein the support surface is a bottom surface of the container.
16. A magnetic material structure comprising:
- 25 an intermediate structure comprising fragments of at least one single piece of magnetic material, wherein lateral movement of the plurality of fragments with respect to each other is inhibited; and
- a cured curable material encapsulating the intermediate structure;
- wherein the intermediate structure conforms to a support surface of the magnetic material structure.
- 30 17. The magnetic material structure as claimed in claim 16, wherein the intermediate structure comprises interconnected respective pluralities of fragments from two or more interconnected pieces of magnetic material, wherein lateral movement of the fragments in each plurality of fragments and lateral movement of the pluralities of fragments relative to each other is inhibited.
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18. The magnetic material structure as claimed in claim 17, wherein the intermediate structure comprises the interconnected pluralities of fragments.
19. The magnetic material structure as claimed in claim 17, wherein the intermediate structure comprises separated respective pluralities of fragments from two or more pieces of magnetic material, wherein lateral movement of the fragments in each plurality of fragments and lateral movement of the pluralities of fragments relative to each other is inhibited
20. The magnetic material structure as claimed in claim 19, wherein the separated pluralities of fragments are placed at a lateral distance from each other, the lateral distance being chosen to achieve a desired magnetic strength and/or mechanical property of the formed magnetic material structure.
21. The magnetic material structure as claimed in any one of claims 16 to 20, wherein the formed magnetic material structure further comprises a container surrounding the intermediate structure and the cured curable material.
22. The magnetic material structure as claimed in claim 21, wherein a surface of the container forms the support surface.
23. The magnetic material structure as claimed in claims 21 or 22, wherein the curable material and a material of the container are chosen to achieve a desired mechanical property of the formed magnetic material structure.
24. The magnetic material structure as claimed in any one of claims 16 to 23, wherein the fragments of the magnetic material are magnetically polarized.
25. The magnetic material structure as claimed in any one of claims 16 to 24, wherein inhibiting lateral movement of the fragments of magnetic material is by means of a fixture element.
26. The magnetic material structure as claimed in claim 25, wherein the fixture element comprises at least one adhesive sheet portion attached along at least one surface of the respective pluralities of fragments.
27. The magnetic material structure as claimed in claim 26, wherein the fixture element comprises two adhesive sheet portions attached along opposing surfaces of the respective pluralities of fragments.
28. The magnetic material structure as claimed in claims 26 or 27, wherein the adhesive sheet is an elastic plastic sheet.
29. The magnetic material structure as claimed in any one of claims 16 to 28, wherein the shape of the support surface is flat, arc shaped, or dome shaped.

30. The magnetic material structure as claimed in any one of claims 16 to 29, wherein a surface of the intermediate structure forms at least part of the support surface.