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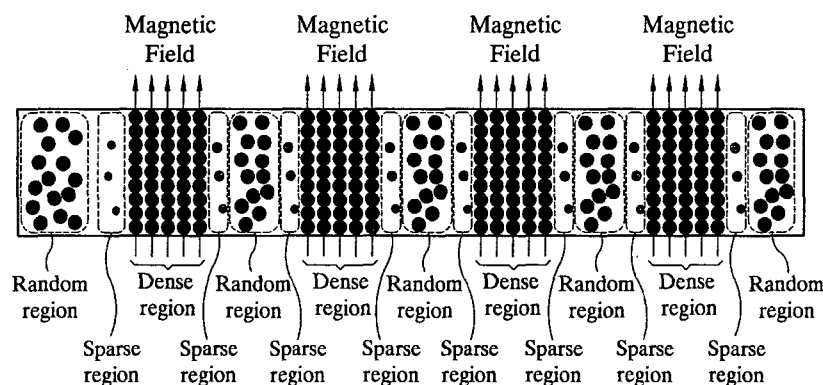
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(54) **Title:** POLYMER COMPOSITE AND METHOD FOR PREPARING THE SAME



(57) **Abstract:** The present invention relates to a polymer composite and its preparation method, and more particularly to a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field, and a method for preparing the polymer composite. The polymer composite to realize pressure response in accordance with one example of the present invention comprises: a non-conductive polymer; a first region being mixed with the non-conductive polymer and comprising a first conductive filler treated with at least either one of magnetic field and electrical field; and a second region being mixed with the non-conductive polymer and comprising a second conductive filler not treated with at least either one of magnetic field and electrical field.

DESCRIPTION

POLYMER COMPOSITE AND METHOD FOR PREPARING THE SAME

BACKGROUND OF THE INVENTIONField of the Invention

[01] The present invention relates to a polymer composite and a method for preparing the same and, more particularly to a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field, and to a method for preparing the polymer composite.

Background Art

[02] Rubber or silicone, which is an insulating material in general, can become an electrically conductive rubber or silicone when mixed with a conductive material, such as metal or carbon.

[03] In this regard, depending on the type and proportion of the material to be mixed with rubber/silicone, the rubber/silicone can turn into either an electrically conductive rubber/silicone having an ability of conducting electricity all the time or a pressure sensor having its conductivity changing according to the pressure applied.

[04] Further, an addition of conductive carbon black or metal fiber renders rubber or silicone electrically conductive, and such a conductive rubber or silicon has been put into practical use as an anti-static material.

[05] With the advance of electronics technology, the conductive rubber or silicone has been utilized on various use purposes, such as contact material, conductive adhesive, and so forth.

[06] The aforementioned conductive rubber or the like is also applicable as a pressure-sensitive material of which the conductivity changes according to the pressure applied.

[07] On the other hand, the pressure-sensitive material has difficulty in providing a uniform distribution of conductive particles in the rubber or silicone, which leads to limitation that it cannot provide uniform performance for the user.

[08] Further, the shorter horizontal distance between the electrodes sensing the change of pressure through the change of voltage may induce a flow of electricity in the horizontal direction to cause interference, which ends up with the difficulty in manufacturing a plurality of small arrays and hence some problems in the manufacture of integrated arrays. Thus, there is a need for a solution to such problems.

SUMMARY OF THE INVENTION

[09] The present invention is contrived to solve the aforementioned problems with the prior art, and its object is to provide a polymer composite comprising at least part of a region treated with at least either of magnetic field and electrical field, and a method for preparing the polymer composite.

[10] More specifically, it is an object of the present invention to provide a polymer composite and its preparation method, where the polymer composite composed of a dense region comprising a conductive filler treated with at least either one of magnetic field and electrical field and a sparse region comprising a conductive filler not treated with at least one of magnetic field and electrical field.

[11] On the other hand, the objects of the present invention are not limited to the above-mentioned objects, and other objects not mentioned herein will be obviously understood in conjunction with the following description by those skilled in the related art of the present invention.

[12] In accordance with one embodiment of the present invention to achieve the object of the present invention, a polymer composite, which is to realize a pressure response, may comprise a non-conductive polymer; a first region being mixed with the non-conductive polymer and comprising a first conductive filler treated with at least either one of magnetic field and electrical field; and a second region being mixed with the non-conductive polymer and comprising a second conductive filler not treated with at least either one of magnetic field and electrical field.

[13] Further, a plurality of particles included in the first region may be more densely distributed than a plurality of particles included in the second region.

[14] Further, the second region may comprise: a second first(2-1) region comprising particles more sparsely distributed than the plural particles included in the first region; and a second second(2-2) region randomly comprising densely distributed particles and sparsely distributed particles.

[15] Further, the plural particles included in the first region may be distributed to align in a defined form.

[16] Further, the plural particles included in the first region may be more densely distributed than the plural particles included in the second region and aligned in a defined form.

[17] In accordance with one embodiment of the present invention to achieve the object of the present invention, an apparatus for preparing a polymer composite may comprise: a solenoid coil for creating an electromagnetic field; and a ferromagnetic core for transferring the created electromagnetic field to the polymer composite. At least part of the ferromagnetic core may comprise a hollow space to

transfer the electromagnetic field. Both ends of the ferromagnetic core corresponding to the hollow space may comprise a plurality of sub-cores. The first region of the polymer composite may be determined in correspondence to the positions of the plural sub-cores.

5 [18] Further, the polymer composite is positioned in the middle between the sub-core at the one end of the ferromagnetic core and the sub-core at the other end of the ferromagnetic core.

10 [19] In accordance with one embodiment of the present invention to achieve the object of the present invention, an apparatus for preparing a polymer composite may comprise a plurality of permanent magnets for creating a magnetic field. The polymer composite may be positioned close to the plural permanent magnets. The first region of the polymer composite may be determined in correspondence to the positions of the plural permanent magnets.

15 [20] Further, the plural permanent magnets may comprise a ferromagnetic core to create a magnetic path.

 [21] Further, the ferromagnetic core may be made of at least one ferromagnetic material selected from iron, cobalt, nickel, and stainless steel (SUS).

20 [22] Further, the plural permanent magnets may be arranged in up-down mirror symmetry, and the polymer composite may be positioned in the middle between the plural permanent magnets arranged in up-down mirror symmetry.

25 [23] In accordance with one embodiment of the present invention to achieve the object of the present invention, an apparatus for preparing a polymer composite may comprise a voltage source for creating an electrical field; and a conductive metal being symmetrically configured and comprising a hollow space to transfer the created electrical field to the polymer composite. The one end of the conductive metal corresponding to the hollow space may comprise a plurality of metal projections. The first region of the polymer composite may be determined in correspondence to the positions of the plural metal projections.

30 [24] Further, the polymer composite may be positioned in the middle between the plural metal projections and the other end of the conductive metal.

35 [25] In accordance with one embodiment of the present invention to achieve the object of the present invention, a method for preparing a polymer composite may comprise: (a) creating an electromagnetic field by a solenoid coil; and (b) transferring the created electromagnetic field to the polymer composite by a ferromagnetic core. At least part of the ferromagnetic core may comprise a hollow space to transfer the electromagnetic field. Both ends of the ferromagnetic core corresponding to the hollow space may comprise a plurality of sub-cores. The first

region of the polymer composite may be determined in correspondence to the positions of the plural sub-cores.

[26] Further, the electromagnetic field created by the solenoid coil may be in such a form as maintained at a constant value or varied periodically.

5 [27] Further, the method may further comprise positioning the polymer composite in the middle between the sub-core at the one end of the ferromagnetic core and the sub-core at the other end, between the step (a) of creating an electromagnetic field and the step (b) of transferring the created electromagnetic field.

10 [28] In accordance with one embodiment of the present invention to achieve the object of the present invention, a method for preparing a polymer composite may comprise: (a) arranging a plurality of permanent magnets; and (b) transferring a magnetic field created by the plural permanent magnets to the polymer composite. The polymer composite may be positioned close to the plural permanent magnets. The first region of the polymer composite may be determined in correspondence to the positions
15 of the plural permanent magnets.

[29] Further, the method may further comprise arranging the plural permanent magnets in a ferromagnetic core.

[30] Further, the plural permanent magnets may be positioned in up-down mirror symmetry, and the polymer composite may be positioned in the middle between the
20 plural permanent magnets arranged in up-down mirror symmetry.

[31] In accordance with one embodiment of the present invention to achieve the object of the present invention, a method for preparing a polymer composite may comprise: (a) creating an electrical field by a voltage source; and (b) transferring the created electrical field to the polymer composite by a conductive metal. The
25 conductive metal may be symmetrically configured and comprise a hollow space to transfer the created electrical field to the polymer composite. The one end of the conductive metal corresponding to the hollow space may comprise a plurality of metal projections. The first region of the polymer composite may be determined in correspondence to the positions of the plural metal projections.

30 [32] Further, the polymer composite may be positioned in the middle between the plural metal projections and the other end of the conductive metal.

[33] In accordance with one embodiment of the present invention to achieve the object of the present invention, there is provided a recording medium, which tangibly realizes a program of commands executable by a digital signal processor and
35 is readable by the digital signal processor in order to perform a method for preparing the polymer composite, where the method may comprise: (a) creating an electromagnetic field by a solenoid coil; and (b) transferring the created electromagnetic field to

the polymer composite by a ferromagnetic core. At least part of the ferromagnetic core may comprise a hollow space to transfer the electromagnetic field. Both ends of the ferromagnetic core corresponding to the hollow space may comprise a plurality of sub-cores. The first region of the polymer composite may be determined in correspondence to the positions of the plural sub-cores.

[34] In accordance with one embodiment of the present invention to achieve the object of the present invention, there is provided a recording medium, which tangibly realizes a program of commands executable by a digital signal processor and is readable by the digital signal processor in order to perform a method for preparing the polymer composite, where the method may comprise: (a) arranging a plurality of permanent magnets; and (b) transferring a magnetic field created by the plural permanent magnets to the polymer composite. The polymer composite may be positioned close to the plural permanent magnets. The first region of the polymer composite may be determined in correspondence to the positions of the plural permanent magnets.

[35] In accordance with one embodiment of the present invention to achieve the object of the present invention, there is provided a recording medium, which tangibly realizes a program of commands executable by a digital signal processor and is readable by the digital signal processor in order to perform a method for preparing the polymer composite, where the method may comprise: (a) creating an electrical field by a voltage source; and (b) transferring the created electrical field to the polymer composite by a conductive metal. The conductive metal may be symmetrically configured and comprise a hollow space to transfer the created electrical field to the polymer composite. The one end of the conductive metal corresponding to the hollow space may comprise a plurality of metal projections. The first region of the polymer composite may be determined in correspondence to the positions of the plural metal projections.

[36] The present invention can provide the user with a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field, and a method for preparing the polymer composite.

[37] More specifically, the present invention can provide the user with a polymer composite composed of a dense region comprising a conductive filler treated with at least either one of magnetic field and electrical field and a sparse region comprising a conductive filler not treated with at least either one of magnetic field and electrical field, and a method for preparing the polymer composite.

[38] On the other hand, the effects of the present invention are not limited to the above-mentioned effects, and other objects not mentioned herein will be obviously understood in conjunction with the following description by those skilled in the related art of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[39] The accompanying drawings of this specification are to exemplify the preferred embodiment of the present invention and given to detail the description of the present invention and help better understanding of the technical concepts of the present invention, which should not be understood to be confined to the contents of the drawings.

[40] FIGS. 1 and 2 illustrate an example of a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[41] FIG. 3 shows the concrete internal configuration of the polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[42] FIG. 4 is an illustration that specifies the dense region, the sparse region, and the random region in FIG. 2.

[43] FIG. 5 shows the measurement results in the dense region of the present invention; and FIG. 6 shows the measurement results in the sparse region of the present invention.

[44] FIG. 7 illustrates a first apparatus for preparing a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[45] FIG. 8 is a flow chart showing an operation of the first apparatus of FIG. 7.

[46] FIGS. 9 and 10 are graphs comparing the results depending on the position of the polymer composite between the first apparatus of FIG. 7 and a conductive rubber.

[47] FIGS. 11 and 12 illustrate a second apparatus for preparing a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[48] FIG. 13 is a flow chart showing an operation of the second apparatus of FIGS. 11 and 12.

[49] FIG. 14 is a graph showing the results depending on the position of the polymer composite between the second apparatus of FIGS. 11 and 12 and a conductive rubber.

[50] FIG. 15 and 16 illustrate a third apparatus for preparing a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[51] FIG. 17 illustrates a fourth apparatus for preparing a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[52] FIG. 18 is a flow chart showing an operation of the fourth apparatus of FIG. 17.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[53] Hereinafter, the preferred embodiment of the present invention will be described with reference to the accompanying drawings. Further, the aforementioned embodiment of the present invention is not intended to be limiting the contents of the present invention as defined by the appended claims, and the whole construction as disclosed in the embodiment is not considered to be necessary as a solution of the present invention.

[54] Rubber or silicone, which is an insulating material in general, can become an electrically conductive rubber or silicone when mixed with a conductive material, such as metal or carbon.

[55] Depending on the type and proportion of the material to be mixed with rubber/silicone, the rubber/silicone can turn into either an electrically conductive rubber/silicone having an ability of conducting electricity all the time or a pressure sensor having its conductivity changing according to the pressure applied.

[56] Further, an addition of conductive carbon black or metal fiber can render the rubber or silicone electrically conductive. Such a conductive rubber or silicon has been put into practical use as an anti-static material.

[57] With the advance of electronics technology, the conductive rubber or silicone has been utilized on various use purposes, such as contact materials, conductive adhesives, and so forth.

[58] Disposing an electrical contact on the top of the conductive rubber and at least one row, column, or sheet of electrodes on the bottom of the conductive rubber can provide a multi switch or a pressure-sensitive device applicable to the tactile sensor.

[59] In this regard, the electrical contact positioned on the top of the conductive rubber may become a contact freely configured without forming a separate electrode. Further, the contact on the top of the conductive rubber may operate independently.

[60] The end of the electrical contact positioned on the top of the conductive rubber may be formed in a round or tapered shape and produced to have such a structure that secures high surface charge density and maintains high electrical field up to an appropriate distance.

[61] For expedience sake in explanation, the conductive rubber which has an electrical contact disposed on its top and at least one row, column, or sheet of electrodes formed on its bottom is referred to as "smart conductive rubber".

[62] The smart conductive rubber suggested in the present invention may, as described above, contain carbon fiber, metals, or powder and have a change in resistance according to the pressure applied by the user. In other words, the resistance changes according to the amount of pressure applied to the smart conductive rubber by the user, which can be used to provide a more delicate tactile sensor.

[63] However, the smart conductive rubber of the present invention may be problematic in that the performance is variable according to the position to which pressure is applied by the user.

[64] Moreover, the smart conductive rubber of the present invention is difficult to form at small dimensions and desirable only in the vertical flow of the electrical current due to interference occurring in the case of a short horizontal distance between the electrodes, resulting in a problem with its integration. Thus, there is a need for a solution to these problems.

[65] Accordingly, the present invention is to provide a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field, and a specified method for preparing the polymer composite.

[66] For expedience sake in explanation, it is supposed that the polymer composite is a smart conductive rubber. This supposition is for illustration use purposes only, and it is evident that the content of the present invention is applicable to various polymer composites that can be used for tactile sensors.

[67] To solve the aforementioned problems, the present invention is to provide a smart conductive rubber comprising at least part of a region treated with at least either one of magnetic field and electrical field.

[68] FIGS. 1 and 2 illustrate an example of the polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[69] The smart conductive rubber, as shown in FIGS. 1 and 2, comprises: a non-conductive polymer; a dense region 100 being mixed with the non-conductive polymer and comprising a conductive filler treated with at least either one of magnetic field and electrical field; a sparse region 200 being mixed with the non-conductive polymer and comprising a conductive filler not treated with at least either one of magnetic field and electrical field; and a random region 300 comprising the characteristics of both the dense region and the sparse region.

[70] The smart conductive rubber of the present invention may simply comprise the non-conductive polymer, the dense region 100, and the sparse region 200.

[71] Hereinafter, a further detailed description will be given as to the dense region 100 and the sparse region 200 as illustrated in FIGS. 1 and 2.

5 [72] Firstly, a plurality of particles included in the dense region 100 may be more densely distributed than a plurality of particles included in the sparse region 200.

10 [73] The sparse region 200 may comprise a region including particles more sparsely distributed than the plural particles included in the dense region 100, and the random region 300 including, at random, densely distributed particles and sparsely distributed particles.

[74] Further, the plural particles included in the dense region 100 may be distributed to align in a defined form.

15 [75] Further, the plural particles included in the dense region 100 may be more densely distributed than the plural particles included in the sparse region 200 and aligned in a defined form.

20 [76] The smart conductive rubber, when using the dense region 100, the sparse region 200, and the random region 300, can provide uniform performance for the user by increasing the sensitivity of the dense region 100 to the maximum, lowering the sensitivity of the sparse region 200 to the minimum, and maintaining the sensitivity of the random region 300 in the middle.

25 [77] In other words, the sparse region 200 is a deficient region that can be used as a completely insulated site to provide prevention of mutual interference, and the dense region 100 can be used as a concentrated region, which leads to more precise tactile sensing and control. The random region 300 can be a normal region that plays a role to connect the sparse region 200 to the dense region 100.

[78] Further, the smart conductive rubber of the present invention can be processed very thin to provide a beneficial effect in the production of integrated devices.

30 [79] More specifically, while the general conductive rubber which needs to have a thickness to some extent may cause some problems in association with the semiconductor process, the smart conductive rubber of the present invention can provide higher sensitivity as well as secured thinness, making the production of more than 100 x 100 tactile sensors practicable.

35 [80] This fact enables the production of integrated tactile sensors, reduces the production cost to facilitate large-scale production and, furthermore, provides a

means for producing integrated flexible tactile sensors. Such a smart conductive rubber is also applicable to sensors for sensing a push-down force or pressure.

[81] On the other hand, integration of precise sensors is practicable by making fine adjustments to the range of the sparse region 200 that corresponds to a deficient region.

[82] For the sake of preventing contaminations, the conductive rubber may be formed into a thin film, which is then laminated in a desired thickness in the post process to obtain a thick layer of the smart conductive rubber. It is also possible to separately add devices such as diodes between the smart conductive rubber layers during the process.

[83] Thus, the problems with the conductive rubber in regard to the performance changeable depending on the position pressed by the user and the difficulty of integration can be solved by using the smart conductive rubber suggested by the present invention.

[84] On the other hand, the smart conductive rubber may be prepared to have a repeating pattern of the dense region 100, the sparse region 200, and the random region 300.

[85] FIG. 3 shows the concrete internal configuration of the polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[86] Referring to FIG. 3, the polymer composite is configured to have a repeating pattern of the dense region 100, the sparse region 200, and the random region 300.

[87] As described previously, for production of integrated sensors, the smart conductive rubber may be prepared to minimize the sparse region 200 and the random region 300.

[88] FIG. 4 is an illustration that specifies the dense region, the sparse region, and the random region in FIG. 2.

[89] In FIG. 4, the dense region 100 and the sparse region 200 are composed in 3x3 units based on the random region 300.

[90] When the configuration of FIG. 4 provides a function of sensing the pressure applied by the user, the sensitivity is highest in the dense region 100 to provide a more precise tactile sensing.

[91] FIG. 5 shows the measurement results in the dense region of the present invention; and FIG. 6 shows the measurement results in the sparse region of the present invention.

[92] A comparison between the graphs of FIGS. 5 and 6 shows that the performance is higher in the dense region 100 where the metal powder in the smart conductive rubber aligns along the magnetic field.

[93] In other words, it can be seen from FIGS. 5 and 6 that the particles of the dense region 100 align uniformly with a constant density to improve drift and hysteresis and enhance sensitivity.

[94] Hereinafter, a detailed description will be given as to an apparatus and method for preparing the above-specified smart conductive rubber.

[95] First Example

[96] FIG. 7 illustrates a first apparatus for preparing a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[97] The first apparatus shown in FIG. 7 may comprise a solenoid coil 510 for creating an electromagnetic field, and a ferromagnetic core 520 for transferring the created electromagnetic field to the polymer composite.

[98] In this regard, at least part of the ferromagnetic core may comprise a hollow space in order to transfer the electromagnetic field.

[99] Further, both ends of the ferromagnetic core corresponding to the hollow space may comprise a plurality of sub-cores 530.

[100] Further, the position of the dense region 100 of the smart conductive rubber may be determined in correspondence to the positions of the plural sub-cores.

[101] In other words, the portion of the smart conductive rubber close to the plural sub-cores can be treated as the dense region 100.

[102] This process will be described in further detail with reference to FIG. 8.

[103] FIG. 8 is a flow chart showing an operation of the first apparatus of FIG. 7.

[104] Referring to FIG. 8, the solenoid coil 510 creates an electromagnetic field (in S610).

[105] The electromagnetic field created by the solenoid coil 510 may be produced in such a way that it maintains a constant value or changes periodically.

[106] Subsequently, the ferromagnetic core 520 transfers the created electromagnetic field to the polymer composite (in S620).

[107] Further, the dense region of the polymer composite may be determined in correspondence to the positions of the plural sub-cores of the ferromagnetic core 520 (in S630).

[108] Between S620 and S630, there may be further included a step of positioning the polymer composite in the middle between the sub-cores at the one end of the ferromagnetic core and the sub-cores at the other end of the ferromagnetic core.

[109] FIGS. 9 and 10 are graphs comparing the results depending on the position of the polymer composite between the first apparatus of FIG. 7 and the conductive rubber.

[110] FIG. 9 shows the results when the polymer composite is positioned in the middle between the sub-cores at the one end of the ferromagnetic core and the sub-cores at the other end of the ferromagnetic core.

[111] FIG. 10 shows the results when the polymer composite is positioned closer to the sub-cores at the other end of the ferromagnetic core.

[112] Hence, the smart conductive rubber of the present invention can be prepared using the above-described apparatus and method.

[113] Second Example

[114] FIGS. 11 and 12 illustrate a second apparatus for preparing a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

[115] The second apparatus shown in FIGS. 11 and 12 may comprise a plurality of permanent magnets 620 for creating a magnetic field. Further, the plural permanent magnets may additionally comprise a ferromagnetic core for creating a magnetic path.

[116] In this regard, the ferromagnetic core may be made of at least one ferromagnetic material selected from iron, cobalt, nickel, and stainless steel (SUS).

[117] In the second apparatus, the plural permanent magnets may be arranged in up-down mirror symmetry, and the polymer composite may be positioned in the middle between the plural permanent magnets arranged in up-down mirror symmetry.

[118] On the other hand, the polymer composite may be positioned close to the plural permanent magnets, and the dense region 100 of the polymer composite may be determined in correspondence to the positions of the plural permanent magnets.

[119] This process will be described in further detail with reference to FIG. 13.

[120] FIG. 13 is a flow chart showing an operation of the second apparatus of FIGS. 11 and 12.

[121] Referring to FIG. 13, the plural permanent magnets are arranged (in S910).

[122] Here, the plural permanent magnets may be arranged in the ferromagnetic core.

[123] Further, the plural permanent magnets may be arranged in up-down mirror symmetry.

[124] Subsequently, the polymer composite may be positioned close to the plural permanent magnets (in S920).

5 [125] In this regard, the polymer composite may be positioned in the middle between the plural permanent magnets arranged in up-down mirror symmetry.

[126] Further, the magnetic field created by the plural permanent magnets may be transferred to the polymer composite (in S930).

10 [127] Subsequently, the dense region 100 of the polymer composite may be determined in correspondence to the positions of the plural permanent magnets (in S940).

[128] FIG. 14 shows the results when the polymer composite is positioned in the middle between the plural permanent magnets arranged in up-down mirror symmetry.

15 [129] Hence, the smart conductive rubber of the present invention can be prepared using the above-described apparatus and method.

[130] Third Example

[131] FIG. 15 and 16 illustrate a third apparatus for preparing a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

20 [132] Referring to FIG. 15, there are disclosed a pure iron base 710 and a pure iron spacer 720, which are coupled to a permanent magnet array 730 to form the third apparatus.

[133] FIG. 16 is a detailed design drawing of the third apparatus shown in FIG. 15.

25 [134] The specified embodiment of the third apparatus is illustrated in FIG. 17.

[135] FIG. 17 illustrates a fourth apparatus for preparing a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field in accordance with the present invention.

30 [136] The fourth apparatus of FIG. 17 may comprise a voltage source 810 for creating an electrical field, and a conductive metal 820 being configured symmetrically and comprising a hollow space to transfer the created electrical field to the polymer composite.

35 [137] In this regard, the one end of the conductive metal corresponding to the hollow space may comprise a plurality of metal projections 830, and the dense region 100 of the polymer composite may be determined in correspondence to the positions of the plural metal projections 830.

[138] Further, the polymer composite may be positioned in the middle between the plural metal projections and the other end of the conductive metal.

[139] This process will be described with reference to FIG. 18, which is a flow chart showing an operation of the fourth apparatus of FIG. 17.

5 [140] Referring to FIG. 18, the voltage source creates an electrical field (in S1310).

[141] Subsequently, the conductive metal transfers the created electrical field to the polymer composite (in S1320).

10 [142] In this regard, the polymer composite may be positioned in the middle between the plural metal projections and the other end of the conductive metal.

[143] Further, the dense region of the polymer composite may be determined in correspondence to the positions of the plural metal projections included at the one end of the conductive metal (in S1330).

15 [144] Hence, the smart conductive rubber of the present invention can be prepared using the above-described apparatus and method.

20 [145] On the other hand, the present invention as described herein can be implemented by computer-readable codes on a computer-readable recording medium. The computer-readable recording medium comprises any type of recording devices that hold data readable by a computer system. The examples of the computer-readable recording medium may include ROM, RAM, CD-ROM, magnetic tape, floppy disk, optical data storage medium, and so forth, and further a recording medium implemented in the carrier wave form (for example, Internet transfer). Further, the computer-readable recording medium may be distributed to the networked computer systems, so the computer-readable codes can be stored and executed in a distributed manner. The functional programs, codes, and code segments for implementation of the present invention can be easily deduced by the programmers in the related art of the present invention.

25 [146] In addition, the apparatus and method of the present invention as disclosed herein are not limited to the aforementioned embodiments of the apparatus and method, but the whole or the parts of the embodiments can be selectively combined and thus realized in various other ways.

30 [147] The present invention is directed to a polymer composite and its preparation method, and more particularly to a polymer composite comprising at least part of a region treated with at least either one of magnetic field and electrical field. More specifically, the present invention can provide the user with a polymer composite and its preparation method, which polymer composite comprises a dense region including a conductive filler treated with at least either one of magnetic field and

electrical field, and a sparse region including a conductive filler not treated with at least either one of magnetic field and electrical field.

Claims**[Claim 1]**

A polymer composite, which is to realize a pressure response, the polymer composite comprising:

5 a non-conductive polymer;

a first region being mixed with the non-conductive polymer and comprising a first conductive filler treated with at least either one of magnetic field and electrical field; and

10 a second region being mixed with the non-conductive polymer and comprising a second conductive filler not treated with at least either one of magnetic field and electrical field.

[Claim 2]

The polymer composite as claimed in claim 1, wherein a plurality of particles included in the first region are more densely distributed than a plurality of
15 particles included in the second region.

[Claim 3]

The polymer composite as claimed in claim 2, wherein the second region comprises:

20 a second first(2-1) region comprising particles more sparsely distributed than the plural particles included in the first region; and

a second second(2-2) region randomly comprising densely distributed particles and sparsely distributed particles.

[Claim 4]

The polymer composite as claimed in claim 1, wherein the plural particles
25 included in the first region are distributed to align in a defined form.

[Claim 5]

The polymer composite as claimed in claim 1, wherein the plural particles included in the first region are more densely distributed than the plural particles included in the second region and aligned in a defined form.

[Claim 6]

30 An apparatus for preparing a polymer composite, which polymer composite is as claimed in claim 1, the apparatus comprising:

a solenoid coil for creating an electromagnetic field; and

35 a ferromagnetic core for transferring the created electromagnetic field to the polymer composite,

wherein at least part of the ferromagnetic core comprises a hollow space to transfer the electromagnetic field,

wherein both ends of the ferromagnetic core corresponding to the hollow space comprise a plurality of sub-cores,

wherein the first region of the polymer composite is determined in correspondence to the positions of the plural sub-cores.

5 【Claim 7】

The apparatus as claimed in claim 6, wherein the polymer composite is positioned in the middle between the sub-core at the one end of the ferromagnetic core and the sub-core at the other end of the ferromagnetic core.

 【Claim 8】

10 An apparatus for preparing a polymer composite, which polymer composite is as claimed in claim 1, the apparatus comprising a plurality of permanent magnets for creating a magnetic field,

 wherein the polymer composite is positioned close to the plural permanent magnets,

15 wherein the first region of the polymer composite is determined in correspondence to the positions of the plural permanent magnets.

 【Claim 9】

The apparatus as claimed in claim 8, wherein the plural permanent magnets comprise a ferromagnetic core to create a magnetic path.

20 【Claim 10】

The apparatus as claimed in claim 9, wherein the ferromagnetic core is made of at least one ferromagnetic material selected from iron, cobalt, nickel, and stainless steel (SUS).

 【Claim 11】

25 The apparatus as claimed in claim 8, wherein the plural permanent magnets are arranged in up-down mirror symmetry,

 wherein the polymer composite is positioned in the middle between the plural permanent magnets arranged in up-down mirror symmetry.

 【Claim 12】

30 An apparatus for preparing a polymer composite, which polymer composite is as claimed in claim 1, the apparatus comprising:

 a voltage source for creating an electrical field; and

 a conductive metal being symmetrically configured and comprising a hollow space to transfer the created electrical field to the polymer composite,

35 wherein the one end of the conductive metal corresponding to the hollow space comprises a plurality of metal projections,

wherein the first region of the polymer composite is determined in correspondence to the positions of the plural metal projections.

【Claim 13】

The apparatus as claimed in claim 12, wherein the polymer composite is positioned in the middle between the plural metal projections and the other end of the conductive metal.

【Claim 14】

A method for preparing a polymer composite, which polymer composite is as claimed in claim 1, the method comprising:

(a) creating an electromagnetic field by a solenoid coil; and

(b) transferring the created electromagnetic field to the polymer composite by a ferromagnetic core,

wherein at least part of the ferromagnetic core comprises a hollow space to transfer the electromagnetic field,

wherein both ends of the ferromagnetic core corresponding to the hollow space comprise a plurality of sub-cores,

wherein the first region of the polymer composite is determined in correspondence to the positions of the plural sub-cores.

【Claim 15】

The method as claimed in claim 14, wherein the electromagnetic field created by the solenoid coil is in such a form as maintained at a constant value or varied periodically.

【Claim 16】

The method as claimed in claim 14, further comprising:

positioning the polymer composite in the middle between the sub-core at the one end of the ferromagnetic core and the sub-core at the other end, between the step (a) of creating an electromagnetic field and the step (b) of transferring the created electromagnetic field.

【Claim 17】

A method for preparing a polymer composite, which polymer composite is as claimed in claim 1, the method comprising:

(a) arranging a plurality of permanent magnets; and

(b) transferring a magnetic field created by the plural permanent magnets to the polymer composite,

wherein the polymer composite is positioned close to the plural permanent magnets,

wherein the first region of the polymer composite is determined in correspondence to the positions of the plural permanent magnets.

【Claim 18】

The method as claimed in claim 17, further comprising:

5 arranging the plural permanent magnets in a ferromagnetic core.

【Claim 19】

The method as claimed in claim 17, wherein the plural permanent magnets are positioned in up-down mirror symmetry,

10 wherein the polymer composite is positioned in the middle between the plural permanent magnets arranged in up-down mirror symmetry.

【Claim 20】

A method for preparing a polymer composite, which polymer composite is as claimed in claim 1, the method comprising:

(a) creating an electrical field by a voltage source; and

15 (b) transferring the created electrical field to the polymer composite by a conductive metal,

wherein the conductive metal is symmetrically configured and comprises a hollow space to transfer the created electrical field to the polymer composite,

20 wherein the one end of the conductive metal corresponding to the hollow space comprises a plurality of metal projections,

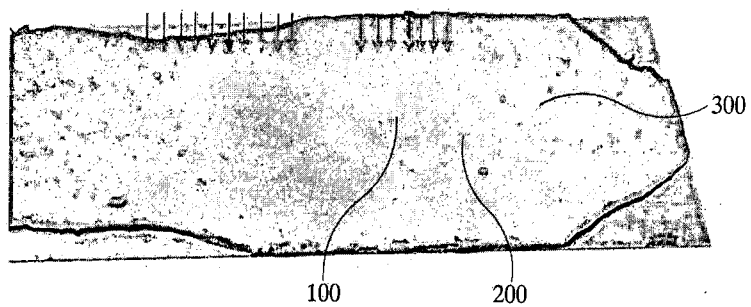
wherein the first region of the polymer composite is determined in correspondence to the positions of the plural metal projections.

【Claim 21】

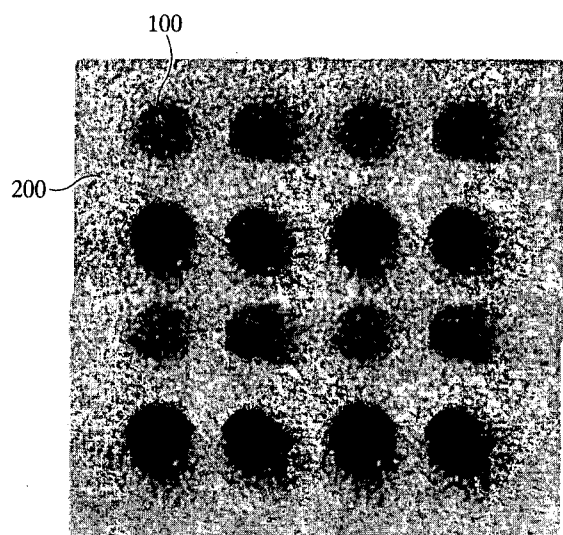
25 The method as claimed in claim 20, wherein the polymer composite is positioned in the middle between the plural metal projections and the other end of the conductive metal.

DRAWINGS

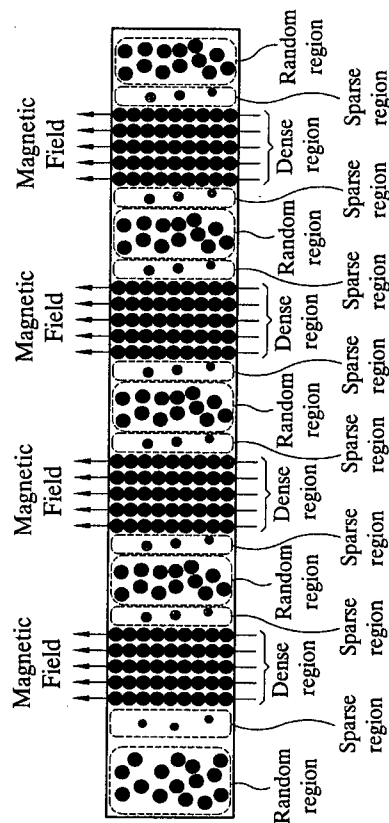
【Figure 1】



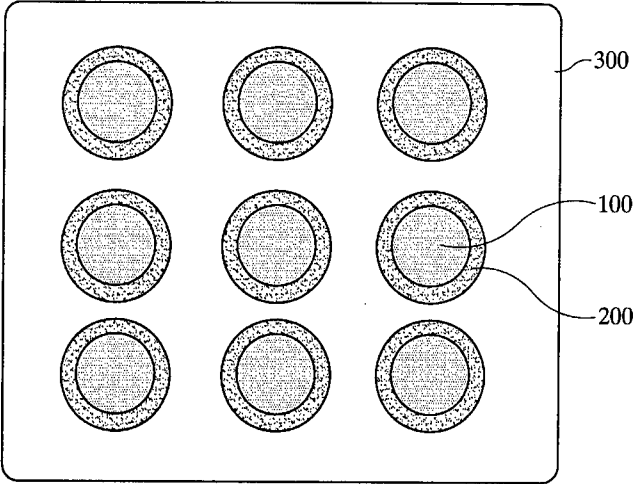
【Figure 2】



【Figure 3】

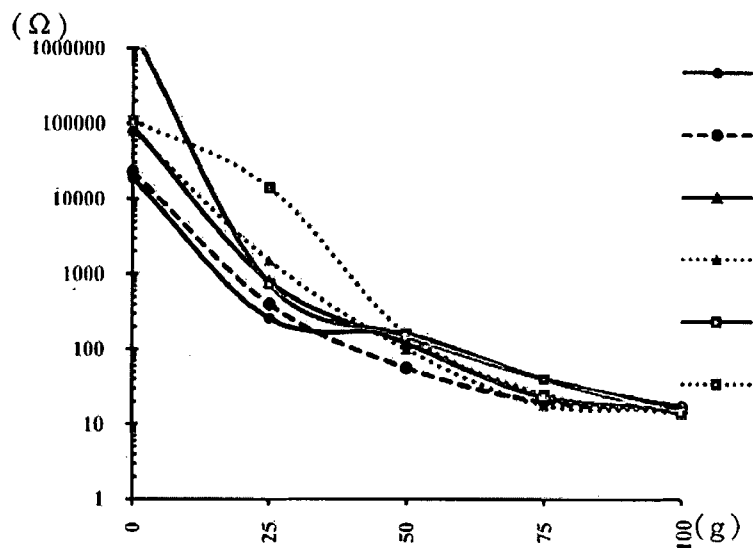


【Figure 4】



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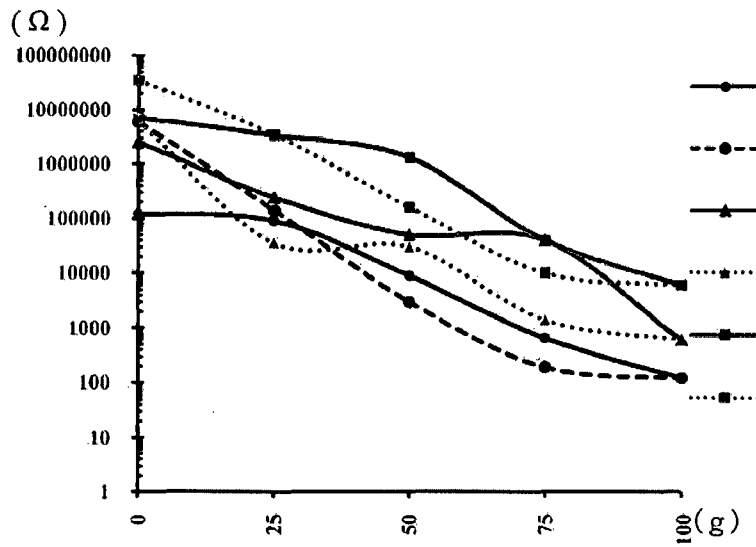
【Figure 5】



Mass	Magnetized, $\Phi 1$ mm Tip					
(g)	Loading (Ω)	Unloading (Ω)	Loading (Ω)	Unloading (Ω)	Loading (Ω)	Unloading (Ω)
0	19000	23000	90000	80000	1700000	110000
25	260	400	800	1500	740	14000
50	160	56	120	100	150	160
75	40	20	23	18	40	25
100	17	17	17	17	14	14

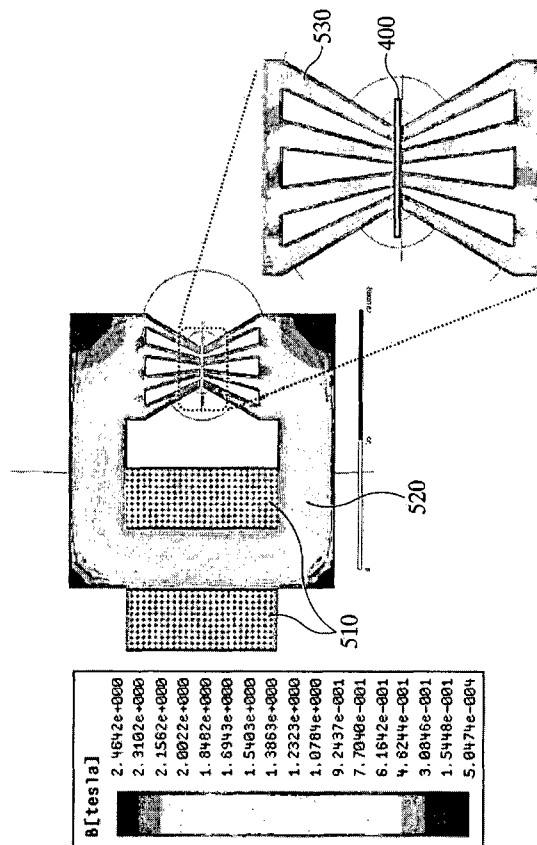
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【Figure 6】

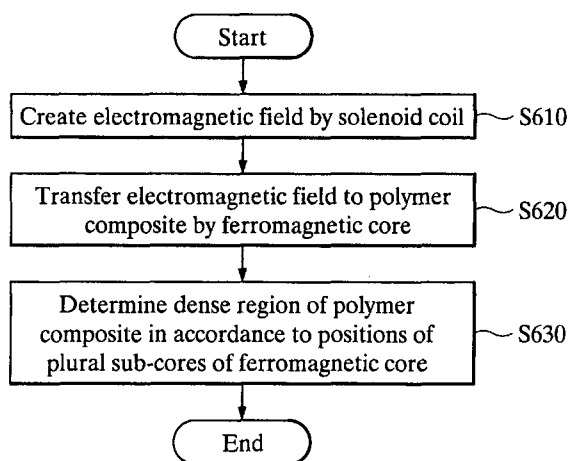


Mass	Non-Magnetized, $\Phi 1$ mm Tip					
(g)	Loading (Ω)	Unloading (Ω)	Loading (Ω)	Unloading (Ω)	Loading (Ω)	Unloading (Ω)
0	120000	6000000	2500000	6000000	7000000	35000000
25	90000	140000	240000	35000	3300000	3400000
50	9000	3000	50000	30000	1300000	160000
75	650	190	40000	1400	40000	10000
100	120	120	600	600	6000	6000

【Figure 7】

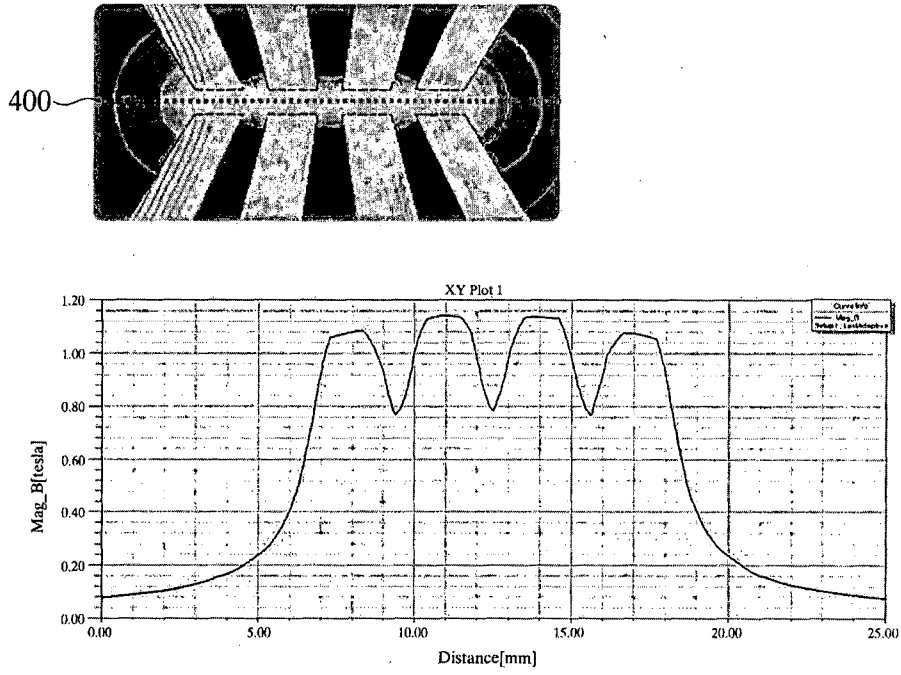


【Figure 8】

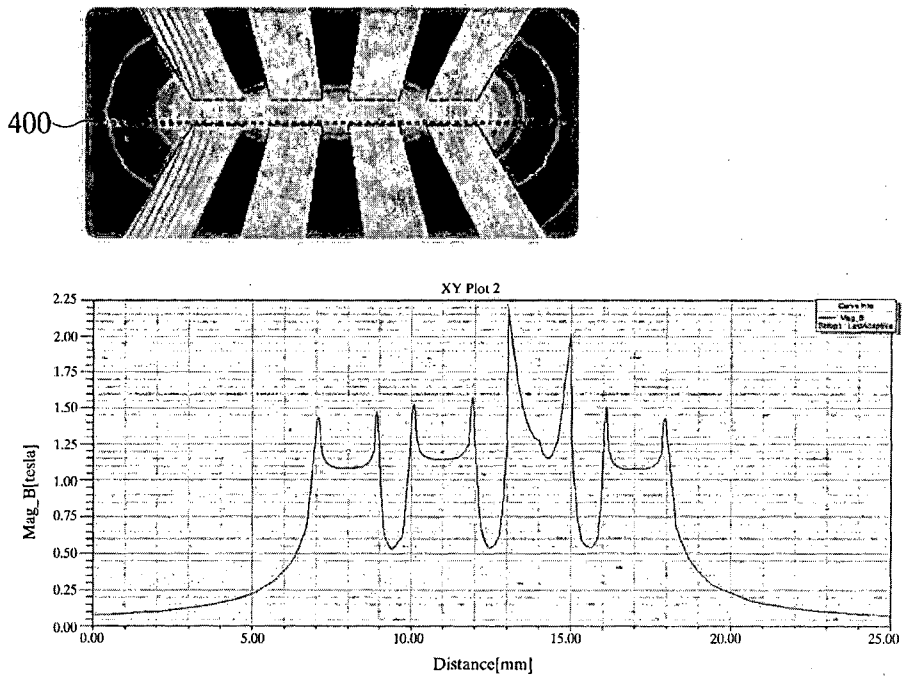


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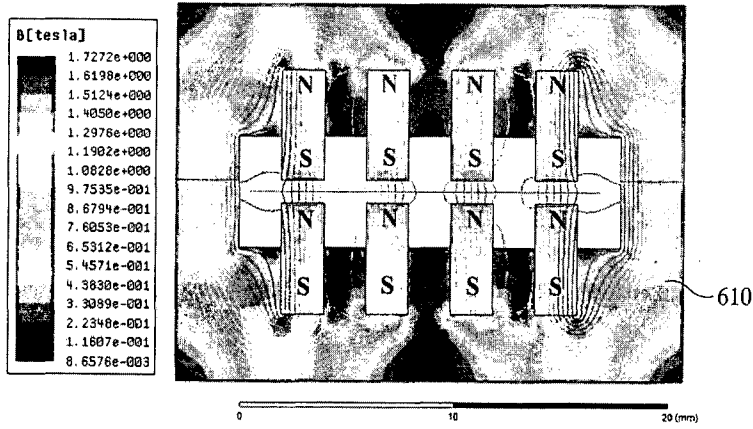
【Figure 9】



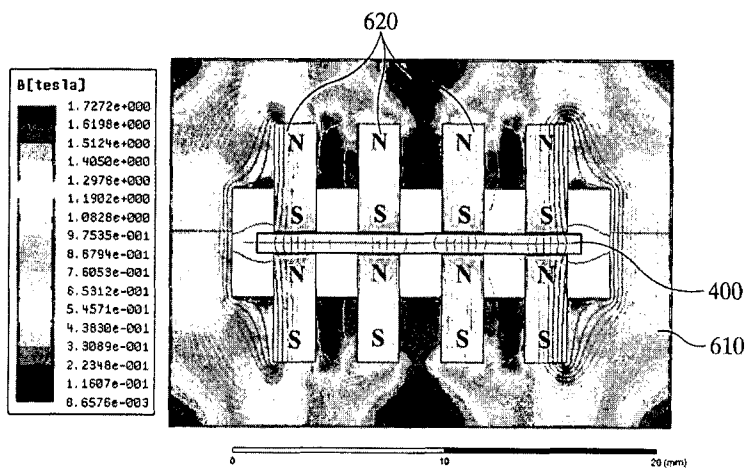
【Figure 10】



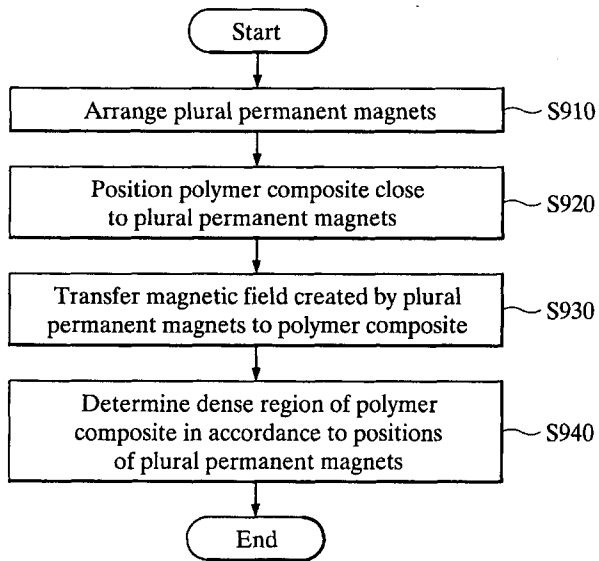
【Figure 11】



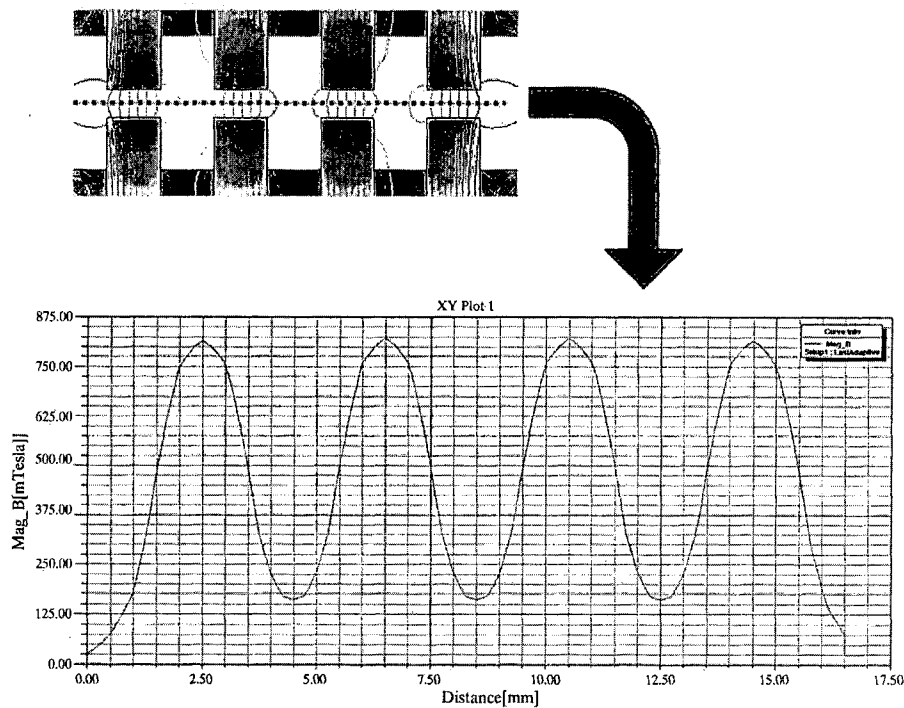
【Figure 12】



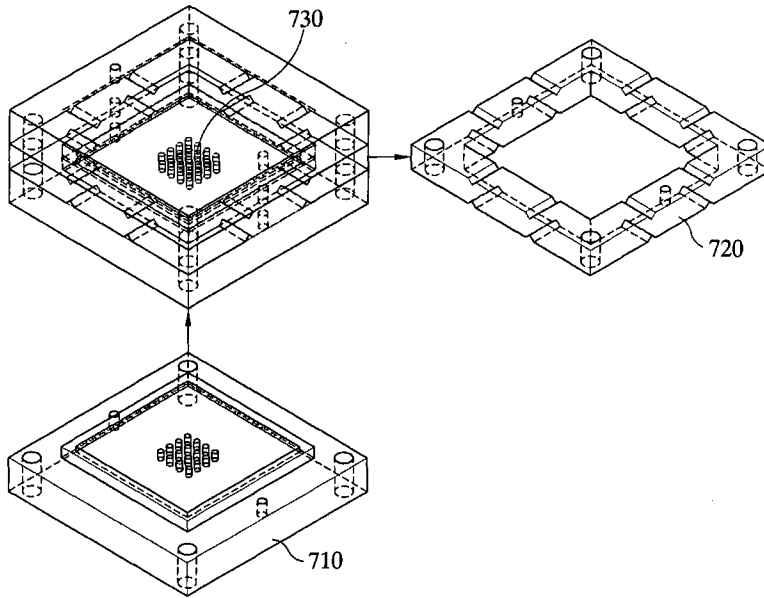
【Figure 13】



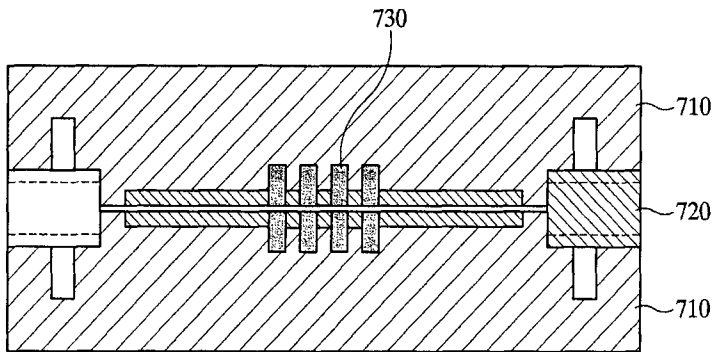
【Figure 14】



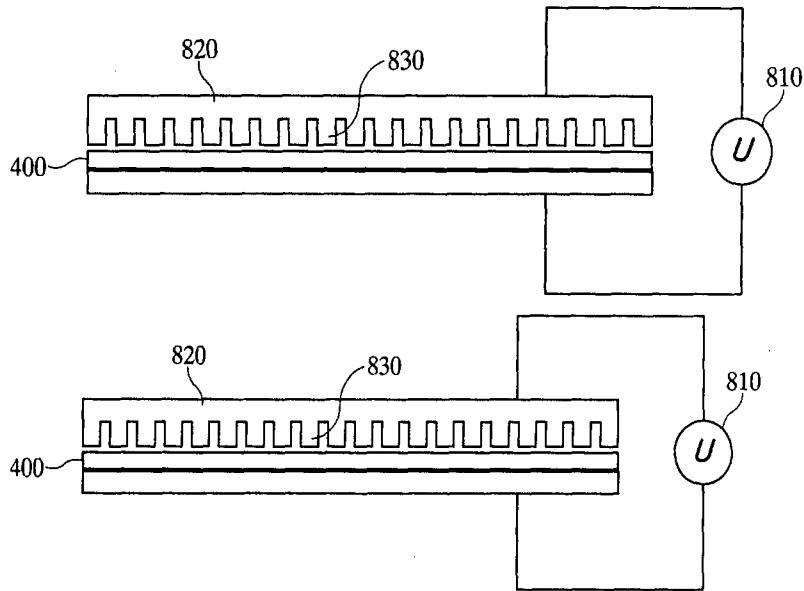
【Figure 15】



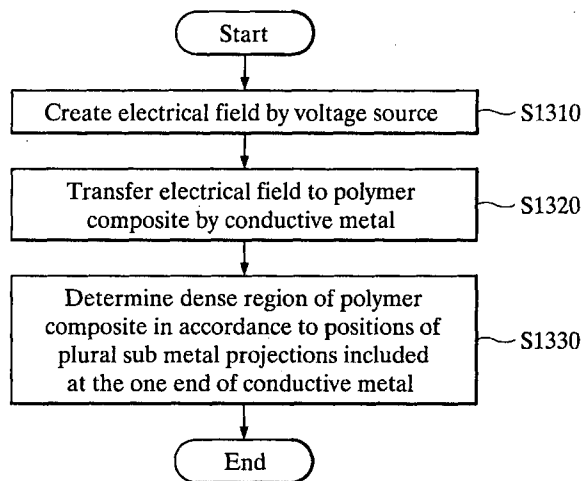
【Figure 16】



【Figure 17】



【Figure 18】



A. CLASSIFICATION OF SUBJECT MATTER**H01B 1/20(2006.01)i, H01F 41/00(2006.01)i**

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)

H01B 1/20; B05D 5/12; H01R 004/04; H01B 1/06; H01B 1/22; H01B 5/00; H01B 001/22; H01B 1/00; H01F 41/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: polymer, rubber, pressure response, non-conductive polymer, first region, second region, filler, solenoid, ferromagnetic core, magnets, volt

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012-0037399 A1 (HSIAO, CHIEN-CHIH et al.) 16 February 2012 See abstract; claims 1, 11, 12; figures 2, 5, 6.	1-5, 8, 17
A		6, 7, 9-16, 18-21
A	US 2010-0187483 A1 (FLEMING, ROBERT et al.) 29 July 2010 See abstract; claim 1; figure 1.	1-21
A	EP 0174777 B1 (MINNESOTA MINING AND MANUFACTURING COMPANY) 14 March 1990 See abstract; claim 1; figure 1.	1-21
A	US 4765930 A (MASHIMO, SATOSHI et al.) 23 August 1988 See abstract; claim 1.	1-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent 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 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

11 July 2013 (11.07.2013)

Date of mailing of the international search report

11 July 2013 (11.07.2013)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2013/002315

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