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(54) COMPOSITE ACTUATOR DEVICE

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(57) **ABSTRACT**

Disclosed is a composite actuator device, which comprises a composite actuator including a silicone and an iron oxide disposed to be mixed inside the silicone, the composite actuator being configured to be driven by applying a power thereto, wherein the composite actuator includes the iron oxide in an amount of 1 to 20 wt %.

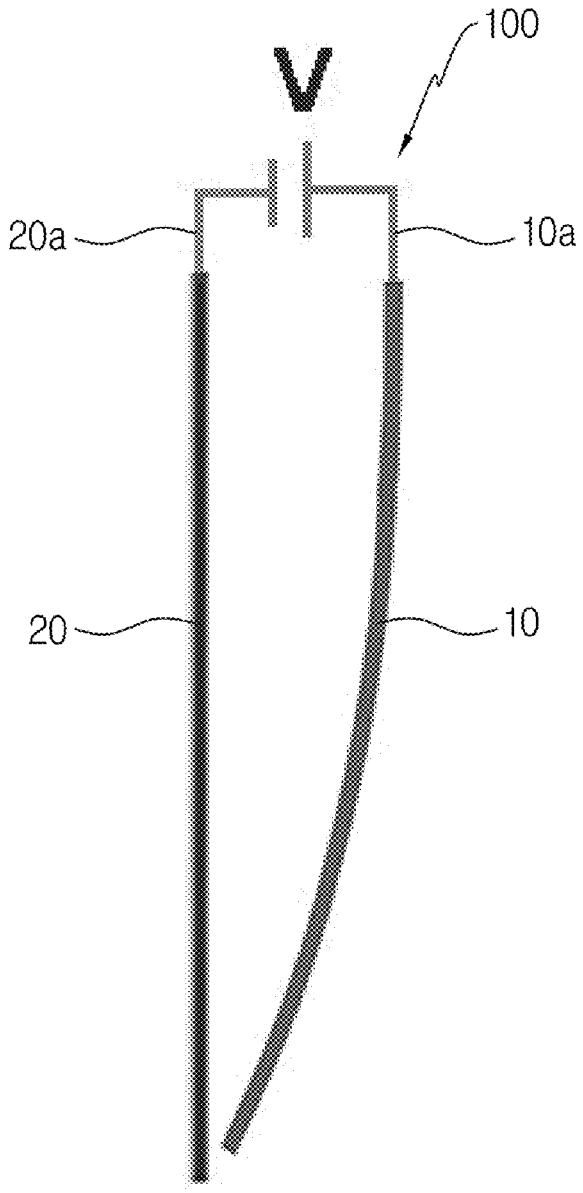

FIG. 1

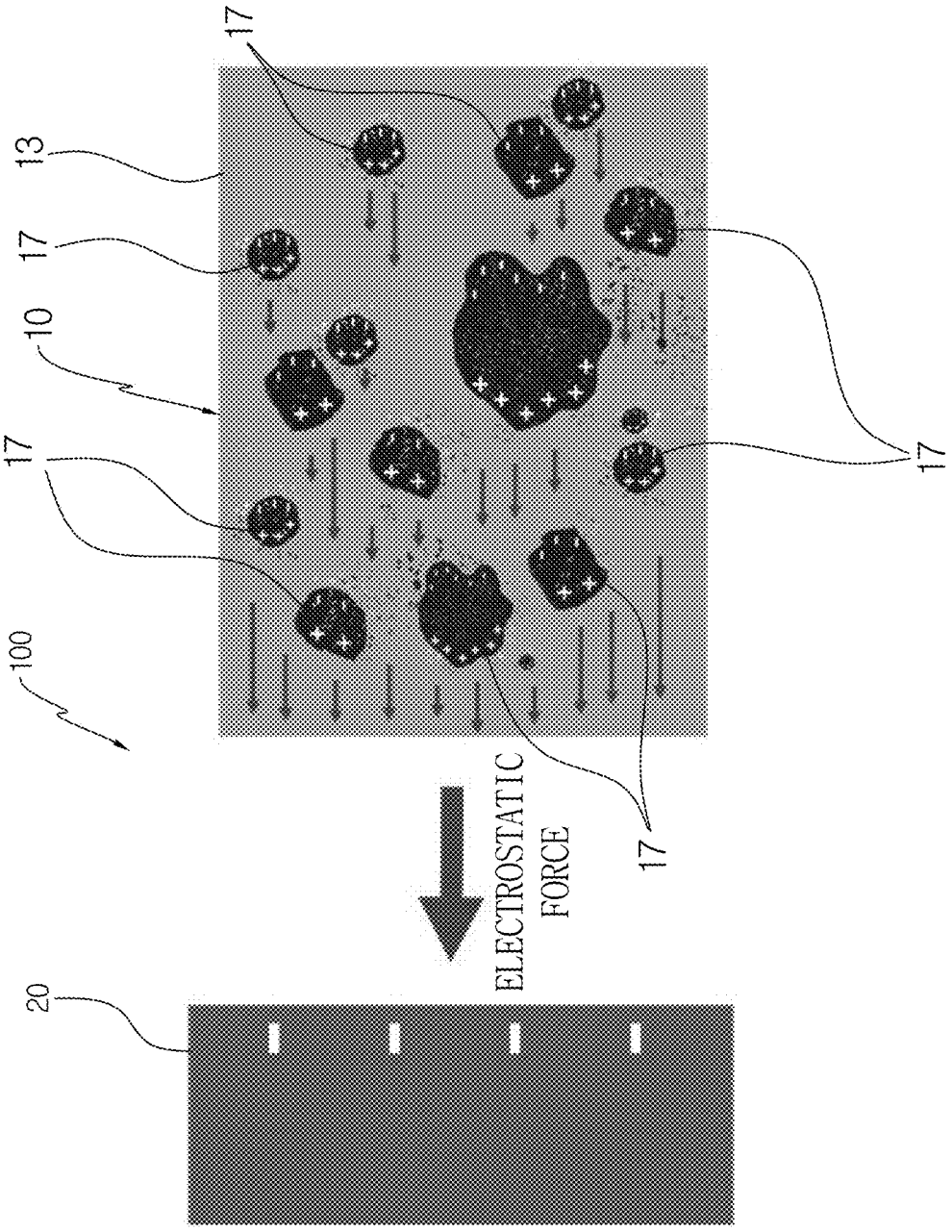

FIG. 2

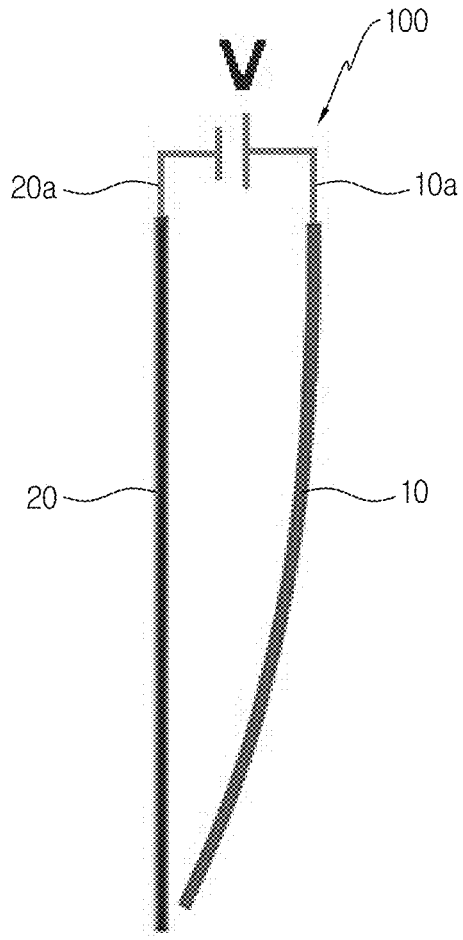

FIG. 3A

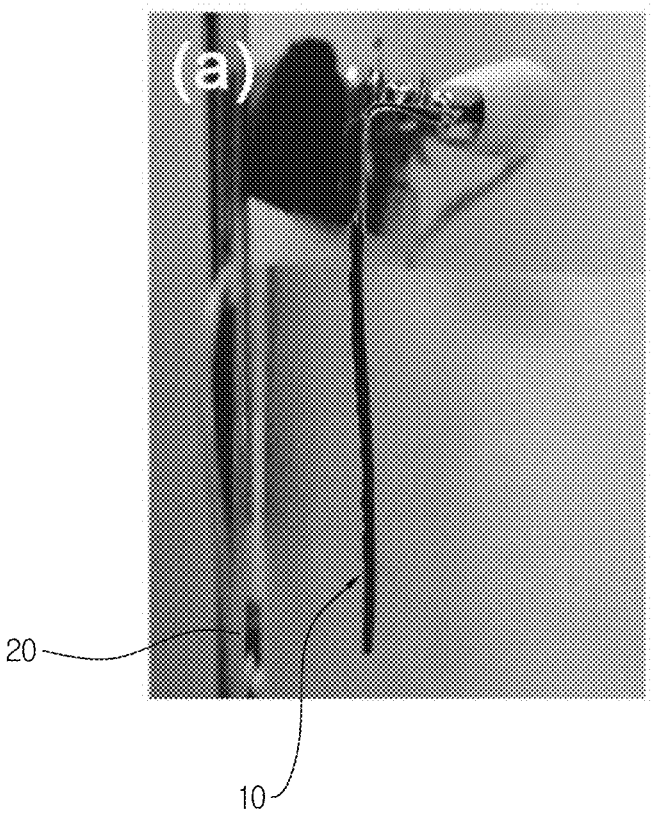

FIG. 3B

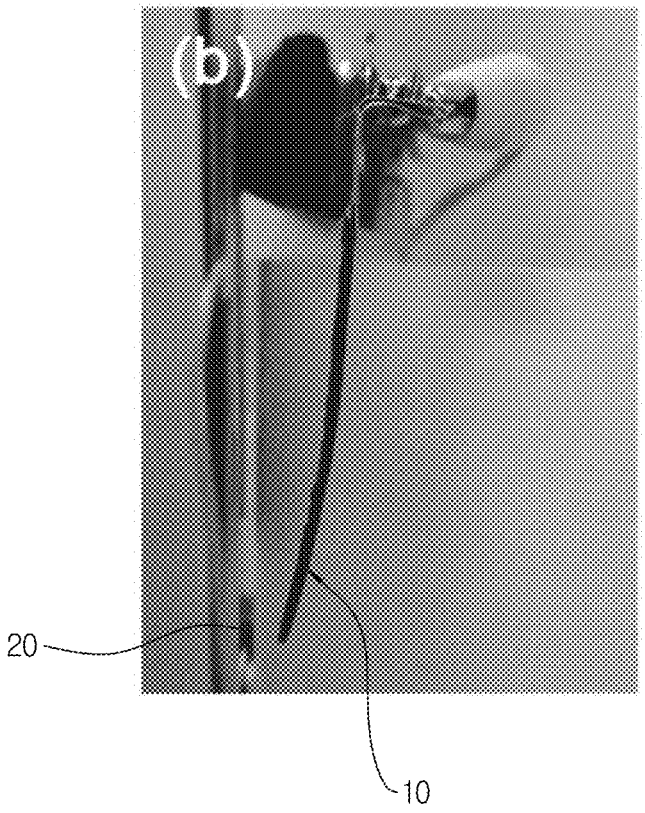

FIG. 3C

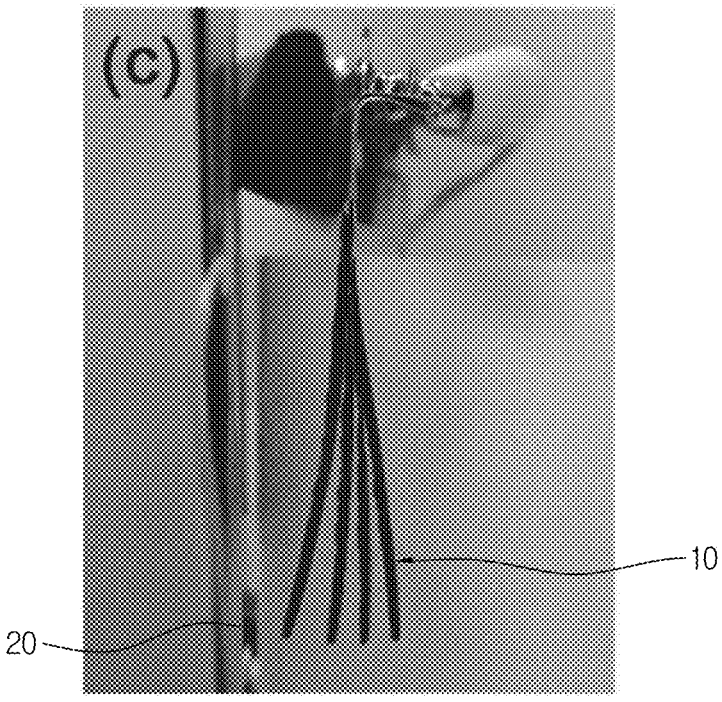

FIG. 4

CONCENTRATION (wt%)	DISPLACEMENT (mm)
1	3.10
1.5	3.92
2	4.29
2.5	4.98
5	5.19
10	4.94
20	4.78

COMPOSITE ACTUATOR DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent Application No.10-2018-0105390, filed on Sep. 4, 2018, and all the benefits accruing therefrom under 35 U.S.C. § 119, the contents of which in its entirety are herein incorporated by reference.

BACKGROUND

1. Field

[0002] The present disclosure relates to a composite actuator device, and more particularly, to a composite actuator device driven by an electrostatic force using charge polarization of an iron oxide and a silicone composite.

2. Description of the Related Art

[0003] As an example of a flexible actuator, an electroactive polymer (EAP) actuator is known in the art.

[0004] The EAP refers to an 'electroactive polymer' that shrinks when electricity is transmitted, and the EAP is used for artificial limbs for disabled persons who require muscle movement, airship wings, artificial heart valves, and artificial skins of fish robots.

[0005] The electroactive polymer (EAP) actuator is driven by electrical stimulation and chemical stimulation such as optics and heat.

[0006] In addition, the EAP actuator includes a dielectric and an elastic actuator, and the electric field-induced activation reaction is triggered by an electrostatic attraction force between two charged conductive layers.

[0007] An ion EAP actuator operates by the movement of ions within a polymer. The ion EAP actuator varies discretely due to small changes in external variables, temperature, solvent quality and pH. Examples of the ion EAP include polymer electrolyte gel, conductive polymer and bucky gel actuators.

[0008] Recently, research on new materials and its manufacturing has been continued, and it is required to develop actuators capable of improving thermal stability and mechanical performance of materials.

SUMMARY

[0009] The present disclosure is directed to providing an actuator device, which may improve thermal stability and mechanical performance of materials.

[0010] In one aspect, there is provided a composite actuator device, comprising a composite actuator including a silicone and an iron oxide disposed to be mixed inside the silicone, the composite actuator being configured to be driven by applying a power thereto, wherein the composite actuator includes the iron oxide in an amount of 1 to 20 wt %.

[0011] In an embodiment of the present disclosure, the iron oxide may be Fe_3O_4.

[0012] In another embodiment of the present disclosure, the composite actuator device of the present disclosure may further comprise a metal plate installed to be spaced apart from the composite actuator by a predetermined distance, wherein when a power is applied, the composite actuator may be driven toward the metal plate by an electrostatic attractive force.

[0013] Preferably, the composite actuator may include the iron oxide in an amount of 4.9 to 5.1 wt %.

[0014] The composite actuator may have a resonance frequency of 3±0.1 Hz.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is a diagram showing an example of a composite actuator device, where an electrostatic force is generated at the composite actuator of the present disclosure by charge polarization.

[0016] FIG. **2** is a diagram showing an example of the composite actuator device according to the present disclosure.

[0017] FIG. **3**A is a diagram showing a state of the composite actuator before operation.

[0018] FIG. **3**B is a diagram showing an example where the composite actuator is driven toward a metal plate.

[0019] FIG. **3**C is a diagram showing another example where the composite actuator is driven toward the metal plate.

[0020] FIG. **4** is a table showing a displacement at each concentration of iron oxide of the composite actuator at a resonance frequency.

DETAILED DESCRIPTION

[0021] Hereinafter, the embodiments disclosed in this specification will be described in detail. Here, identical or similar components are denoted by identical or similar reference symbols and not described in detail again. In the following description, the word "unit" used in terms is selected or endowed only in consideration of ease naming and does not have any distinguishable meaning or role. In addition, in the following description of the embodiments of the present disclosure, any detailed description of related arts can be omitted if it is determined that the gist of the embodiments disclosed herein can be obscured by the same. Moreover, it should be understood that the accompanying drawings are just for better understanding of the embodiments disclosed herein and are not to be construed as limiting the scope of the present disclosure. The scope of the present disclosure should be understood as including all changes, equivalents and alternatives thereof.

[0022] Terms having an ordinal such as "first" and "second" can be used for explaining various components, but the components are not limited by the terms. These terms are just used for distinguishing any component from another.

[0023] In case it is mentioned that any component is "connected" to another component, the component may be connected directly to another component, but it should be understood that any other component can be further interposed between them.

[0024] The singular expressions are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0025] In this specification, the term such as "include" and "have" is just to specify the presence of features, integers, steps, operations, elements, parts or components thereof, stated in the specification, but does not preclude the presence or addition of one or more other features, integers, steps, operations, elements, parts or components thereof.

[0026] First, a composite actuator device **100** according to the present disclosure includes a composite actuator **10**.

[0027] The composite actuator **10** includes a silicone **13** and an iron oxide **17**, and the composite actuator **10** is configured to be driven by applying a power thereto.

[0028] When a power is applied, charges are polarized at the iron oxide **17**, and the silicone **13** is driven by an electrostatic force between an electrode of an external panel and the iron oxide.

[0029] The iron oxide **17** is disposed to be mixed inside the silicone **13**. When a power is applied to polarize charges, the iron oxide **17** generates an electrostatic attractive force to the external panel.

[0030] For example, the iron oxide **17** may be formed by solidifying together with the silicone **13** so that it is distributed inside the silicone **13** here and there in a lump shape.

[0031] FIG. **1** shows an example where the iron oxide **17** is disposed in the silicone **13** to be distributed inside the silicone **13** here and there in a lump shape, and an electrostatic force is generated by charge polarization of the iron oxide **17**.

[0032] In the composite actuator **10**, the amount of the iron oxide **17** is 1 to 20 wt %. For example, the amount of the iron oxide **17** may be 4.9 to 5.1 wt %. In addition, in the composite actuator device **100** of the present disclosure, the iron oxide **17** may be an iron oxide **17** with a chemical formula Fe_3O_4.

[0033] A power source may be electrically connected to the composite actuator **10** to apply a power thereto.

[0034] The composite actuator device **100** of the present disclosure may further include a metal plate **20**. When a power is applied, the composite actuator **10** may be driven toward the metal plate **20** by the electrostatic attractive force.

[0035] The metal plate **20** may be disposed in parallel to the composite actuator **10**. So, when a power is applied, the composite actuator **10** is driven to move close to the metal plate **20**.

[0036] The metal plate **20** may be made of, for example, aluminum (Al).

[0037] Powers with different polarities are preferably applied to the metal plate **20** and the composite actuator **10**.

[0038] FIG. **2** shows an example where electrodes **10***a*, **20***a* of different polarities are connected to the composite actuator **10** and the metal plate **20**.

[0039] In addition, the composite actuator **10** preferably has a resonance frequency of 3±0.1 Hz in order to allow maximum actuation of the composite actuator **10**.

[0040] Due to this configuration, the composite actuator device **100** of the present disclosure is driven by means of an electrostatic force using charge polarization.

[0041] FIG. **3**A shows a state before the composite actuator **10** operates, FIG. **3**B shows an example where the composite actuator **10** is driven toward the metal plate **20**, and FIG. **3**C shows an example where the composite actuator **10** is driven to vibrate toward the metal plate **20**.

[0042] FIG. **4** shows a displacement at each concentration of the iron oxide **17** of the composite actuator **10**, at the composite actuator device **100** according to the present disclosure. Here, the iron oxide **17** has a displacement of 3.1 mm at a concentration of 1 wt %, a displacement of 3.92 mm at a concentration of 1.5 wt %, a displacement of 4.29 mm at a concentration of 2 wt %, a displacement of 4.98 mm at a concentration of 2.5 wt %, a displacement of 5.19 mm at a concentration of 5 wt %, a displacement of 4.94 mm at a concentration of 10 wt %, and a displacement of 4.78 mm at a concentration of 20 wt %.

[0043] From the results in FIG. **4**, it can be found that a maximum displacement is generated when the iron oxide **17** has a concentration of about 5 wt %.

[0044] Meanwhile, the composite actuator device **100** of the present disclosure may be utilized for patient rehabilitation, soft robot parts, continuum robots, small drilling devices, and vibration generation or tactile feedback devices.

[0045] The composite actuator device of the present disclosure may be driven by an electrostatic force between an electrode of an external panel and the composite as charges are polarized at an iron oxide in the composite actuator when a voltage is applied thereto.

[0046] The composite actuator device of the present disclosure may be utilized for patient rehabilitation, soft robot parts, continuum robots, small drilling devices, and vibration generation or tactile feedback devices.

[0047] The composite actuator device **100** described above is not limited to the configuration and method of the embodiments described above, and the embodiments may be modified in various ways by selectively combining all or a part of the embodiments.

[0048] It will be apparent to those skilled in the art that the present disclosure can be embodied in other specific forms without departing from the essential characteristics of the present disclosure. Accordingly, the above detailed description should be considered in all respects as illustrative and not restrictive. The scope of the present disclosure shall be determined by rational interpretation of the appended claims, and all changes within the equivalence scope of the present disclosure shall fall within the scope of the present disclosure.

What is claimed is:

1. A composite actuator device, comprising:

a composite actuator including a silicone and an iron oxide disposed to be mixed inside the silicone, the composite actuator being configured to be driven by applying a power thereto,

wherein the composite actuator includes the iron oxide in an amount of 1 to 20 wt %.

2. The composite actuator device according to claim **1**, wherein the iron oxide is Fe_3O_4.

3. The composite actuator device according to claim **2**, further comprising:

a metal plate installed to be spaced apart from the composite actuator by a predetermined distance,

wherein when a power is applied, the composite actuator is driven toward the metal plate by an electrostatic attractive force.

4. The composite actuator device according to claim **2**,

wherein the composite actuator includes the iron oxide in an amount of 4.9 to 1 wt%.

5. The composite actuator device according to claim **2**, wherein the composite actuator has a resonance frequency of 3±0.1 Hz.

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