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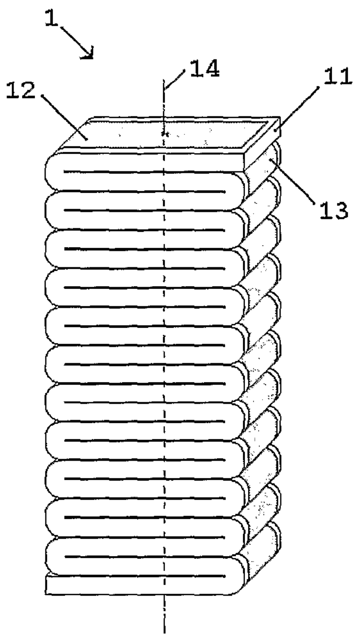
(54) Title: ELECTROACTIVE POLYMER BASED ACTUATOR, SENSOR AND GENERATOR WITH FOLDED CONFIGURATION



(57) Abstract: Electroactive polymer based actuator, sensor and generator (1) with folded configuration, for converting electric energy into mechanical energy or vice-versa, comprising: - at least a first and at least a second monolithic electrode (12, 13), parallel to each other, folded several times, according to folds orthogonal to one axis, and spatially arranged as a sequence of parallel planar parts joined together by the folds, without any solution of continuity; - at least a monolithic element (11), consisting of an electroactive polymer or a solid electrolyte, continuously interposed between the electrodes and resulting alternated to and solidary with them, along the entire device. The device converts electric energy into mechanical energy when between at least a first and at least a second electrode a voltage is applied, causing a deformation of either the material interposed between the electrodes or at least one of the electrodes. The device converts mechanical energy into electric energy when a stress is applied suitable for generating an electric field between at least a first and at least a second electrode.

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TITLE

ELECTROACTIVE POLYMER BASED ACTUATOR, SENSOR AND GENERATOR WITH FOLDED CONFIGURATION

Technical field of the invention

The present invention relates to a device that can be used in particular, but not exclusively, in the field of robotics, automation, micro-technologies and bioengineering for converting electric energy into mechanical energy or vice-versa. In particular, the invention relates to a device based on electroactive polymers and acting as an electromechanical actuator, sensor or generator.

Background of the invention and prior art

Several types of electromechanical actuators, sensors or generators are available to convert electric energy into mechanical energy or vice-versa. Some examples consist of piezoelectric, electrostatic and electromagnetic devices, made of inorganic materials, such as ceramics, semiconductors or metals.

In addition to such well-established technologies, electromechanical devices made of so-called 'electroactive polymers' (shortly 'EAP'), capable of deforming in response to suitable electrical stimuli, are currently available too. EAP can be classified as 'ionic EAP' (comprehending gels, ionic polymer metal composites, conducting polymers and carbon nanotubes) and 'electronic EAP' (including piezoelectric polymers, electrostrictive polymers, dielectric elastomers and flexoelectric polymers). EAP permit to obtain electromechanical devices characterized at least by high compliance, low density and low costs.

Electronic EAP offer at present the best electromechanical performances. Related elementary devices with planar configuration consist of a thin layer of electroactive polymer included between a couple of electrodes. When a certain voltage is applied between them, the material deforms with a variation of its thickness. Therefore, a conversion of electric energy into mechanical energy is achieved, suitable for actuation. On the contrary, for certain materials an imposed deformation can induce an electric potential difference between the electrodes. Accordingly, the device converts mechanical energy into electric energy and can be used as a sensor or electric generator.

A large number of applications can take advantage of EAP based actuators capable of contracting along an axis (linear contractile actuators). Two basic configurations can be used for such a purpose: a multi-layer stack and a helical structure. The first consists of a stack of several elementary planar actuators, connected in mechanical series and electrical parallel. An electrically activated thickness contraction of each layer enables an overall contraction of the entire device. The helical configuration consists of a couple of helical electrodes alternated to a couple of helical EAP layers. A thickness compression of both the EAP layers generates a resulting contraction of the device along its main axis.

Despite the utility of both these configurations, their fabrication with EAP materials presents today some specific problems, basically arising from the peculiarity of each structure. The structural discontinuity of a stack requires multi-step depositions of several EAP layers alternated to layers of electrode material and needs an electrical shorting of the two resulting series of electrodes. The helical configuration offers, on the contrary, a structural continuity but its particular geometry complicates the fabrication. Therefore, a simpler configuration may result advantageous.

Disclosure of the invention

It is therefore a feature of the present invention to describe an EAP based electromechanical device capable of working as an actuator, sensor and generator, structurally much easier than the devices of prior art and with at least comparable performances.

These and other features are accomplished with the electroactive polymer based device with folded configuration, according to the present invention, for converting electric energy into mechanical energy or vice-versa, whose main characteristic is to comprise:

- at least a first and at least a second parallel and monolithic electrodes folded several times, according to folds orthogonal to one axis (main working axis of the device), and spatially arranged as a sequence of parallel planar parts joined together by the folds, without any solution of continuity;
- at least a monolithic element, consisting of an electroactive polymer or a solid electrolyte, continuously interposed between the electrodes and resulting alternated to and solidary with them, along the entire device.

Preferably, the final shape of the or each first and the or each second electrode can be obtained by folding several times a starting planar strip, according to folds orthogonal to one axis.

Preferably, at least one electrode is:

- for electronic-EAP based devices: compliant and advantageously made of either a polymeric material (e.g. elastomer) loaded with conductive fillers (e.g. graphite powder, carbon nanotubes, metal particles, conducting polymers, etc.) or a conducting polymer (e.g. polypyrrole, polyaniline, polythiophene and their derivatives). In the first case, the commercial material Elastosil® LR 3162 A;B produced by Wacker can be advantageously used.

- for ionic-EAP based devices: an ionic electroactive polymer, such as a conducting polymer (e.g. polypyrrole, polyaniline, polythiophene and their derivatives), carbon nanotubes, etc.

Preferably, the element interposed between the electrodes is:

- for electronic-EAP based devices: an electronic electroactive polymer, such as a dielectric elastomer (e.g. silicone, acrylic and polyurethane elastomers, along with related composite derivatives, natural rubber, etc.), a piezoelectric polymer (e.g. PVDF), an electret, an electrostrictive polymer (e.g. PVDF copolymers) or a flexoelectric polymer (e.g. liquid crystal elastomers). In the case of dielectric elastomers, two commercial materials can be used: VHB™ family acrylic tapes by 3M and TC-5005 A/B-C silicone by BJB Enterprises Inc.
- for ionic-EAP based devices: an ionic electroactive polymer, such as an electrolyte gel (e.g. polyacrylonitrile and its derivatives) or a solid electrolyte. In the second case, a commercial perfluorosulfonate ionomer produced by Du Pont under the name of Nafion® can be advantageously used.

By applying a voltage difference between a couple of electrodes of the device, the following actuation mechanism is achieved:

- for electronic-EAP based devices: the generated electric field induces a deformation of the dielectric material interposed between the electrodes, obtaining a conversion of electric energy into mechanical energy. In particular, the dielectric material undergoes substantially the same type of deformation characteristic of a single elementary planar actuator. This consists of a thickness variation with a related axial deformation of the device. As an example, for a dielectric consisting of a dielectric elastomer, an axial contraction of the actuator is obtained.

– for ionic-EAP based devices: electro-chemo-mechanical phenomena (depending on the particular type of material used) determine a dimensional variation of the ionic EAP or the solid electrolyte and, therefore, of the actuator.

As an alternative or in parallel to the use as an actuator, the device can also be used as a sensor of deformation/displacement or force. This can be either passive (e.g. by exploiting the piezocapacitive or the piezoresistive effects) or active (e.g. by exploiting the piezoelectric, the inverse electrostrictive or the inverse electrokinetic effects). The piezocapacitive and the piezoresistive effects consist of the variation, due to an imposed deformation, of the device electrical capacitance and of the electrical resistance of one of the device electrodes, respectively. The exploitation of the piezoelectric or the inverse electrostrictive effects requires the use of dielectric materials intrinsically able to transduce mechanical energy into electric energy, arising as electric charges collected by the device electrodes and used a sensing output. An analogous functionality is enabled by the inverse electrokinetic effect with ionic EAP or solid electrolytes for ionic-EAP based devices.

The device can also be used as an electric generator. For this purpose, the same effects of energy transduction from the mechanical to the electrical form exploitable for active sensing (as described above) can be used. The electric charges collected by the electrodes can be stored into external auxiliary devices, to provide a source of electric power.

In order to use the device as an actuator and a sensor or generator at the same time, advantageously it can consist of separate parts, having each of them a functionality of actuation, sensing or generation. As an example, the device can integrate either an additional compliant conductor, distinct from the electrodes, for piezoresistive sensing or additional couples of electrodes (e.g. at the borders of the structure) to exploit the piezocapacitive, the piezoelectric, the inverse electrostrictive or the inverse electrokinetic effects.

The use of more than one couple of electrodes within the device can permit also an independent activation (either as an actuator, sensor or generator) of different portions of the structure, having a couple of electrodes each. For this purpose, the device can have either an even or an odd number of electrodes (by using a common reference in the second case). As an example, separate activations as actuators of different portions of the device can be used to induce deflections of the structure towards preferential directions.

Advantageously, the entire device or portions of it can be subjected to pre-compressions or pre-tensions, prior to the functional activation, along preferential directions. Such pre-deformations can be used both to improve the mechanical or electrical response of the material (e.g. by changing its elastic modulus or dielectric strength), to increase the electromechanical response of the device (e.g. by decreasing the distance between the electrodes so that to produce higher electric fields) and to favour the actuation towards preferential directions (e.g. by proving different pre-deformations for different portions). Pre-deformations can be obtained and maintained by using either structural elements proper to the device itself (e.g. compression coatings) or external loads.

According to another aspect of the invention, a method for fabricating an EAP based actuator, sensor and generator with folded configuration, according to the present invention, comprises the following steps:

- fabrication (e.g. by mould casting, spin-coating, extrusion, etc.) of a thin continuous planar strip made of electroactive polymer or solid electrolyte (depending on the type of device) and opportunely shaped according to the cross-section preferred for the final device;
- deposition (e.g. by coating, spraying, evaporation, etc.) of at least a first and at least a second electrode on the two surfaces of the strip, so that at least one electrode results eventually compliant or (depending on the type of the device) made of an ionic electroactive polymer;
- repeated folding of the electroded strip, building up a continuous and monolithic structure spatially arranged as a sequence of parallel planar parts joined together by the folds, without any solution of continuity;
- compacting of the structure and eventual pre-compression or pre-tension;
- stabilization of the structure, so that to maintain shape and dimensions, by using for instance a coating (encapsulation) or a special material processing (e.g. thermal or chemical treatments).

According to the described characteristics, the main advantages offered by the present invention, with respect to devices of prior art, consist of:

- in comparison with a multi-layer stack with interdigited electrodes, the device configuration described by the present invention can offer analogous electromechanical performances, owing to a final structure which results substantially equivalent but which can be advantageously obtained without solution of continuity, by using a unique continuous electroded body, instead of a multiplicity of them. This permits the adoption of easier, faster and cheaper fabrication techniques.

- in comparison with the helical structure, the device configuration described by the present invention can offer even greater electromechanical performances, owing to the perpendicularity (and not obliquity) of the electrodes to the working axis. Moreover, although both these configurations have monolithic electrodes, the folded configuration permits, due to a higher structural simplicity, the adoption of easier, faster and cheaper fabrication techniques.

Brief description of the drawings

Further characteristics and advantages of the present invention will be made clearer with the following description of possible exemplary embodiments, with reference to the attached drawings, in which like reference characters designate the same or similar parts throughout the figures, of which:

- figure 1 shows an axonometric view of a device 1, according to the invention, made of a layer of electroactive polymer 11 interposed between two compliant electrodes 12 and 13. The device is shown at rest, that is without any applied voltage;

- figure 2 presents an axonometric view of the device 1 of figure 1, used, according to the invention, as an actuator and shown under axial contraction, due to the application of an electric potential difference ΔV between the electrodes;

- figure 3 shows an axonometric view of a device 2, according to the invention, at rest and consisting of two sub-parts 2a and 2b, being each of them made of an electroactive polymer 21a (21b) interposed between two compliant electrodes 22a and 23a (not visible in figure 3) (22b and 23b);

– figure 4 presents a lateral cross-sectional view of the borders of the device 2 of figure 3, used, according to the invention, as an actuator and shown under lateral deflection, due to the application of an electric potential difference ΔV between the electrodes 22b and 23b;

– figure 5 shows the essential steps of a fabrication method of the device 1, according to the invention, wherein a strip of electroactive polymer 11 is electroded with two compliant electrodes 12 and 13, is folded several times and finally is compacted;

– figure 6 presents, as a different example of embodiment of the device described by the present invention, an axonometric view of a device 3 and of its starting electroded strip, opportunely shaped so that to obtain a final device with a circular (instead of rectangular) cross-section. The strip consists of a layer of electroactive polymer 31 interposed between two compliant electrodes 32 and 33.

Description of preferred exemplary embodiments

Figures 1 and 2 show a first exemplary embodiment of a device 1 that can be used to convert electric energy into mechanical energy or vice-versa, according to the present invention.

In particular, as shown in figure 1, the device comprehends two compliant electrodes 12 and 13 (e.g. made of an elastomer loaded with conductive particles), fabricated on a strip of electroactive polymer 11, for instance of electronic type (e.g. a dielectric elastomer, a piezoelectric polymer, an electret, an electrostrictive polymer or a flexoelectric polymer). The polymer/electrodes complex is folded several times, so that to obtain a continuous and monolithic structure consisting of a sequence of parallel planar parts joined together by the folds.

By applying to the couple of compliant electrodes 12 and 13 a voltage ΔV, a deformation of the electroactive polymer 11 is obtained, by converting electric energy into mechanical energy (actuation). As an example, for an electroactive polymer consisting of a dielectric elastomer, an axial contraction of the actuator along the axis 14 (orthogonal to the planar parts of the electrodes) is obtained, as shown in figure 2, along with a related constant-volume expansion in the plane orthogonal to the same axis. This is a consequence of the thickness contraction of the monolithic dielectric strip.

By neglecting edge effects, the applied electric field results parallel to the working direction of the actuator (axis 14). Therefore, the folded structure described by the present invention is, substantially, functionally equivalent to a multi-layer stack with interdigited electrodes, but results more advantageous in terms of fabrication, since it can be obtained as a unique monolithic body.

According to the invention, the device 1 can also be used to convert mechanical energy into electric energy (by working either as an active sensor of deformation/displacement or force or as an electric generator). This is possible if the element interposed between the electrodes is able to generate an electric field when it is subjected to a mechanical stress. For this purpose, piezoelectric polymers, electrets, electrostrictive polymers, ionic electroactive polymers and solid electrolytes can be advantageously used.

Furthermore, the device 1 can also work as a passive sensor of deformation/displacement or force, according to the piezocapacitive or piezoresistive effect.

According to the invention, the device can comprehend more than one couple of electrodes for a separate activation of different portions. As an example, figure 3 shows such a device 2 consisting of two sub-parts 2a e 2b, being each f them analogous to the device 1 of figure 1. If used as an actuator, the device 2 can undergo a lateral deflection, identified by the tilting of the axes 24a e 24b as shown in figure 4, which can be induced by a different activation of the two portions 2a e 2b. For instance, it is possible either to activate them with a phase opposition (e.g. if the elements 21a and 21b are piezoelectric polymers, electrets or electrostrictive polymers) or to activate the portion 2b only (e.g. if the elements 21a and 21b are dielectric elastomers). In the second case, the portion 2a is inactive and can also be used, for instance, as a piezocapacitive or piezoresistive sensor of deformation/displacement, in order to monitor the deflection of the entire structure.

The method sketched in figure 5 to obtain the device 1 is also applicable for different shapes of the starting planar electroded strip. As an example, figure 6 shows the shape of a strip useful to obtain the device 3 having a circular cross-section.

The foregoing description of a specific embodiment fully reveals the invention according to the conceptual point of view, so that others, by applying current knowledge, will be able to modify and/or adapt for various applications such an embodiment without further research and without parting from the invention, and it is therefore to be understood that such adaptations and modifications will have to be considered as equivalent to the specific embodiment. The means and the materials to realise the different functions described herein could have a different nature without, for this reason, departing from the field of the invention. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

CLAIMS

1. Electroactive polymer based actuator, sensor and generator with folded configuration, for converting electric energy into mechanical energy or vice-versa, characterized in that it comprises:

– at least a first and at least a second parallel and monolithic electrodes folded several times, according to folds orthogonal to one axis (main working axis of the device), and spatially arranged as a sequence of parallel planar parts joined together by the folds, without any solution of continuity;

– at least a monolithic element, consisting of an electroactive polymer or a solid electrolyte, continuously interposed between the electrodes and resulting alternated to and solidary with them, along the entire device.

2. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein the final shape of the or each first and the or each second electrodes can be obtained by folding several times a starting planar strip, according to folds orthogonal to one axis.

3. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least one electrode is compliant (deformable).

4. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least one electrode is made of a polymeric material (e.g. an elastomer) loaded with conductive fillers (e.g. graphite powder, carbon nanotubes, carbon black, metal particles, conducting polymers, etc.)

5. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least one

electrode is made of the commercial material Elastosil® LR 3162 A,B produced by Wacker.

6. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least one electrode is made of a conducting polymer (e.g. polypyrrole, polyaniline, polythiophene and their derivatives).

7. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least one electrode is made of particles of a conductive material (e.g. graphite powder, carbon black, carbon nanotubes, metal, conducting polymer, etc.)

8. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least one electrode is made of an electroactive material consisting of either a polymer, a copolymer, a polymer blend, a macromolecule, a composite, etc.

9. Electroactive polymer based actuator, sensor and generator, according to claim 8, wherein the electrode material is classified as an ionic-type electroactive polymer, such as a conducting polymer (e.g. polypyrrole, polyaniline, polythiophene and their derivatives), carbon nanotubes, etc.

10. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least a first and at least a second electrode have the same shape, structure and spatial arrangement.

11. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least a first and at least a second electrode have different shape, structure and spatial arrangement.

12. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least a

first and at least a second electrode have the same dimensions.

13. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least a first and at least a second electrode have different dimensions.

14. Electroactive polymer based actuator, sensor and generator, according to claim 1, having an even total number of electrodes.

15. Electroactive polymer based actuator, sensor and generator, according to claim 1, having an odd total number of electrodes.

16. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein the element interposed between the electrodes is an electronic-type electroactive polymer, such as a dielectric elastomer (e.g. silicone, acrylic and polyurethane elastomers, along with related composite derivatives, natural rubber, etc.), a piezoelectric polymer (e.g. PVDF), an electret, an electrostrictive polymer (e.g. PVDF copolymers) or a flexoelectric polymer (e.g. liquid crystal elastomers).

17. Electroactive polymer based actuator, sensor and generator, according to claim 16, wherein the electroactive polymer is a commercial dielectric elastomer belonging to the VHB™ family of acrylic tapes produced by 3M.

18. Electroactive polymer based actuator, sensor and generator, according to claim 16, wherein the electroactive polymer is a dielectric elastomer consisting of the commercial silicone TC-5005 A/B-C produced by BJB Enterprises Inc.

19. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein the element interposed between the electrodes is an ionic-type electroactive polymer, such as an electrolyte gel (e.g. polyacrylonitrile and its derivatives).

20. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein the element interposed between the electrodes is a solid electrolyte.

21. Electroactive polymer based actuator, sensor and generator, according to claim 20, wherein the solid electrolyte is Nafion® produced by Du Pont.

22. Electroactive polymer based actuator, sensor and generator, according to claim 1, characterized in that electric energy is converted into mechanical energy when between said at least first and at least second electrode a voltage is applied, causing a deformation of either the material interposed between the electrodes or at least one of the electrodes.

23. Electroactive polymer based actuator, sensor and generator, according to claim 1, characterized in that mechanical energy is converted into electric energy when a stress is applied suitable for generating an electric field between said at least first and at least second electrode.

24. Electroactive polymer based actuator, sensor and generator, according to claim 23, characterized in that it is used as a sensor of deformation/displacement or force.

25. Electroactive polymer based actuator, sensor and generator, according to claim 23, characterized in that it is used as an electric generator.

26. Electroactive polymer based actuator, sensor and generator, according to claim 23, wherein the element interposed between the electrodes operates the energy transduction according to the piezoelectric, the inverse electrostrictive or the inverse electrokinetic effects.

27. Electroactive polymer based actuator, sensor and generator, according to claim 1, wherein at least one electrode is used as a piezoresistive sensor.

28. Electroactive polymer based actuator, sensor and generator, according to claim 1, characterized in that it integrates an additional compliant conductor, distinct from the electrodes, used as a piezoresistive sensor.

29. Electroactive polymer based actuator, sensor and generator, according to claim 1, characterized in that it integrates more than one couple of electrodes, used to separately activate (either as an actuator or as a sensor) different portions of the device.

30. Electroactive polymer based actuator, sensor and generator, according to claim 29, wherein at least one couple of electrodes and the related interposed material are used as a piezocapacitive sensor.

31. Electroactive polymer based actuator, sensor and generator, according to claim 1, characterized in that it is used at the same time or alternatively as an actuator and as a sensor.

32. Electroactive polymer based actuator, sensor and generator, according to claim 29, wherein separate actuations of different portions are used to deflect the device towards preferential directions.

33. Electroactive polymer based actuator, sensor and generator, according to claim 29, wherein some of the electroded portions are used as actuators while others as sensors, at the same time.

34. Electroactive polymer based actuator, sensor and generator, according to claim 1, characterized in that it is subjected to pre-compressions or pre-tensions along preferential directions.

35. Electroactive polymer based actuator, sensor and generator, according to claim 34, wherein pre-compressions or pre-tensions are obtained and maintained by using structural elements proper to the device itself (e.g. compression coatings).

36. Method for fabricating an electroactive polymer based actuator, sensor and generator, according to claim 1, characterized in that it comprises the following steps:

– fabrication (e.g. by mould casting, spin-coating, extrusion, etc.) of a thin continuous planar strip made of electroactive polymer or solid electrolyte (depending on the type of device) and opportunely shaped according to the cross-section preferred for the final device;

– deposition (e.g. by coating, spraying, evaporation, etc.) of at least a first and at least a second electrode on the two surfaces of the strip, so that at least one electrode results eventually compliant or (depending on the type of the device) made of an ionic electroactive polymer;

– repeated folding of the electroded strip, building up a continuous and monolithic structure consisting of a sequence of parallel planar parts joined together by the folds, without any solution of continuity;

– compacting of the structure and eventual pre-compression or pre-tension;

– stabilization of the structure, so that to maintain shape and dimensions, by using for instance a coating (encapsulation) or a special material processing (e.g. thermal or chemical treatments).

Fig. 1

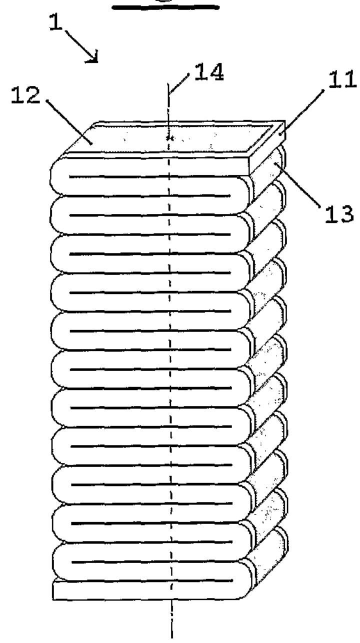


Fig. 2

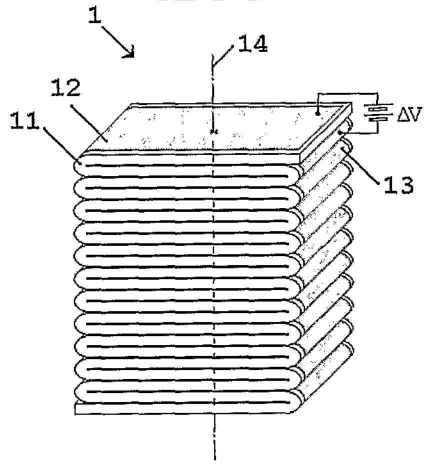


Fig. 3

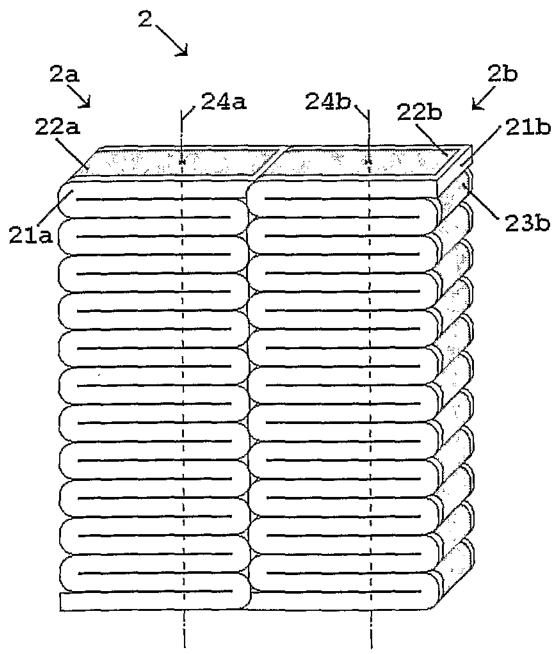


Fig. 4

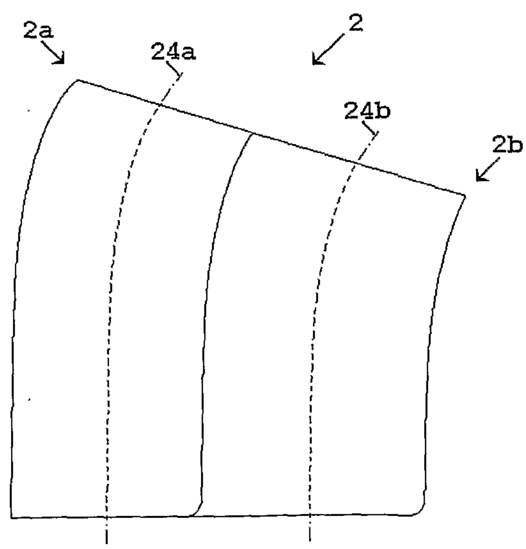


Fig. 5

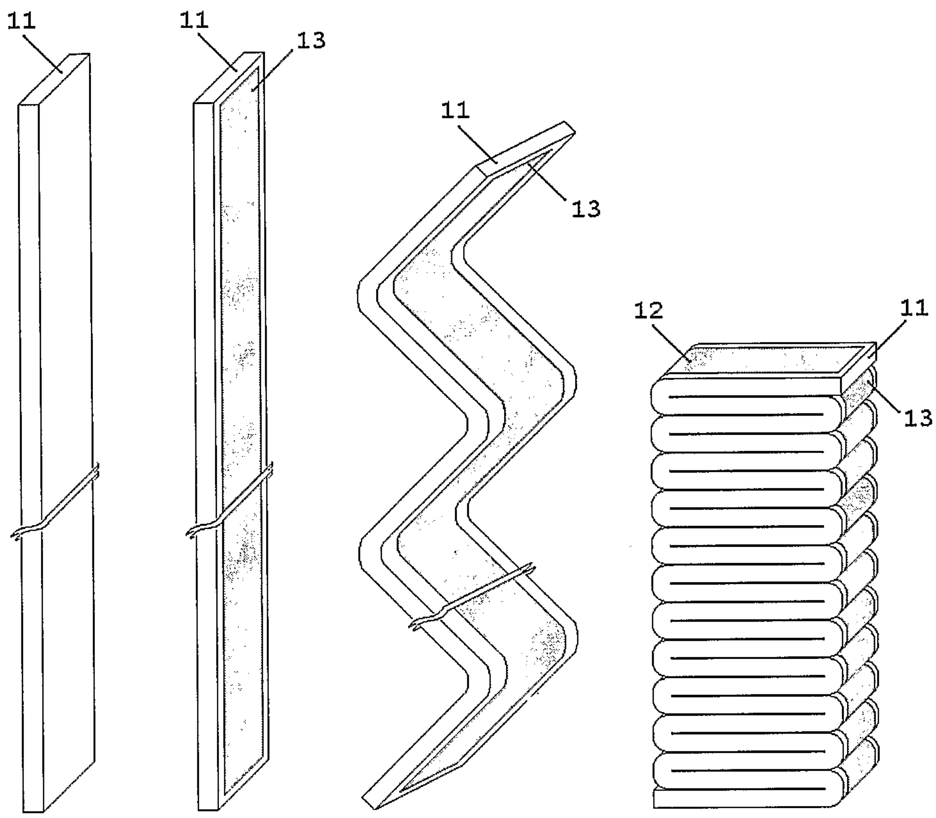
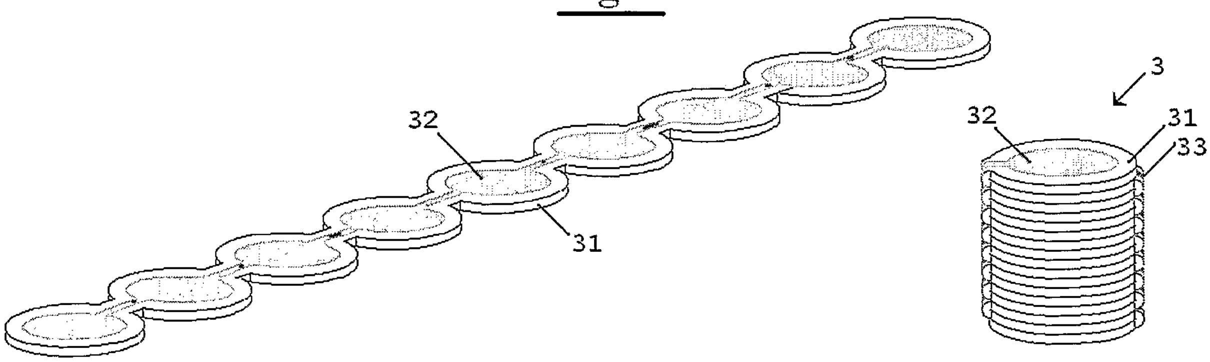


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2006/000634

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L41/083 H01L41/047 H01L41/113 H01L41/193 H01L41/26

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

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

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

EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LEE J K ET AL: "Multilayered piezoelectric flexure device" RESEARCH DISCLOSURE, MASON PUBLICATIONS, HAMPSHIRE, GB, vol. 187, November 1979 (1979-11), pages 627-628, XP002148391 ISSN: 0374-4353	1-3, 10-13, 15-18, 22,29, 31-34
Y	page 628, left-hand column, line 25 - right-hand column, line 57; figures 3,4	1,4-9, 19-21, 28,31,33
A		27,30

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

[X] See patent family annex.

* Special categories of cited documents :

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

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Date of the actual completion of the international search	Date of mailing of the international search report
30 November 2006	21/12/2006

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

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