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(19) **United States**(12) **Patent Application Publication****Suh et al.**(10) **Pub. No.: US 2011/0271497 A1**(43) **Pub. Date: Nov. 10, 2011**(54) **DRY ADHESIVE FASTENER SYSTEM AND METHOD OF USING THE SAME**(52) **U.S. Cl. 24/451; 24/442**

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(57) **ABSTRACT**

Provided are a dry adhesive fastening system which has a relatively superior adhesion, does not almost generate noises during the attaching or detaching operation, has a simplified structure adapted to mass production requirements, and a method of using the same. For this, the dry adhesive fastening system includes a first adhesion member having a first microvillus disposed on a first board and a second adhesion member having a second microvillus disposed on a second board to contact the first adhesion, thereby providing adhesion. Also, unlike the existing velcro fastening system, the hook and loop may not be classified to improve production yield and effectiveness. Also, during the attachment/detachment, the noises may do not occur. In addition, since the microvillus having the micro or nano size is used, the adhesion may be realized even though a very small area is provided. Therefore, the dry adhesive fastening system according to the embodiment of the present invention may be applied in fields greater than those of the existing velcro fastening system.

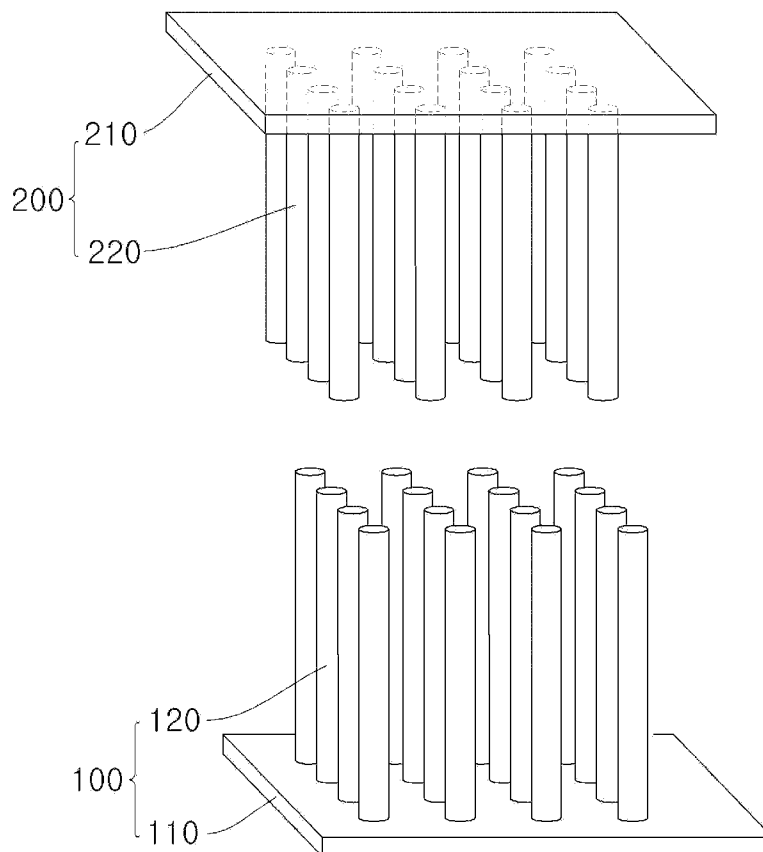


FIG. 1

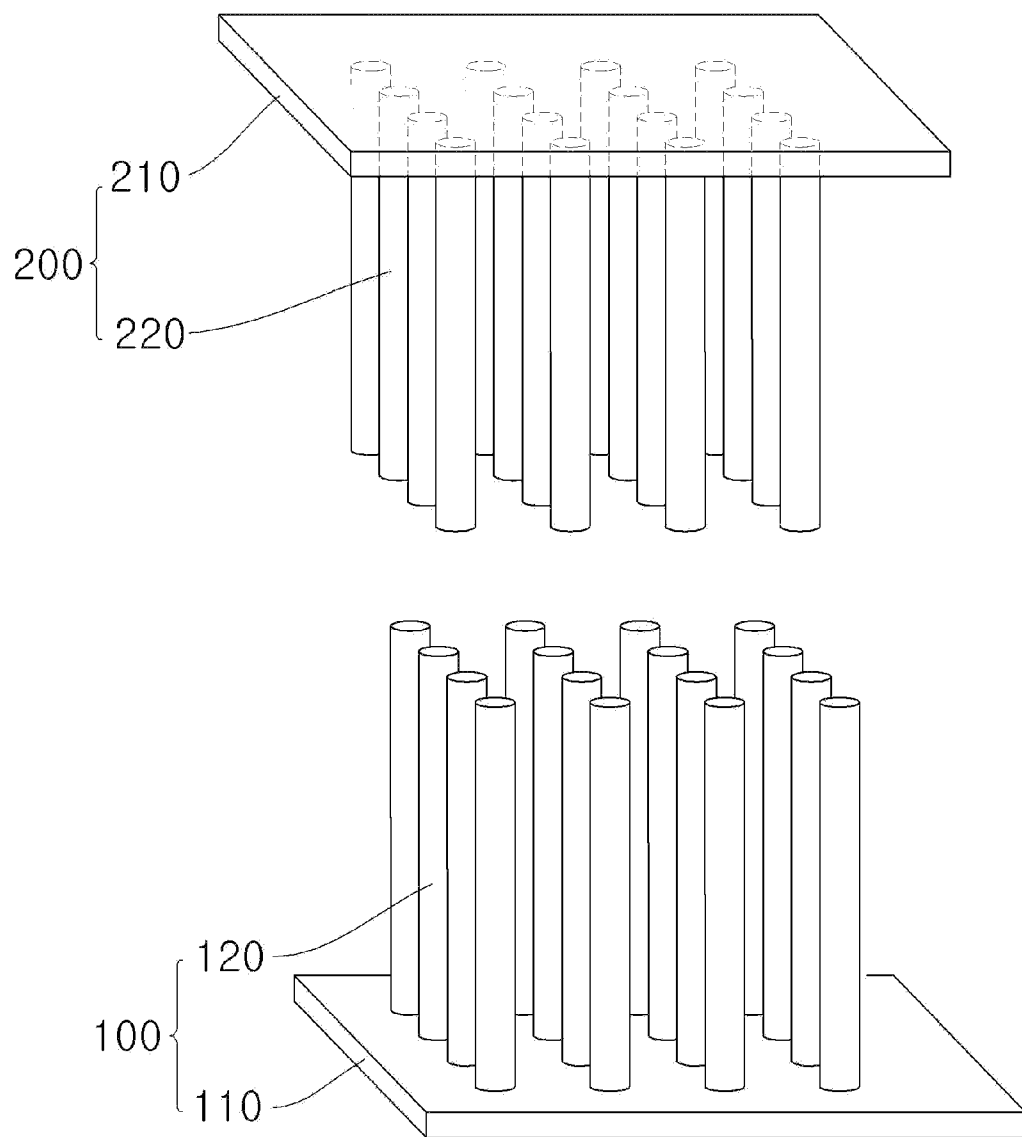


FIG. 2

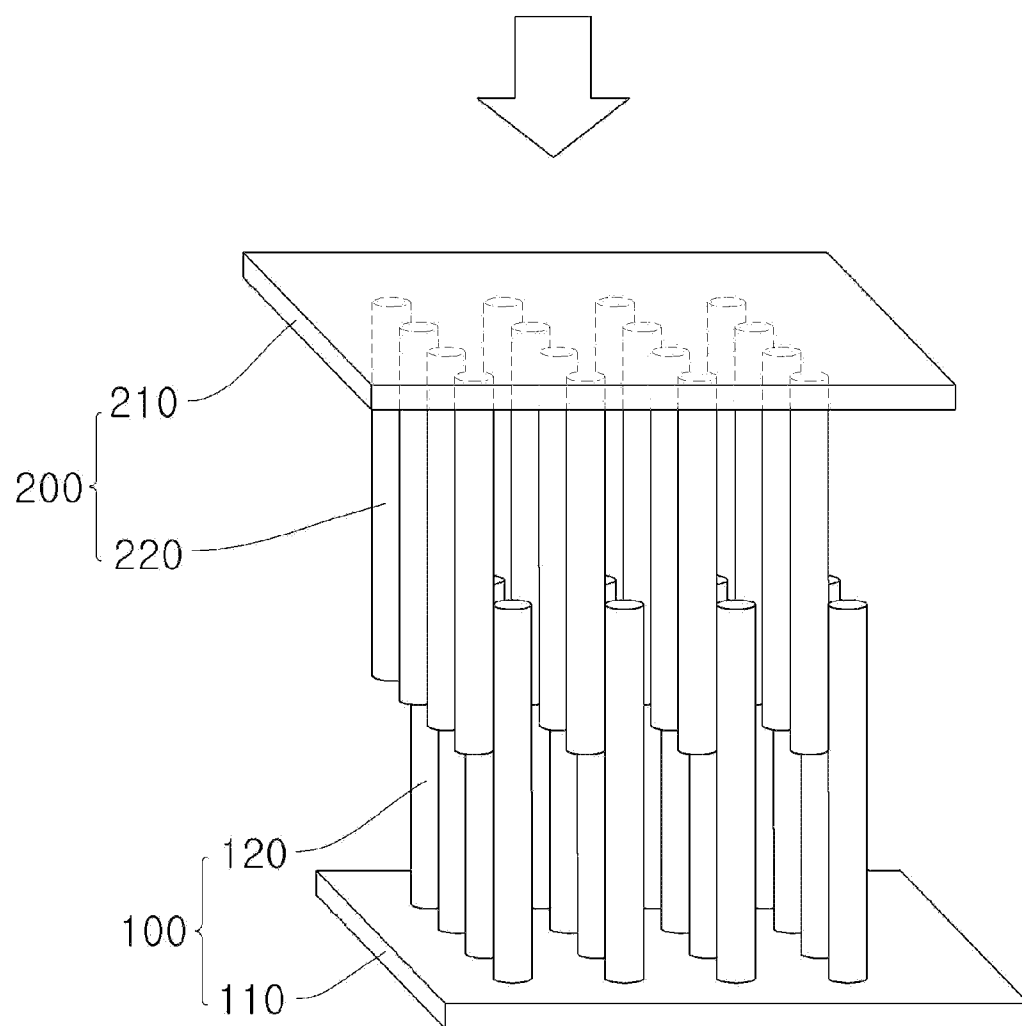


FIG. 3

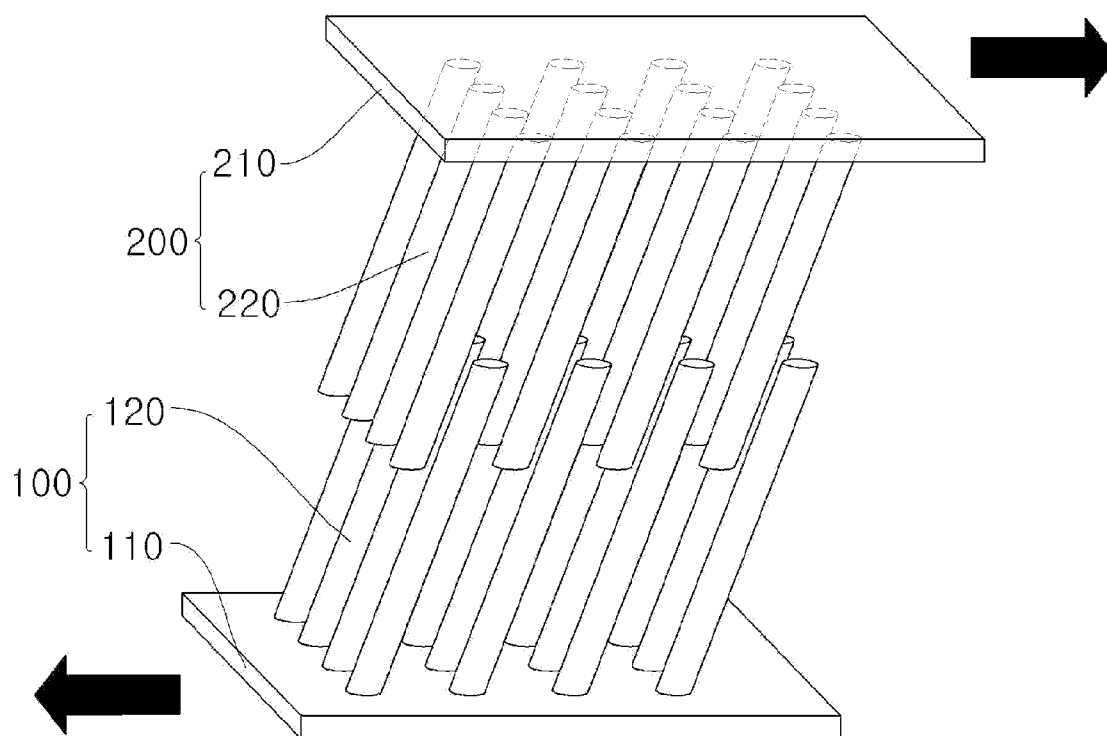


FIG. 4

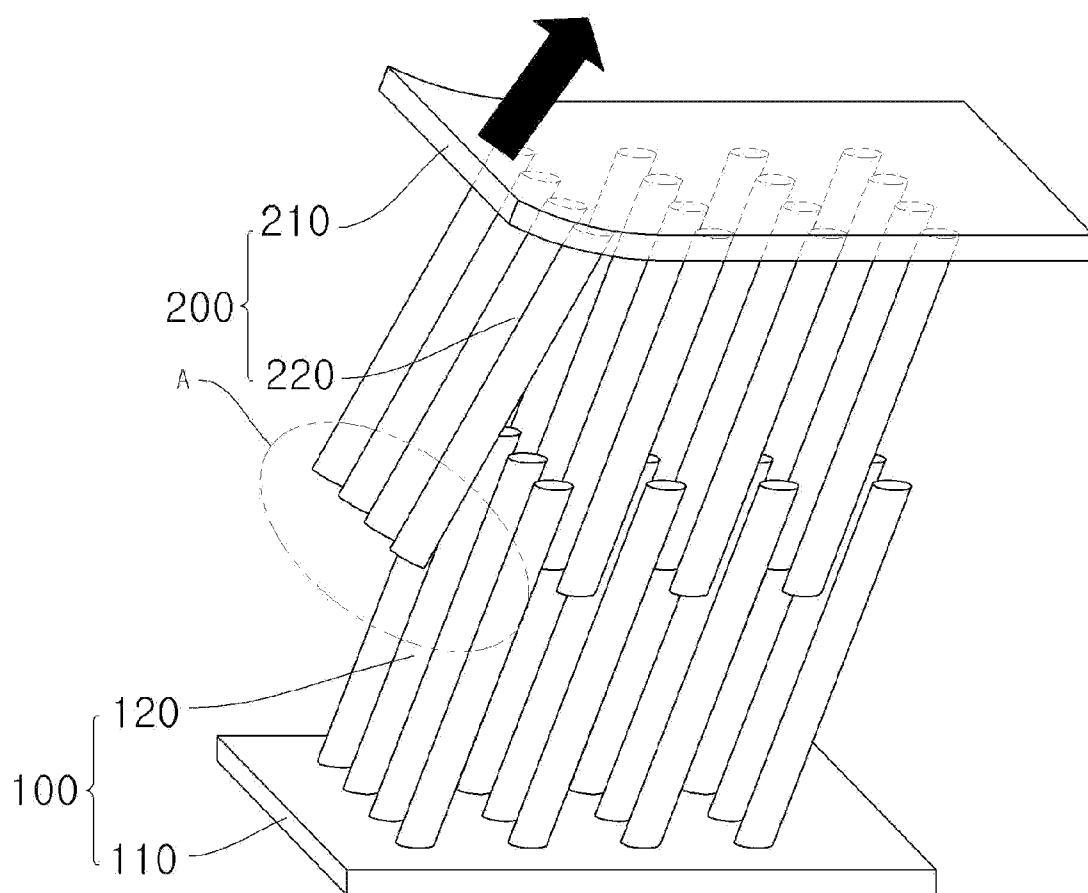


FIG. 5

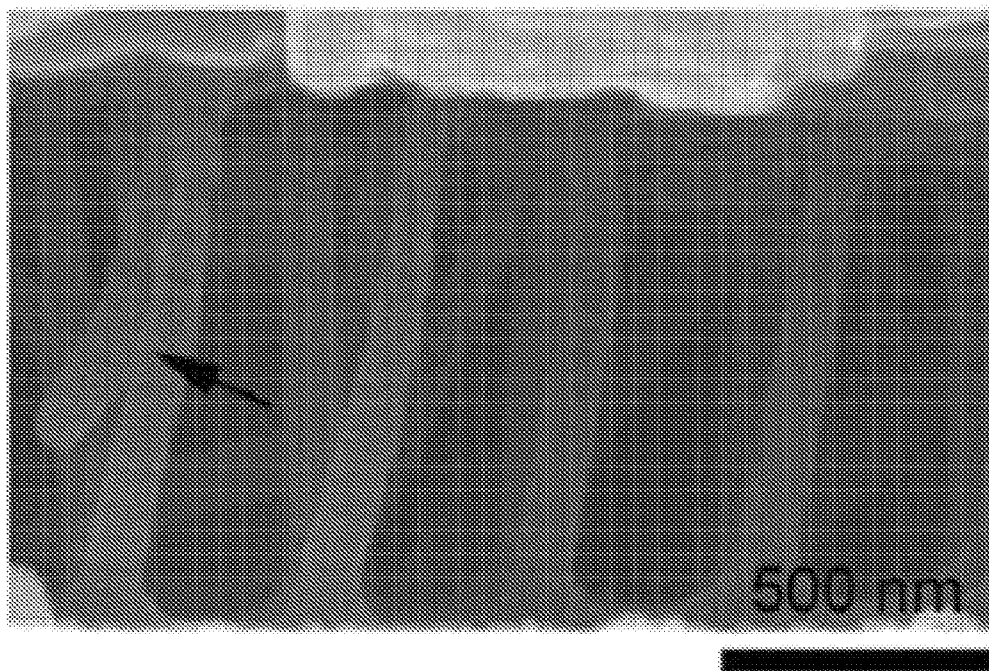


FIG. 6

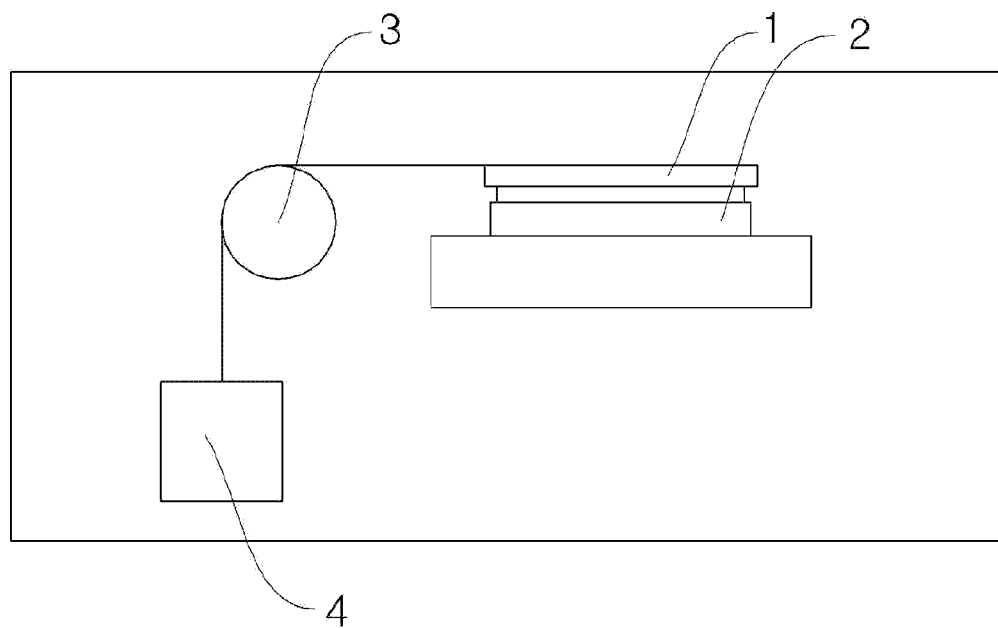
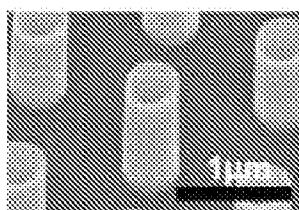


FIG. 7



(a)

FIG. 8

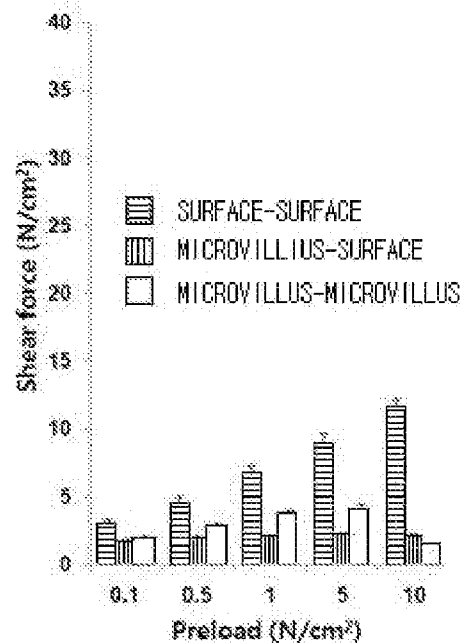
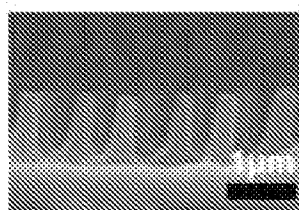


FIG. 9



(b)

FIG. 10

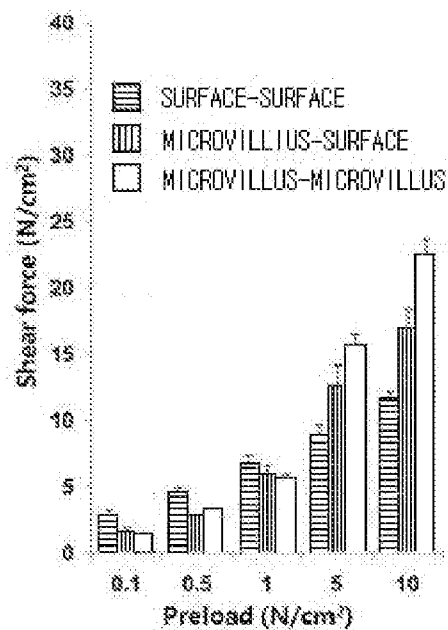


FIG. 11

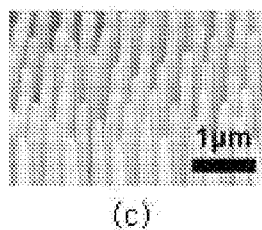


FIG. 12

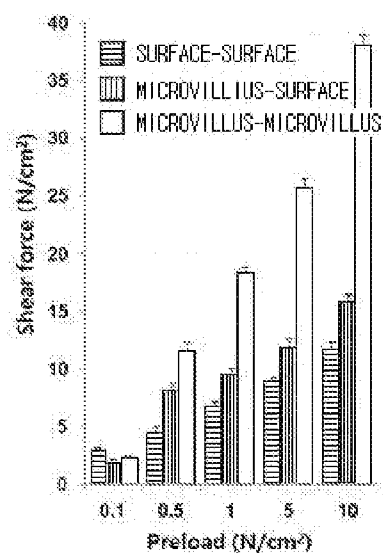
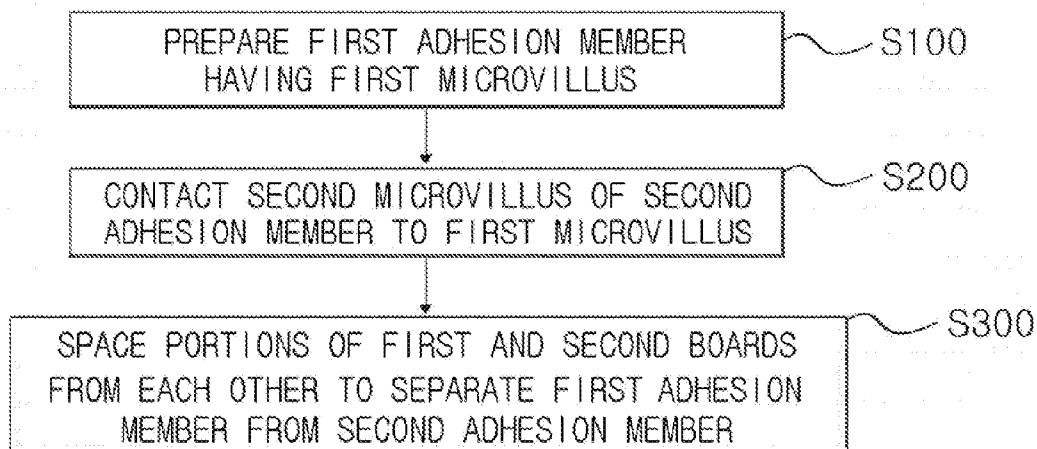


FIG. 13



DRY ADHESIVE FASTENER SYSTEM AND METHOD OF USING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a dry adhesive fastening system and a method of using the same, and more particularly, to a dry adhesive fastening system which has a relatively superior adhesion when compared to that of the existing velcro fastening system, does not almost generate noises during the attaching or detaching operation, has a simplified structure adapted to mass production requirements, and has improved usage convenience, and a method of using the same.

[0003] 2. Description of the Related Art

[0004] In general, an adhesive may be classified into a wet-type adhesive and a dry-type adhesive. For example, an adhesive tape on which an adhesive material is coated on a film is being widely used as a representative wet-type adhesive. However, although the wet-type adhesive has the superior adhesion, it may be difficult to reuse the adhesive when used once. Also, even though the adhesive is separated, an object to which the adhesive adheres (hereinafter, referred to as an "adherend object") such as a substrate, a specific portion of a human body, and an inner wall of a building may be damaged or the adhesive material may remain on a surface of the adherend object.

[0005] Representative examples of the dry-type fastening system may include a hook and loop type velcro adhesive system copied from burdock seeds. The velcro adhesive system was designed first by George de Mestral. Thereafter, the velcro adhesive system is being widely used as a fastener which can be replaced with a zipper or a button. In recent, technologies which supplement the existing velcro structure and technologies in which the supplemented technologies are applied to various application fields such as spacesuits, dive suits, athletic equipment such as skis, children's clothes and fashion bags are being developed.

[0006] For example, such an example is disclosed in Korean Patent Registration Gazette No. 10-0928394 (Nov. 17, 2009), entitled "Velcro fastener". This may be expected to increase the number of hooks per unit area of a tape body, thereby improving an adhesion strength.

[0007] Also, other examples are disclosed in Korean Patent Publication Gazette No. 10-2002-0023343 (Mar. 28, 2002), entitled "Jacket having velcro (jjikjjiky) band", Korean Patent Publication Gazette No. 10-2002-0023341 (Mar. 28, 2002), entitled "Pants jacket having velcro (jjikjjiky) band", Korean Patent Registration Gazette No. 10-0542328 (Jan. 3, 2006), entitled "Velcro-attached wig", Korean Utility Model Registration Gazette No. 20-0356413 (Jul. 6, 2004), entitled "Velcro of ends of sleeve", and Korean Utility Model Registration Gazette No. 20-0379829 (Mar. 15, 2005), entitled "Structure for detaching air-conditioner filter using velcro".

[0008] However, a pair of hooks and loops should be provided in the above-described existing velcro system. Thus, a process for manufacturing the existing velcro system may be cumbersome. Also, since the necessary hooks and loops have structures which are coupled to each other only through an adhesion member including the hooks and an adhesion member including the loops, there are limitations that production efficiency and effectiveness are deteriorated. Also, since a sufficient adhesion force is not provided, its application field

may be limited. For example, when the velcro system is attached or detached, noises may occur.

[0009] To solve the above-described limitations, researches to be copied from adhesion systems found in the natural world are being actively carried out. Among these, a research with respect to an adhesion system copied from sole of tokay gecko's foot is being actively carried out. That is, several hundreds of millions or several billions of microvilli disposed on the sole of the tokay gecko's foot may generate a strong adhesion force due to van der Waals attraction. Researches for developing various dry adhesive fastening systems invented from understanding the microvilli are being attempted.

[0010] Thus, it is required to develop a dry adhesive fastening system with the new concept which improves the limitations of the existing velcro system using the microvilli, i.e., limitations such as low productivity, constraints of use, an insufficient adhesion force, noise occurrence, and demand of a predetermined adhesion area, which occur because hooks and loops are provided in pair.

SUMMARY OF THE INVENTION

[0011] Accordingly, the present invention is directed to a dry adhesive fastening system, which secures economic feasibility in a manufacturing process due to the identical shape of both structures, does not generate noises, and has superior adhesion force, that substantially obviates one or more problems due to limitations and disadvantages of the related art.

[0012] It is an object of the present invention to provide a method of using the dry adhesive fastening system.

[0013] Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0014] In an aspect of the present invention, there is provided a dry adhesive fastening system including: a first adhesion member having a first microvillus disposed on a first board; and a second adhesion member having a second microvillus disposed on a second board to contact the first adhesion, thereby providing adhesion.

[0015] The method according to the present invention provides a method of using a dry adhesive fastening system including: preparing a first adhesion member having a first microvillus disposed on a first board; and preparing a second adhesion member having a second microvillus disposed on a second board to contact the first adhesion, thereby providing adhesion.

[0016] It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illus-

trate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

[0018] FIG. 1 is a schematic view of a dry adhesive fastening system according to an embodiment of the present invention;

[0019] FIGS. 2 and 3 are schematic views for explaining adhesion of the dry adhesive fastening system according to an embodiment of the present invention;

[0020] FIG. 4 is an image photographing a state in which a first adhesion member and a second adhesion member of the dry adhesive fastening system adhere to each other through a microscope according to an embodiment of the present invention;

[0021] FIG. 5 is a schematic view for explaining separation of the dry adhesive fastening system according to an embodiment of the present invention;

[0022] FIG. 6 is a view illustrating a test condition for confirming a tensile strength of the dry adhesive fastening system according to an embodiment of the present invention;

[0023] FIGS. 7 to 12 are graphs for exemplifying a relationship with a tensile strength depending on a size, an aspect ratio, a density, and a pressure of a microvillus structure of the dry adhesive fastening system according to an embodiment of the present invention; and

[0024] FIG. 13 is a flowchart of a method of using the dry adhesive fastening system according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. However, the present invention is not limited to the embodiments illustrated herein after, and the embodiments herein are rather introduced to provide easy and complete understanding of the scope and spirit of the present invention.

[0026] Hereinafter, a dry adhesive fastening system and a method of using the same according to an embodiment of the present invention will be described in detail with reference to the accompanying drawings.

[0027] In a velcro fastening system according to a related art, it is necessary to involve a hook and loop. Here, each of the hook and loop are provided in pair and the pair of hooks and loops are coupled to each other. However, in a dry adhesive fastening system according to an embodiment of the present invention, it is unnecessary to provide a hook and loop. That is, the dry adhesive fastening system is a fastening system with the new concept using a van der waals force generated by the contact of microvilli in which it is unnecessary to separate a hook and loop from each other.

[0028] Also, in the dry adhesive fastening system according to an embodiment of the present invention, a microvillus having a nano size may be provided so that the dry adhesive fastening system is firmly fastened and adheres to an object. In addition, unlike a velcro fastening system according to a related art, it is unnecessary to provide a hook and loop. Thus, a pair of structures having the same shape may adhere to each other.

[0029] FIG. 1 is a schematic view of a dry adhesive fastening system according to an embodiment of the present invention.

[0030] Referring to FIG. 1, a dry adhesive fastening system according to an embodiment of the present invention includes a first adhesion member 100 and a second adhesion member 200.

[0031] Specifically, the first adhesion member 100 includes a first board 110 and a first microvillus 120 disposed on the first board 110. Similarly, the second adhesion member 200 includes a second board 210 and a second microvillus 220 disposed on the second board 210 to adhere to the first microvillus 120.

[0032] According to the existing velcro system, a pair of hook and loop, which have shapes different from each other, are provided. Thus, the pair of hook and loop is mechanically coupled to each other. However, according to the present invention, the microvilli having the same shape or having shapes similar to each other are provided to attach the two adhesion members to each other. Thus, the first adhesion member 100 including the first board 110 and the first microvillus 120 and the second adhesion member 200 including the second board 210 and the second microvillus 220 may have the same shape as each other. That is, although a length, an aspect ratio, and a thickness of the microvillus and a direction of the microvillus with respect to the board are different from each other, both adhesion members, which adhere to each other using the microvilli, have the same shape.

[0033] Each of the first microvillus 120 and the second microvillus 220 has a microvillus structure having a micro or nano size. Also, the first microvillus 120 and the second microvillus 220 have cilia shapes having the same diameter as each other.

[0034] Also, the first board 110 of the first adhesion member 100 and the second board 210 of the second adhesion member 200 may be formed of various materials. That is, each of the first and second boards 110 and 210 may be formed of a flexible polymer resin which is capable of forming a microvillus through implant lithography or capillary force lithography. For example, each of the first and second boards 110 and 210 may be formed of a poly ethylene terephthalate (PET) material.

[0035] Also, the first microvillus 120 of the first adhesion member 100 is disposed on the first board 110. The first microvillus 120 may be disposed perpendicular to the first board 110 or inclined with respect to the first board 110. However, when the first microvillus 120 is inclined with respect to the first board 110, the adhesion members may contact each other so that which the microvilli of both adhesion members approach each other in directions parallel to each other. Thus, both adhesion members may be selected in consideration of the inclined direction.

[0036] When the first and second microvilli 120 and 220 are disposed perpendicular to the first and second boards 110 and 210, a force may be vertically applied to the first board to contact and adhere to the second adhesion member. Thus, if objects to be attached contact each other in a state where the objects are disposed parallel to each other, the microvillus may be vertically disposed with respect to each of the boards 110 and 210.

[0037] The more the number of first and second microvilli 120 and 220 per unit area of each of the first and second boards 110 and 210 are increased, the more the adhesion may be improved. That is, the more a density of the microvilli is increased, the more a van der waals force due to the contact between the microvilli is increased. Thus, the adhesion may

be further improved. Thus, in the dry adhesive fastening system according to the present invention, the density of the microvilli may be adjusted according to an operating environment of the dry adhesive fastening system.

[0038] In the dry adhesive fastening system, the van der waals force may occur when the first adhesion member **100** and the second adhesion member **200** adhere to each other, i.e., the first microvillus **120** of the first adhesion member **100** and the second microvillus **220** of the second adhesion member **200** adhere to each other. Specifically, the van der waals force may occur when ends of the first and second microvilli **120** and **220** adhere to each other or when side surfaces of the first and second microvilli **120** and **220** contact each other in case where an additional pressure is applied to fit (engage) the first and second microvilli **120** and **220** into (with) each other.

[0039] As described above, to increase the van der waals force for providing the adhesion in the dry adhesive fastening system, a contact area between the first microvillus **120** and the second microvillus **220** may be increased. Thus, when the first and second microvilli **120** and **220** contact each other, pressures are respectively applied into the first and second boards to fit (engage) the first and second microvilli **120** and **220** into (with) each other, thereby increasing the contact area therebetween. As a result, the adhesion may be further improved.

[0040] Also, since the first and second adhesion members **100** and **200** do not occur noises almost when they are separated from each other, the first and second adhesion members **100** and **200** may be easily separated from each other using a little force when compared to the velcro adhesion system according to the related art.

[0041] The above-described structure will be described in detail with reference to the accompanying drawings.

[0042] FIGS. **2** and **3** are schematic views for explaining adhesion of the dry adhesive fastening system according to an embodiment of the present invention. FIG. **4** is a schematic view for explaining separation of the dry adhesive fastening system according to an embodiment of the present invention.

[0043] Referring to FIG. **2**, the first adhesion member **100** and the second adhesion member **200** adhere to each other to perform an adhesion process in the dry adhesive fastening system according to an embodiment of the present invention. Here, the first and second microvilli **120** and **220** of the first and second adhesion members **100** and **200** have numberless microvillus structures having the same arrangement as each other. Thus, the first and second microvilli **110** and **220** are crossingly coupled and adhere to each other so that the microvillus structures having the same arrangement as each other are not crushed by overlapping each other.

[0044] Referring to FIG. **3**, even though a strong shear stress is applied into the first and second adhesion members **100** and **200** which adhere to each other through above-described processes, the first and second adhesion members **100** and **200** are not separated from each other due to the adhesion generated by the van der waals force. Furthermore, since the side surface of the first microvillus **120** and the side surface of the second microvillus **220** are closely attached to each other in the process in which the shear stress is applied, the adhesion may be further improved, thereby being endured against a strong pressure.

[0045] Through the above-described processes, the first and second adhesion members **100** and **200** may adhere to each other with a high tensile strength.

[0046] FIG. **4** is an image photographing a state in which a first adhesion member and a second adhesion member of the dry adhesive fastening system adhere to each other through a microscope according to an embodiment of the present invention; Referring to FIG. **4**, it is seen that the first and second adhesion members **100** and **200** adhere to each other to maintain a van der waals force of about 38 N/cm^2 under a relative humidity of about 50%.

[0047] FIG. **5** is a schematic view for explaining separation of the dry adhesive fastening system according to an embodiment of the present invention.

[0048] Referring to FIG. **5**, a process in which the first and second adhesion members **100** and **200**, which adhere to each other through the above-described processes is described. Here, a predetermined force is applied to an end of a side of the second adhesion member **200** to separate the second adhesion member **200** from the first adhesion member **100**. That is, when the end of the side of the second adhesion member **200** (or the first adhesion member **100**) is pulled upward, but is laterally pulled, the adhesion between the first and second adhesion members **100** and **200** may be released from a portion A to separate the second adhesion member **200** from the first adhesion member **100**.

[0049] According to an embodiment, it is seen that the first and second adhesion members **100** and **200**, which adhere to each other with the van der waals force of about 38 N/cm^2 , are separated from each other using a very little force because just a force of about 0.02 N/cm^2 is required for separating the first and second adhesion members from each other.

[0050] As described above, in the dry adhesive fastening system according to an embodiment of the present invention, the first and second adhesion members **100** and **200** adhere to each other using the van der waals force. A method for improving the adhesion will be described below.

[0051] The adhesion between the first microvillus **120** of the first adhesion member **100** and the second microvillus **220** of the second adhesion member **200** may be confirmed by measuring a tensile strength therebetween.

[0052] The tensile strength may be increased as a diameter of each of the first and second microvilli **120** and **220** is decreased, the aspect ratio is increased, and the density of the microvilli is increased. Thus, in the dry adhesive fastening system, the microvillus structure may have a small diameter, a large aspect ratio, and a high density to improve the tensile strength.

[0053] Also, the surfaces of the first and second microvilli **120** and **220** may be intentionally treated to adjust the adhesion therebetween. For example, a self assembly monolayer (SAM) may be formed on the surfaces of the first and second microvilli **120** and **220** using (tridecafluoro-1,1,2,2-tetrahydrooctyl)-trichlorosilane. Alternatively, a metal or a polymer may be additionally coated.

[0054] The methods for improving the tensile strength may be confirmed through tests. FIG. **6** is a view illustrating a test condition for confirming a tensile strength of the dry adhesive fastening system according to an embodiment of the present invention. FIGS. **7** to **12** are graphs for exemplifying a relationship with a tensile strength depending on a size (a thickness of the microvillus), an aspect ratio, a density, and a pressure of the microvillus structure of the dry adhesive fastening system according to an embodiment of the present invention.

[0055] Referring to FIG. **6**, in test conditions for confirming a tensile strength, a pulley **3** is disposed at a center to connect a weight **4** to an adhesion member **1** disposed above the

weight 4 using a wire in a state where a manufactured adhesive system is prepared. A shear stresses (a Y-axis) at a portion on which the upper adhesion member 1 and the lower adhesion member 2 contact each other according to a weight (an X-axis) of the weight is compared to each other through the above-described method. The shear stress is measured at each of contact portions in which the adhesion member is varied in position to classify the contact portions into a surface-surface, a microvillus-surface, and a microvillus-microvillus.

[0056] FIGS. 7, 9, and 11 are photographs of the microvilli. Referring to FIGS. 7, 9, and 11, in the microvilli illustrated in FIGS. 7, 9, and 11, it is seen that a length, an aspect ratio, and a density of each of the microvilli are successively increased in order of FIG. 7, FIG. 9, and FIG. 11 and a thickness (diameter) of the microvillus is successively decreased in order of FIG. 7, FIG. 9, and FIG. 11.

[0057] FIGS. 8, 10, and 12 are graphs illustrating results measured through tests using the microvilli of FIGS. 7, 9, and 11, respectively.

[0058] Here, shear stresses in case where adhesion members having flat shapes on which the microvilli are not provided are used as the pair of adhesion members 1 and 2 contacting each other (surface-surface; see FIGS. 7 and 8), in case where an adhesion member having a flat shape and the adhesion member on which the microvillus is disposed according to an embodiment of the present invention are provided (surface-microvillus; see FIGS. 9 and 10), and in case where the pair of adhesion members on which the microvilli are disposed according to an embodiment of the present invention is provided are compared to each other. Here, in case of the surface-surface of FIG. 7, the share stress is the best. However, in case of the microvillus-microvillus of FIGS. 9 and 10, it is seen that the share stress is the best as the weight is gradually increased in weight.

[0059] Thus, a relationship between a tensile strength and the size, aspect ratio, density, and pressure of the microvillus may be confirmed through the above-described tests. According to the results measured by the above-described tests, it is seen that the more each of the first and second microvillus 120 and 220 is decreased in diameter, increased in aspect ratio, and increased in density, the more the share stress is increased to increase the tensile strength.

[0060] In the dry adhesive fastening system according to an embodiment of the present invention, each of the first and second microvilli 120 and 220 may be formed of one of an UV polymer such as poly urethane acrylate (PUA), polystyrene (PS) polymer, and acryl resin polymer such as poly methyl methacrylate (PMMA).

[0061] The first and second microvilli 120 and 220 formed of the above-described material may be manufactured through nano implant lithography or capillary force lithography. Alternatively, various methods capable of manufacturing a fine structure having a small size may be applied to the embodiment of the present invention.

[0062] For example, the nano implant lithography is well known as a representative method for forming the fine structure. According to the foregoing method, a mold having a large strength may be used to realize the fine structure having several ten nano size.

[0063] A method of using the dry adhesive fastening system according to an embodiment of the present invention will be described below.

[0064] FIG. 13 is a flowchart of a method of using the dry adhesive fastening system according to an embodiment of the present invention.

[0065] Referring to FIG. 13, in a method of using the dry adhesive fastening system, a first adhesion member 100 having a first microvillus 120 formed on a first board 110 is prepared in operation S100. Then, in operation S200, a second microvillus 220 formed on a second board 210 contacts the first microvillus 120 to provide adhesion between the first and second microvilli 120 and 220.

[0066] In operation S200, a force applied when the first and second microvilli 120 and 220 contact each other may be adjusted to adjust the adhesion therebetween. Also, a diameter of the first or second microvillus 120 or 220, a density of the first or second microvillus 120 or 220 formed on the first or second board 110 or 210, or an aspect ratio of the first or second microvillus 120 or 220 may be adjusted to adjust the adhesion.

[0067] Thereafter, if the first adhesion member 100 and the second adhesion member 200 are separated from each other, portions of the first and second boards 110 and 210 contacting each other, i.e., ends of the first and second boards 110 and 210 are spaced from each other to separate the first adhesion member 100 from the second adhesion member 200. That is, when the ends of the first and second boards 110 and 210 adhering to each other through the method illustrated in FIG. 4 are spaced from each other, the first and second adhesion members 100 and 200 may be separated from each other even though a very small force is applied.

[0068] According to the dry adhesive fastening system of the present invention and a method of using the same, the microvilli having the micro or nano size may adhere to each other using the van der waals force to realize a relatively large tensile strength when compared to the existing velcro fastening system. Also, unlike the existing velcro fastening system, the hook and loop may not be classified to improve production yield and effectiveness.

[0069] Also, during the attachment/detachment, the noises may do not occur. In addition, since the microvillus having the micro or nano size is used, the adhesion may be realized even though a very small area is provided. Therefore, the dry adhesive fastening system according to the embodiment of the present invention may be applied in fields greater than those of the existing velcro fastening system.

[0070] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A dry adhesive fastening system comprising:
a first adhesion member having a first microvillus disposed on a first board; and
a second adhesion member having a second microvillus disposed on a second board to contact the first adhesion, thereby providing adhesion.
2. The dry adhesive fastening system of claim 1, wherein each of the first and second microvilli has a micro or nano size.
3. The dry adhesive fastening system of claim 1, wherein each of the first and second boards comprises a poly ethylene terephthalate (PET) board.

4. The dry adhesive fastening system of claim 1, wherein the adhesion between the first and second microvilli is an attraction force due to a van der Waals force.

5. The dry adhesive fastening system of claim 1, wherein each of the first and second microvilli is formed of a UV curable resin.

6. The dry adhesive fastening system of claim 1, wherein the first and second microvilli are disposed perpendicular to the first and second boards, respectively.

7. The dry adhesive fastening system of claim 1, wherein the first and second microvilli are surface-treated to adjust the adhesion therebetween.

8. A method of using a dry adhesive fastening system, the method comprising:

preparing a first adhesion member having a first microvillus disposed on a first board; and

preparing a second adhesion member having a second microvillus disposed on a second board to contact the first adhesion, thereby providing adhesion.

9. The method of claim 8, wherein a force applied when the first and second microvilli contact each other is adjusted to adjust the adhesion.

10. The method of claim 8, wherein each of the first and second microvilli is varied in diameter to adjust the adhesion.

11. The method of claim 8, wherein each of the first and second microvilli respectively formed on the first and second boards is varied in density to adjust the adhesion.

12. The method of claim 8, wherein each of the first and second microvilli is varied in aspect ratio to adjust the adhesion.

13. The method of claim 8, further comprising, after the contacting of the first and second microvilli, spacing portions of the first and second boards from each other to separate the first adhesion member from the second adhesion member.

* * * * *