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(54) Title: MULTI-FUNCTION EMERGENCY BANDAGE

(57) Abstract: A unique multi-functional emergency bandage is introduced, wherein bleeding is stopped by: (1) optimizing mechanical properties and preventing ischemia and/or necrosis while applying enough pressure to help stop bleeding, and (2) incorporating inorganic anti-bleeding nano-structures (embedded within a gauze and/or microbial cellulose) with almost infinite life-time. Additionally, pathogen passage through the bandage is prohibited (via an intermediate filter layer). Together with the overall anti- microbial character of the bandage, the unique multi-functional bandage offers all these vital features within a single design. The unique bandage can be applied by using a single hand and bandaging direction can be changed using a unique binding apparatus. Visual aids, such as printed rectangles, on the final fabric provides the user with an indication of how to control the amount of stretch, as vertical rectangles would turn into horizontal rectangles when stretched too much, whereas rectangles turn to squares around the optimum region of the stress-strain curve.

TITLE

Multi-Function Emergency Bandage

BACKGROUND OF THE INVENTION

Field of Invention

The present invention relates generally to the field of medical bandages. More specifically, the present invention is related to a unique multi-functional bandage in pre-hospital emergency situations such as civilian condition, disaster, conflict area, warfare and other military applications that target uncontrolled bleeding while preventing ischemia, inflammations, necrosis, pathogen and toxic substrate passage through the bandage.

Discussion of Prior Art

Currently, there are a variety of bandages available on the market to be used in pre-hospital and hospital emergency situations as a first-aid device to stop bleeding from hemorrhagic, amputate or crush wounds caused by traumatic injuries. In recent years, trauma-related mortality of 58% in warfare is due to extremity (e.g. arms, legs, head) injuries as reported in "WIA wounded areas" published unclassified by the U.S. Army on 19 March 2003 – 18 May 2004. The applicators in the field, therefore, appreciate a bandage –additionally to other functions disclosed here in this application- having the capability of taking the shape of the body and immobilize itself once placed over the wounded area without extra support. This would make it easier -if not possible- to start bandaging with one-hand especially in the following hard-to-bandage areas besides the extremities: axillar, inguinal, buttock, abdominal, and thoracic areas.

However, only a limited percentage of these bandages are available for pre-hospital emergency situations such as accidents, falling down, catastrophic disaster, conflict area, occupational accident and warfare. More particularly, such prior art bandages suffer from at least one of the following shortcomings, if not all:

1. the prior art bandages fail to optimize physical properties of the construction of the bandage fabric by means of stress-strain curves, and as a results of the lack of such optimization, majority of the bandages on the market either cannot stop bleeding or, in case they do, cause ischemia and/or necrosis due to overpressure;

2. the prior art bandages are often impractical as majority of the bandages on the market today are formed by discrete pieces, requiring such discrete pieces to be assembled together by either a single user utilizing both his/her hands or by two users;

3. the prior art bandages lack a mechanism that offers bio-protection of the wound from the environment as none of the emergency bandages available on the market today can properly isolate the wound from a variety of pathogens, such as microbes and/or viruses;

4. the prior art bandages also lack an optimal mechanism to help stop bleeding as majority of the bandages on the market today do not employ mechanisms promoting blood clotting, as such prior art bandages prevent bleeding by merely applying pressure, which is problematic as mentioned previously in bullet item (1); even in the few cases that have mechanisms to promote blood clotting, such mechanisms are limited to

organic substances, which is a contributing factor to limiting the life time of such a bandage.

5. the prior art bandages lack elastic immobilization stripes around the wound dressing, making it difficult for one-handed application, which renders vital in the field.

6 none of the prior art bandages has optimized and unified all three functions in a single design such as optimization of i) physical properties by means of stress-strain curve and anti-slip stripes, ii) addition of anti-microbial chemical properties, iii) together with incorporating biological properties of pathogen and harmful substrate blocking/trapping as well as of contributing factor to stop bleeding.

The following references are all representative of the prior art mentioned above and suffer from the shortcomings mentioned above.

The patent application to Grau (US 5,628,723) discloses an emergency bandage with an apparatus allowing the user to apply pressure onto the wound and change the bandaging direction abruptly by a single hand.

The patent to Ma et al. (US 7,462,753) provides for a nano-silver wound dressing. In Ma et al., the dressing comprises a skin contact layer, a disinfected antitoxic layer of activated charcoal cloth impregnated with nano-crystalline silver, an isolation layer of a

composite fabric having a very small pore size that provides a barrier to bacterial penetration, and an elastic bandage.

The patent to Bechert et al. (US 7,605,298) provides for a Wound Covering. In Bechert, the wound covering comprises an absorbent matrix of non-woven material having nano-scale silver that contacts the wound and a gas-permeable, liquid impermeable layer 14.

The patent to Dubrow et al. (US 8,025,960) provides for porous substrates, articles, systems and compositions comprising nano-fibers and methods of their use and production. In Dubrow et al., the bandage comprises a flexible porous substrate strip having a nano-fiber coating (wherein the nano-fibers comprises antimicrobial materials, such as ZnO) and a protective pad which provides the contact surface for the wound.

The patent to Daniels et al. (US 8,304,595) provides for a resorbable nano-enhanced hemostatic structures and bandage materials. In Daniels et al., the bandage comprises bandage material and nanoparticles which are provided to assist clotting and slow down the bleeding.

The patent application publication to Villanueva et al. (US 2007/0141130) provides for a wound or surgical dressing. In Villanueva et al., the bandage comprises a

base layer of non-woven sheet or film and a substrate, such as an absorbent pad, positioned in the center of the base layer, the pad having a bacteriostatic composition applied thereto to trap bacteria, pathogens, microbes, etc., wherein the bacteriostatic composition may be an ammonium salt that is embedded within the fibers of the pad.

The patent application publication to Lin et al. (US 2012/0064145) provides for a Wound Dressing. In Lin et al., the double-layer wound dressing comprises an outer polymer material layer containing antibacterial material 11 to function as a bacterial barrier, and a porous carbon material layer having epithelial cells therein to promote wound healing.

The patent to Siniaguine (US 8,237,009) discloses a wound covering comprising a topmost dressing layer fabricated of a non-woven mesh of polymer microfibers and a second layer of non-woven microfiber mesh having a very small pore size sufficient to form a microbe impermeable layer.

The patent application publication to Jung et al. (US 2012/0027681) discloses utilizing carbon nanostructures to deliver a target agent, such as sialic acid, which can be used to target various viruses.

The patent application publication to Vasilev et al. (US 2012/0107592) discloses using copper, silver or gold nano-particles in a wound dressing.

Whatever the precise merits, features, and advantages of the above cited references, none of them achieves or fulfills the purposes of the present invention.

SUMMARY OF THE INVENTION

The present invention discloses a multi-functional emergency bandage comprising: a base layer comprising an elastic textile fabric coated with anti-microbial nano-structures, wherein physical properties of said base layer is optimized using a stress-strain curve to both prevent ischemia and/or necrosis and stop bleeding; an intermediate layer filtering pathogens; and a gauze and/or microbial cellulose that is decorated with anti-bleeding nano-structures. Such a multi-functional emergency bandage may further comprise a plurality of printed geometric shapes disposed on the base layer, wherein an aspect ratio associated with each of the geometric shapes changes as an indication of how much the bandage is stretched corresponding to a calibrated stress. Such a multi-functional emergency bandage may further comprise a binding apparatus disposed on said base layer allowing either a one-handed application of the multifunctional emergency bandage or an abrupt change in bandaging direction. One handed application is further facilitated by the addition of silicone stripes surrounding the

wound dressing in order to increase the friction coefficient between the bandage and the tissue.

The present invention also discloses a multi-functional emergency bandage comprising: a base layer comprising an elastic textile fabric coated with anti-microbial nano-structures, wherein physical properties of said base layer is optimized using a stress-strain curve to both prevent necrosis and stop bleeding, said base layer having a calibrated display disposed thereon; an intermediate layer filtering pathogens; and a gauze and/ or microbial cellulose that is decorated with anti-bleeding nano-structures, wherein an aspect ratio associated with a geometric shape viewable within said calibration display changes as an indication of how much the bandage is stretched corresponding to a calibrated stress.

The present invention also discloses a multi-functional emergency bandage comprising: a base layer comprising an elastic textile fabric coated with anti-microbial nano-structures, wherein physical properties of said base layer is optimized using a stress-strain curve to both prevent necrosis and stop bleeding, said base layer having a plurality of printed geometric shapes are disposed thereon; an intermediate layer filtering pathogens; and a gauze and/ or microbial cellulose that is decorated with anti-bleeding nano-structures, wherein an aspect ratio associated with each of the geometric shapes

changes as an indication of how much the bandage is stretched corresponding to a calibrated stress.

In one embodiment, the strength and slope of said stress-strain curve are maintained around an optimum region such that the multi-functional emergency bandage applies required pressure onto a wound to help stop bleeding while preventing ischemia and/or necrosis due to potential overpressure.

In one embodiment, the strength of said fabric is fixed around an optimum region associated with the stress-strain curve associated with said fabric material, such that the multi-functional emergency bandage applies required pressure onto a wound to help stop bleeding while preventing necrosis due to potential overpressure.

In one embodiment, the slope of said stress-strain curve is set small so that pressure said multi-functional bandage applies onto a wound is a weak function of how much it is stretched but a strong function of how many times it wraps around said wound.

In one embodiment, the anti-microbial nano-structures in the base layer are any of the following: quaterne ammonium nano-swords, metal nano-particles (e.g., silver or gold nano-particles), and antimicrobial oxides (e.g., TiO_2 and ZnO).

In one embodiment, the anti-bleeding nano-structures in the gauze and/or microbial cellulose comprises any of the following: natural minerals known as double salts (e.g., $KNa_{46,72}Ca_3Mg_{1,305}Al_{69,46}HSi_{86,1}S_{42}O_{431}$ nH_2O), synthetic platelets and amino acids sequences.

In one embodiment, the intermediate layer is decorated with microbial and/or viral pathogen blocking structures wherein said microbial and/or viral pathogen blocking structures comprises any of the following: polymer chains containing sialic acid and a sialic acid derivative.

In one embodiment, the base layer around the wound dressing gauze has coated elastic silicone stripes in order to establish high friction coefficient between the bandage and the tissue helping immobilization of the bandage at the initial stage of the application.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A-B and FIGS. 1C-D illustrate two structures associated with two embodiments of the present invention.

FIGS. 2A through 2C illustrate various stress-strain curves in commercially available bandages (FIGS. 2A and 2B) as compared with stress-strain curve of a non-limiting example of a bandage made in accordance with the teachings of the present invention.

FIG. 2D illustrates stress-strain curves measured on a single fiber where the solid line is the measurement of the first run exhibiting a high modulus, whereas the dashed ones are those after the first run, showing the intrinsic fatigue behavior of the elastomeric fiber, exhibiting a lower modulus.

Figure 3 illustrates a comparison of stress-strain curves for picking the optimal properties associated with the present invention's bandage structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

While this invention is illustrated and described in a preferred embodiment, the device may be produced in many different configurations, forms and materials. There is depicted in the drawings, and will herein be described in detail, a preferred embodiment of the invention, with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and the associated functional specifications for its construction and is not intended to limit the invention to the embodiment illustrated. Those skilled in the art will envision many other possible variations within the scope of the present invention.

FIG. 1A, FIG. 1B, FIG. 1C and FIG. 1D depict two embodiments of the present invention's bandage **100**.

In the first embodiment, as shown in FIG. 1A-B, bandage **100** comprises the following layers: a base layer **102** comprising an elastic textile fabric that is coated with anti-microbial nano-structures and with optimized physical properties (i.e., optimized in relation to a stress-strain curve) as well as coated with elastic silicone stripes **103** around the wound dressing gauze to immobilize the bandage to the tissue; an intermediate layer **104** that functions as a filter to trap and block various pathogen families; and gauze and/or microbial cellulose **106** that is decorated with anti-bleeding nano-structures. The multi-functional emergency bandage may further comprise a binding apparatus **110**

disposed on the base layer **102** allowing either a one-handed application of the multifunctional emergency bandage or an abrupt change in bandaging direction. In one embodiment, base layer **102** is woven. In another embodiment, base layer **102** is accompanied by elastomers such as lycra and/or structures containing synthetic yarns made of polyamide and polyurethane, many of which are knitted rather than woven. These offer considerable advantages over their predecessors, being more conformable (and thus easier to apply) as well as more elastic due to the use of new elastomeric yarns. Bandages applied with excessive tension as a consequence cause tissue damage leading to necrosis. Therefore, the safe application of the bandage is achieved by introducing geometrical shapes **108** as visual aids printed throughout the bandage on the base layer, wherein an aspect ratio associated with each of the geometric shapes **108** changes as a function of how much the bandage is stretched. Base layer **102** is further facilitated by the presence of a printed application guide **108** consisting of a rectangular shape that changes to a square when the bandage is extended to the optimum working range of 60-80 mm Hg. The optimum working range is derived based on many clinical trial studies where a certain amount of pressure is applied to the wound to control bleeding without constricting normal circulation and maintaining oxygen delivery to the tissues. Most literature suggests that a pressure of about 70 mm Hg is necessary to nearly occlude the deep femoral veins. Therefore, the bandage fabric tension is pre-programmed into the product during the manufacturing process and calibrated to achieve the 60-80 mm Hg of applied pressure range after certain number of turns. Additionally, the total pressure the

bandage applies is made a weak function of the flexing (i.e., how much it flexes) but is a strong function of the number of turns the user applies. Weak function is a function where the result does not change significantly when the dependent variable changes. On the contrary, a strong function or a heavily dependent function changes significantly even when the variable on which the function is based varies slightly. As examples $f(x)=x+1$ is a much weaker function of x compared to $g(x)=x^2$ due to the fact that for a given variation in dependent variable "x", g changes much more then f. This is achieved by physical pre-aging of the elastic fibers within the fabric construction as seen in FIG. 2D where the solid line shows a measured stress-strain characteristic of an elastomeric fiber at the first test cycle and the other dotted/dashed ones each are those after the first test cycle, representing a consistent and lower Young's modulus. The printed application guide **108**, spread throughout the bandage, will visually help to guide the user on how to apply the bandage correctly as depicted in FIG. 3.

Another embodiment as shown in FIG. 1C-D utilizes a small transparent display to better control the amount of pressure the bandage applies. In this embodiment, the tension of the fabric will be calibrated in the following manner: as the printed rectangular shape **108** is stretched to cover the area denoted by **113**, the user will understand that the strain under this much strain is 100%, which corresponds to a certain amount of pressure to the wound. Similarly, the stretch of **108** to cover the area denoted by **114**, gives 200% etc., which helps the user to achieve the right amount of pressure per turn, say 10 mm Hg

per an additional 100% extension and per turn. Similarly, the stretch of **108** to cover the area denoted by **115**, gives 300% strain. Therefore, the user can apply pressure on the wound accurately and precisely. Element **117** is a transparent piece of plastic to be used as a calibration meter holding the printed numbers "i", "ii", and "iii". Element **116** is a stitch which holds **117** on the fabric. FIG. 1C is a detail of the same embodiment of the emergency bandage. FIG. 1C does not show the bandage structure (as shown in FIG. 1A-B, but represents a visual aid for the user to better control the amount of bandage strain, where the visual aid is somewhere other than the wound dressing part.

The present invention optimizes the physical properties of the construction of the bandage by optimizing its stress-strain behavior. This is accomplished via changing the construction of the fabric that the base layer **102** is formed of, which is formed by various types of fibers each having a different function, by means of fiber cross-sections and their numbers as well as the way the fabric is woven.

The present invention's bandage structure does not allow bacteria to localize on and populate within the bandage matrix, as it uses anti-microbial nano-structures in base layer **102** wherein such anti-microbial nano-structures may be any one of, but not limited to, the following: quaterne ammonium nano-swords, metal nano-particles such as silver and gold, antimicrobial oxides such as TiO_2 and ZnO, natural minerals, wherein such

anti-microbial nano-structures kill the bacteria via destroying cell-walls of a variety of bacteria both Gram+ and Gram-.

The present invention's bandage structure prevents pathogen transfer in both directions through the bandage in order to microbially and virally isolate the wounded region from the environment by trapping and immobilizing them using the intermediate layer **104**. Bacteria and viruses infect the human cells via first interacting with sialic acid (SA) terminated polymer chains (PC) decorating the surface of the human cell and using those as handles to attach onto. Trapping uses the same idea to mimic the surface properties of human cells on textile fabrics in order to trap and immobilize such pathogens.

The present invention's bandage structure also helps halt bleeding by using commercially available products, chemicals or nano-structures embedded within gauze and/or microbial cellulose **106** such as WoundSeal, these products contain hydrophilic polymer and a potassium salt. Together, they work to form an artificial scab over minor cuts. Seal-On products contain cellulose and also work by forming a gel-like layer over the cut. QuikClot® products are made with a natural mineral called zeolite. Zeolite accelerates the body's natural clotting mechanism to create a clot. BloodSTOP® product is made of plant cellulose. When BloodSTOP® comes in contact with blood, it forms a clear gel that seals the wound with a protective transparent layer. Celox™

granules are large surface area flakes and as they come in contact with blood, they swell, gel, and stick together to make a gel like clot, which plugs the bleeding site. Other products such as natural minerals, synthetic platelets and/or amino acids can be used within the gauze and/or microbial cellulose **106** to stop the bleeding. The double salts containing ions of the following elements: Al, Ca, K, Mg, Na, Si, S (such as $KNa_{46,72}Ca_3Mg_{1,305}Al_{69,46}HSi_{86,1}S_{42}O_{431}\ nH_2O$) can be used as well.

The present invention's bandage structure is further decorated with elastic silicone stripes **103** surrounding the wound dressing gauze in order to increase the high friction coefficient between the bandage and the tissue helping immobilization of the bandage at the initial stage of the application, which renders vital for the survival. This anti-slip function allows one to better control the following bandaging turns.

FIG. 2A through FIG. 2C illustrate the measured stress-strain curves of single fibers with different chemical properties which are commercially available (FIG. 2A and FIG. 2B) and the one which is employed in the bandage disclosed in this application (FIG. 2C). Given a specific fabric design and amount of strain, an emergency bandage made out of fibers, of which the stress-strain curve is given in FIG. 2A, might cause necrosis due to excessive force it applies. On the other hand, that of FIG. 2B would not even sustain the stretch required as its breaking point is much lower. Additionally, that of FIG 2B might fail to stop bleeding due to not enough stress being applied. Whereas,

the one depicted in FIG 2C can be used due to its larger expansion range and its low modulus, allowing the present invention to make the pressure the bandage applies a weak function of how much it expands but a strong function of how many turns the user applies.

FIG. 2D depicts a graph of stress versus strain measured during the process of physical pre-aging of the elastic fibers within the fabric construction, where the solid line shows a measured stress-strain characteristic of an elastomeric fiber at the first test cycle and the other dotted/dashed ones each are those after the first test cycle, representing a consistent and lower Young's modulus. The solid line (labeled "1st") is the first cycle of the stress-strain measurement whereas the others, starting from the top of the group, are those measured consecutively after the first one, all belonging to the same sample. During the first measurement, the sample age and, therefore, the other curves go down and their modulus decreases as a result of this aging. The curves shift downward and to the right. The former is due to weakening of the fiber and the latter is due to the fact that the sample is not removed from the sample holder. Therefore, the x-axis expands due to calibration loss as the fiber elongates. A low Young's modulus is desirable. As the fiber is aged just by elongating it once during the fabrication, a lower modulus is attained and its behavior is more stable. That is, the difference between the 1st and 2nd curves is much larger as compared to the 2nd and the 3rd ones. Therefore, it is desired to characterize the final product with the lower curves.

FIG. 3 depicts a comparison of stress-strain curves of three different bandages: weak, optimum and strong, denoted as **200**, **201**, and **202**, respectively. For a given strain denoted as **402**, the weak bandage **200** cannot apply enough stress (a condition shown by dotted vertical line **300**) leading to continued blood loss whereas the strong bandage **202** applies too much pressure causing necrosis (a condition shown by dotted vertical line **301**). The optimum is considered to be somewhere in-between the two extreme conditions denoted as **201**. Considering a single stress-strain curve, say, associated to that of **201** where the shapes **501**, **502**, and **503** exhibit the expected aspect ratios of the printed geometric shapes corresponding to weak (bleeding does not stop), optimum, and overpressure (ischemia and necrosis) regions. Such values are taken from the publications where the conclusion on pressure ranges for optimal blood stopping is extracted by controlled experiments on animals and clinical trials on healthy volunteers (see, for example, the paper to S. Thomas in the EMWA Journal titled "The Use of the Laplace Equation in the Calculation of Sub-Bandage Pressure" and the paper to Logan et al. published in the Journal of Wound Care titled "A Comparison of Sub-Bandage Pressures Produced by Experienced and Inexperienced Bandagers").

CONCLUSION

A system and method has been shown in the above embodiments for the effective implementation of a multi-function emergency bandage. While various preferred embodiments have been shown and described, it will be understood that there is no intent to limit the invention by such disclosure, but rather, it is intended to cover all modifications and alternate constructions falling within the spirit and scope of the invention, as defined in the appended claims. For example, the present invention should not be limited by size, materials, or specific manufacturing techniques.

CLAIMS

1. A multi-functional emergency bandage comprising:

a base layer comprising an elastic textile fabric i) coated with anti-microbial nano-structures and ii) with one or more anti-slip stripes, wherein physical properties of said base layer is optimized using a stress-strain curve to both prevent necrosis and stop bleeding;

an intermediate layer filtering pathogens; and

a gauze and/or microbial cellulose that is decorated with anti-bleeding nano-structures.

2. The multi-functional emergency bandage of claim 1, further comprising a plurality of printed geometric shapes disposed on said base layer, wherein an aspect ratio associated with each of the geometric shapes changes as an indication of how much the bandage is stretched, corresponding to a calibrated stress.

3. The multi-functional emergency bandage of claim 2, further comprising calibration displays that are disposed on said base layer, wherein said geometric shapes change to a first pre-determined shape at a first stress level and to a second pre-determined shape at a second stress level, said first and second stress level corresponding to an applied pressure value picked between 60-80 mm Hg.

4. The multi-functional emergency bandage of claim 1, further comprising calibration displays disposed on said base layer, wherein an aspect ratio associated with a geometric shape viewable within said calibration display changes as an indication of how much the bandage is stretched corresponding to a calibrated stress.

5. The multi-functional emergency bandage of claim 1, wherein strength and slope of said stress-strain curve are maintained around an optimum region such that the multi-functional emergency bandage applies required pressure onto a wound to help stop bleeding while preventing necrosis due to potential overpressure.

6. The multi-functional emergency bandage of claim 1, wherein strength of said fabric is fixed around an optimum region associated with the stress-strain curve associated with said fabric material, such that the multi-functional emergency bandage applies required pressure onto a wound to help stop bleeding while preventing necrosis due to potential overpressure.

7. The multi-functional emergency bandage of claim 1, wherein slope of said stress-strain curve is set small by using fatigue behavior of elastomers so that a pressure said multi-functional bandage applies onto a wound is a weak function of how much it is stretched but a strong function of how many times it wraps around said wound.

8. The multi-functional emergency bandage of claim 1, wherein said anti-microbial nano-structures are any of the following: quaterne ammonium nano-swords, metal nano-particles, and antimicrobial oxides.

9. The multi-functional emergency bandage of claim 1, wherein said anti-microbial nano-structure comprises metal nanoparticles selected from the group consisting of: silver or gold.

10. The multi-functional emergency bandage of claim 1, wherein said anti-microbial nano-structure comprises antimicrobial oxides selected from the group consisting of: TiO_2 and ZnO.

11. The multi-functional emergency bandage of claim 1, wherein said anti-slip stripes are coatings or printings, composed of chemical compounds having high friction coefficients.

12. The multi-functional emergency bandage of claim 1, wherein said anti-slip stripes comprise silicon rubber based mixtures or silicone derivatives.

13. The multi-functional emergency bandage of claim 1, wherein said anti-bleeding nano-structures comprises any of the following: natural minerals known as double salts, synthetic platelets and amino acids.

14. The multi-functional emergency bandage of claim 1, wherein said double salt is $KNa_{46,72}Ca_3Mg_{1,305}Al_{69,46}HSi_{86,1}S_{42}O_{431}\ nH_2O$.

15. The multi-functional emergency bandage of claim 1, wherein said intermediate layer is decorated with microbial and/or viral pathogen blocking structures.

16. The multi-functional emergency bandage of claim 15, wherein said microbial and/or viral pathogen blocking structures comprise any of the following: polymer chains containing sialic acid and a sialic acid derivative.

17. A multi-functional emergency bandage comprising:

a base layer comprising an elastic textile fabric coated with anti-microbial nano-structures, wherein physical properties of said base layer is optimized using a stress-strain curve to both prevent necrosis and stop bleeding, said base layer having a calibrated display disposed thereon;

an intermediate layer filtering pathogens; and

a gauze and/or microbial cellulose that is decorated with anti-bleeding nano-structures,

wherein an aspect ratio associated with a geometric shape viewable within said calibration display changes as an indication of how much the bandage is stretched corresponding to a calibrated stress.

18. The multi-functional emergency bandage of claim 17, wherein strength and slope of said stress-strain curve are maintained around an optimum region such that the multi-functional emergency bandage applies required pressure onto a wound to help stop bleeding while preventing necrosis due to potential overpressure.

19. The multi-functional emergency bandage of claim 17, wherein strength of said fabric is fixed around an optimum region associated with the stress-strain curve associated with said fabric material, such that the multi-functional emergency bandage applies required pressure onto a wound to help stop bleeding while preventing necrosis due to potential overpressure.

20. The multi-functional emergency bandage of claim 17, wherein slope of said stress-strain curve is set small by using fatigue behavior of elastomers so that a pressure said multi-functional bandage applies onto a wound is a weak function of how much it is stretched but a strong function of how many times it wraps around said wound.

21. The multi-functional emergency bandage of claim 17, wherein said anti-microbial nano-structures are any of the following: quaterne ammonium nano-swords, metal nano-particles, and antimicrobial oxides, said metal nanoparticles selected from the group consisting of: silver or gold and said antimicrobial oxides selected from the group consisting of: TiO_2 and ZnO.

22. A multi-functional emergency bandage comprising:

a base layer comprising an elastic textile fabric coated with anti-microbial nano-structures, wherein physical properties of said base layer is optimized using a stress-strain curve to both prevent necrosis and stop bleeding, said base layer having a plurality of printed geometric shapes are disposed thereon;

an intermediate layer filtering pathogens; and

a gauze that is decorated with anti-bleeding nano-structures,

wherein an aspect ratio associated with each of the geometric shapes changes as an indication of how much the bandage is stretched corresponding to a calibrated stress.

ABSTRACT OF THE DISCLOSURE

A unique multi-functional emergency bandage is introduced, wherein bleeding is stopped by: (1) optimizing mechanical properties and preventing ischemia and/or necrosis while applying enough pressure to help stop bleeding, and (2) incorporating inorganic anti-bleeding nano-structures (embedded within a gauze and/or microbial cellulose) with almost infinite life-time. Additionally, pathogen passage through the bandage is prohibited (via an intermediate filter layer). Together with the overall anti-microbial character of the bandage, the unique multi-functional bandage offers all these vital features within a single design. The unique bandage can be applied by using a single hand and bandaging direction can be changed using a unique binding apparatus. Visual aids, such as printed rectangles, on the final fabric provides the user with an indication of how to control the amount of stretch, as vertical rectangles would turn into horizontal rectangles when stretched too much, whereas rectangles turn to squares around the optimum region of the stress-strain curve.

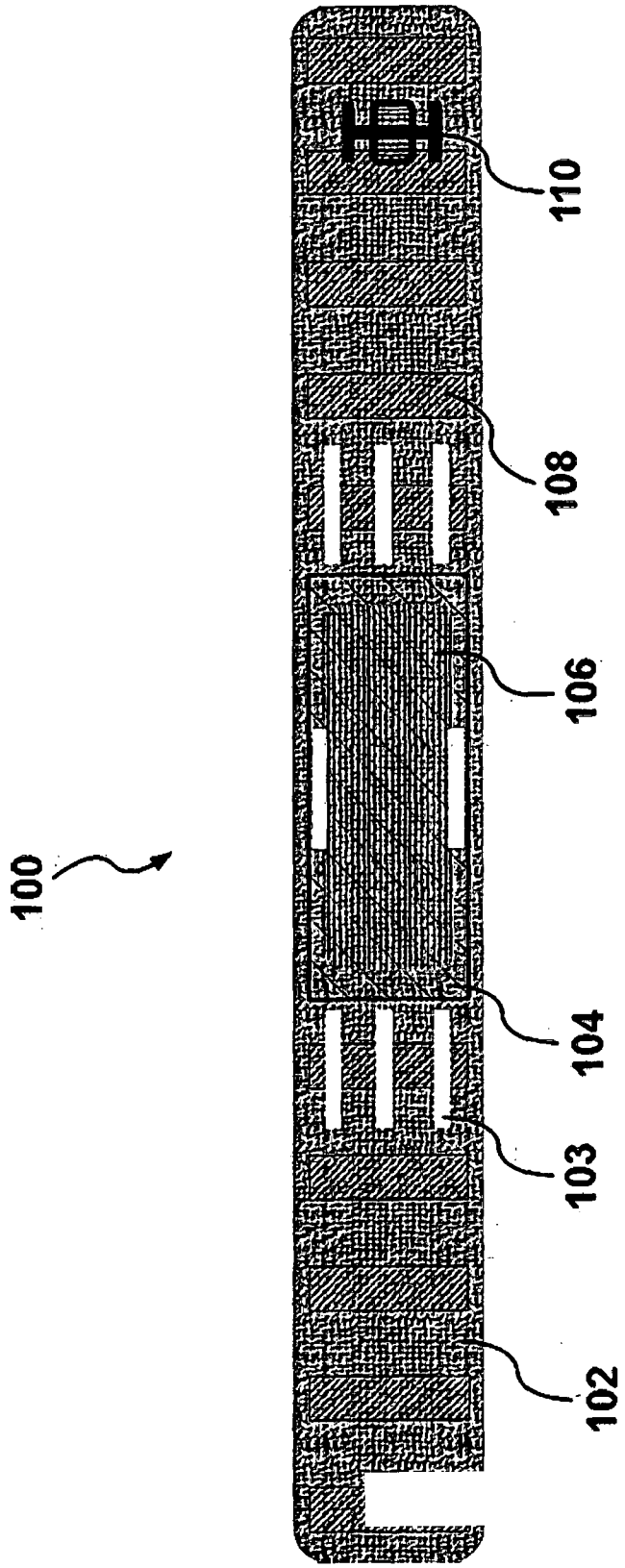


FIG. 1A

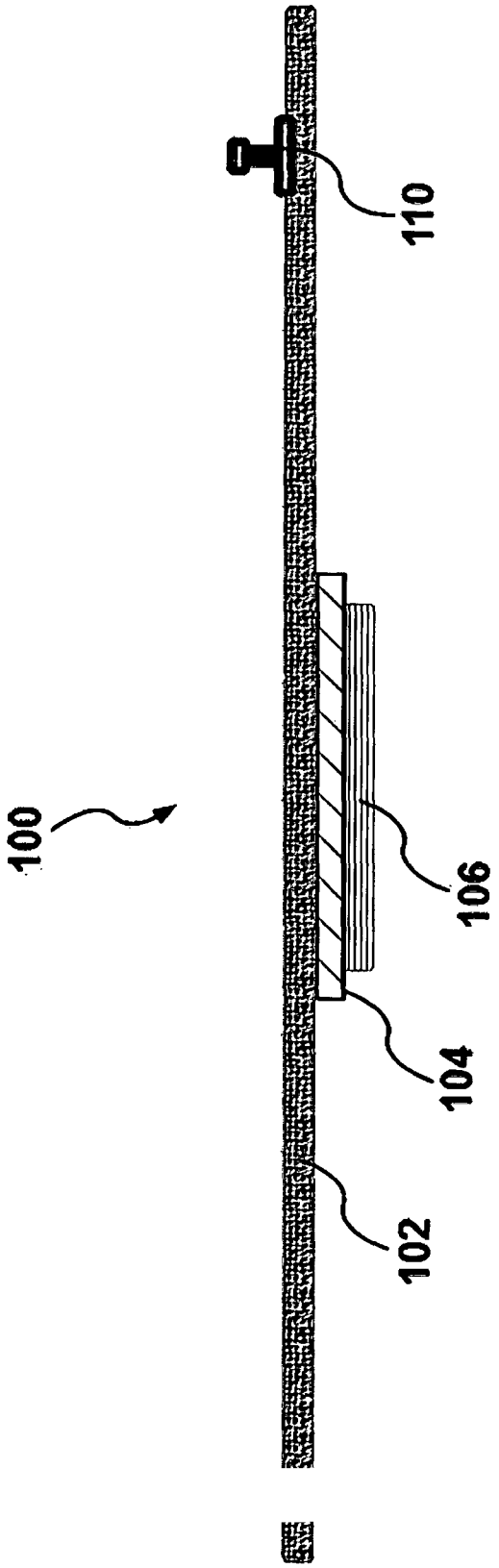


FIG. 1B

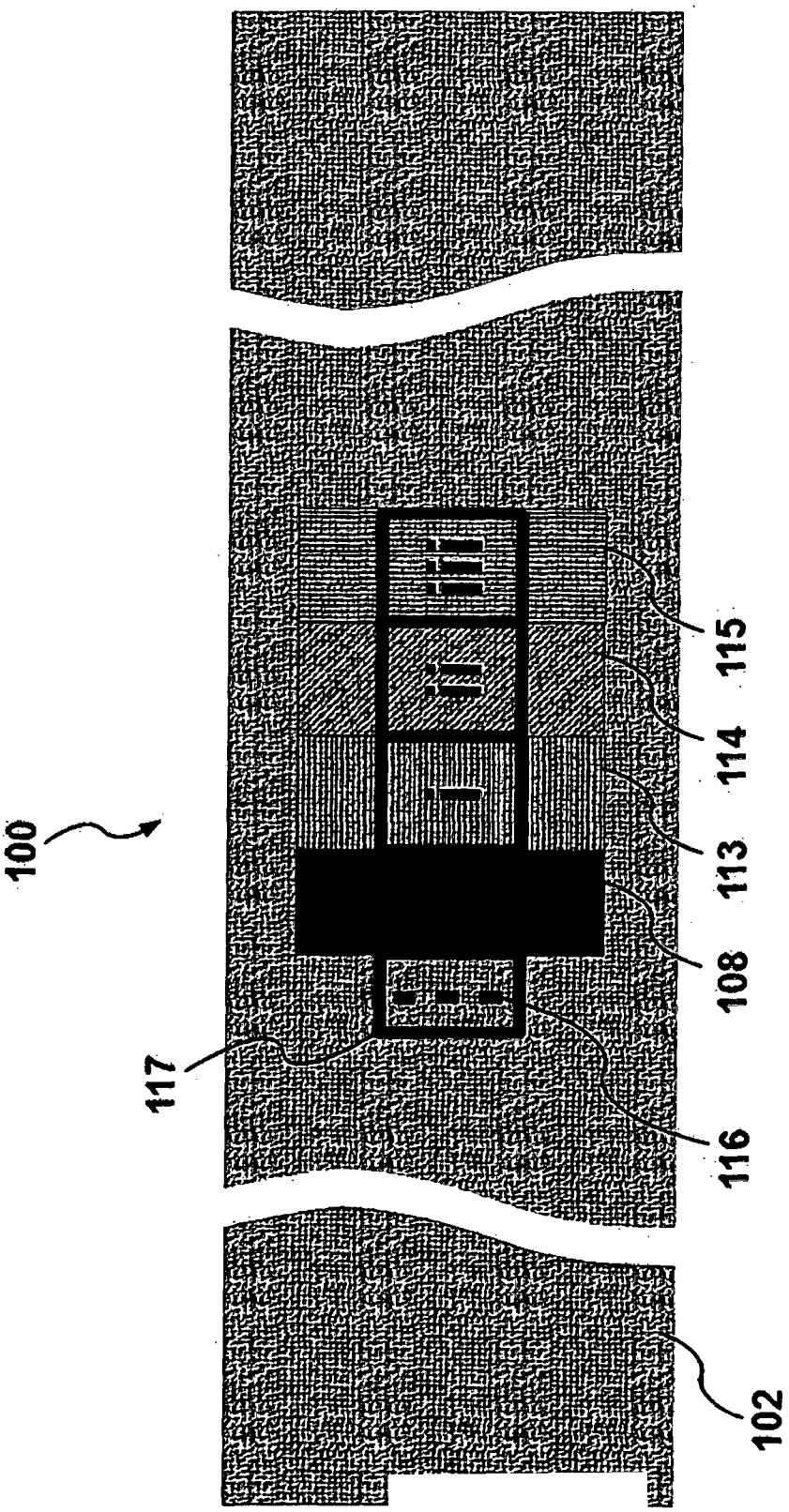


FIG. 1C

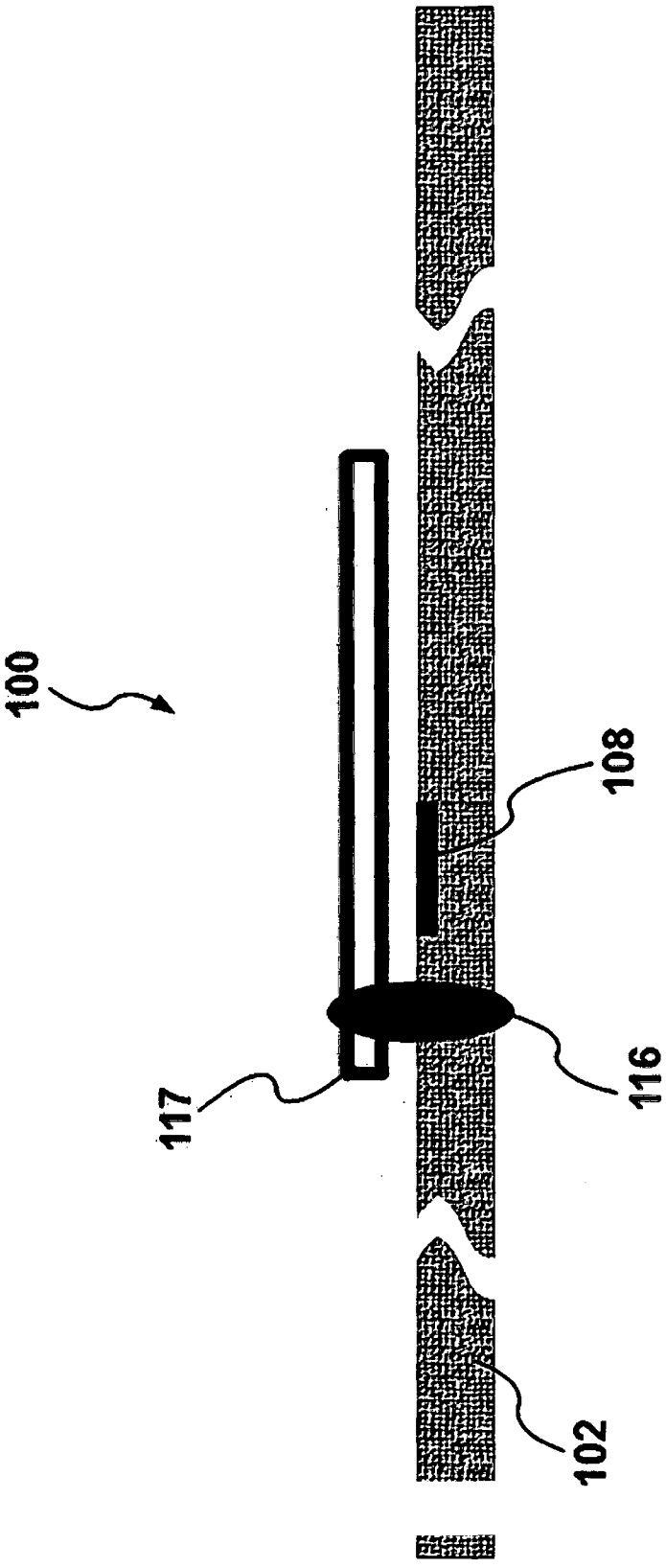


FIG. 1D

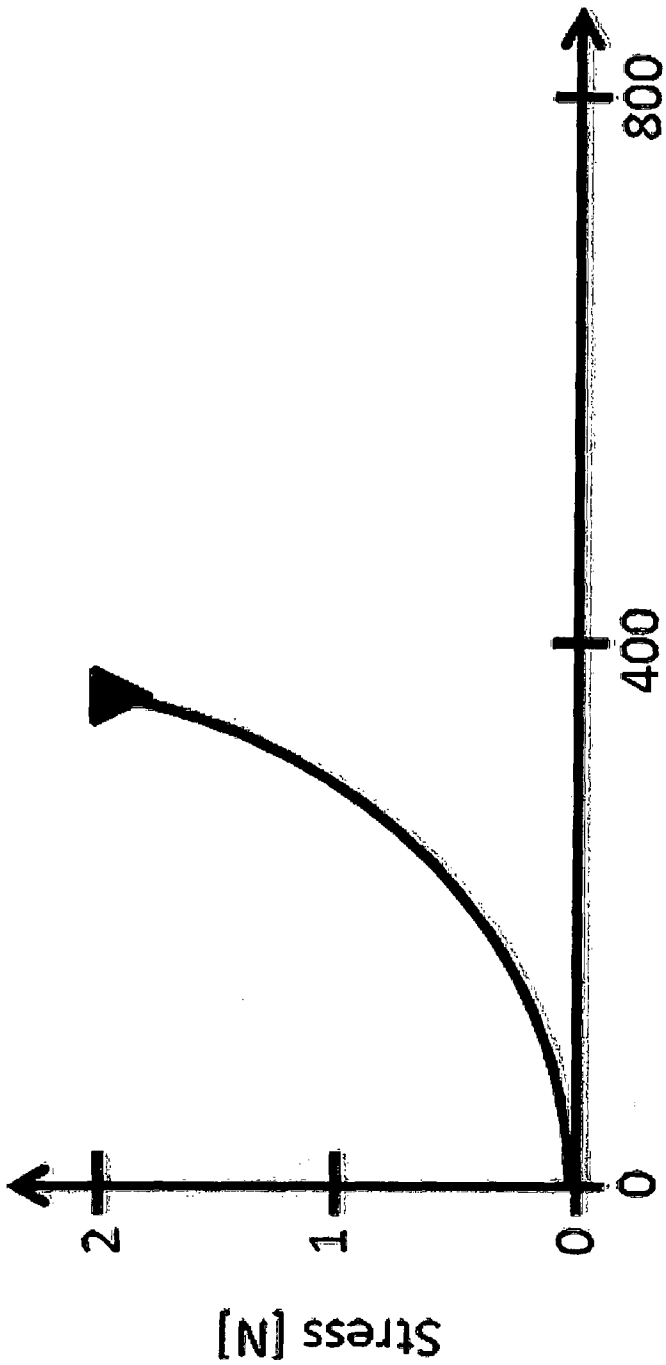


FIG. 2A

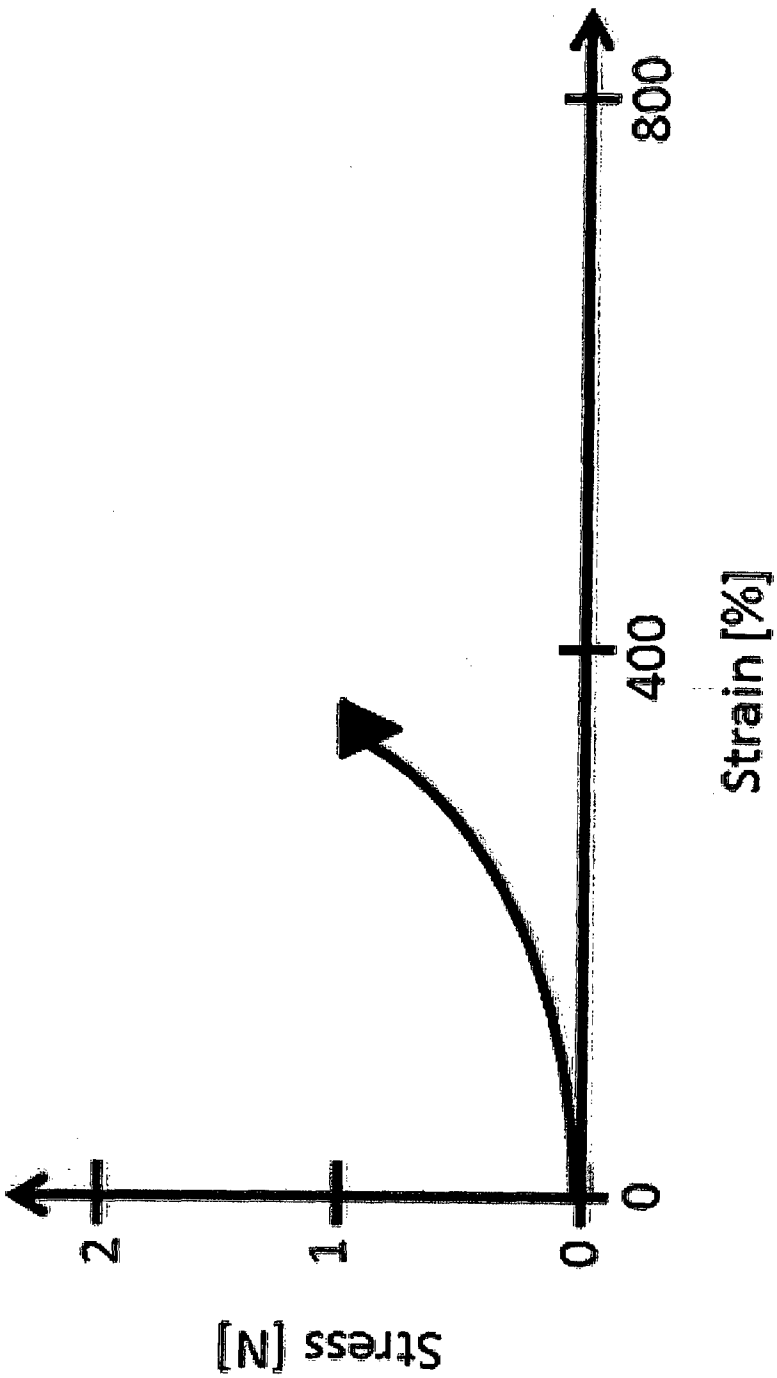


FIG. 2B

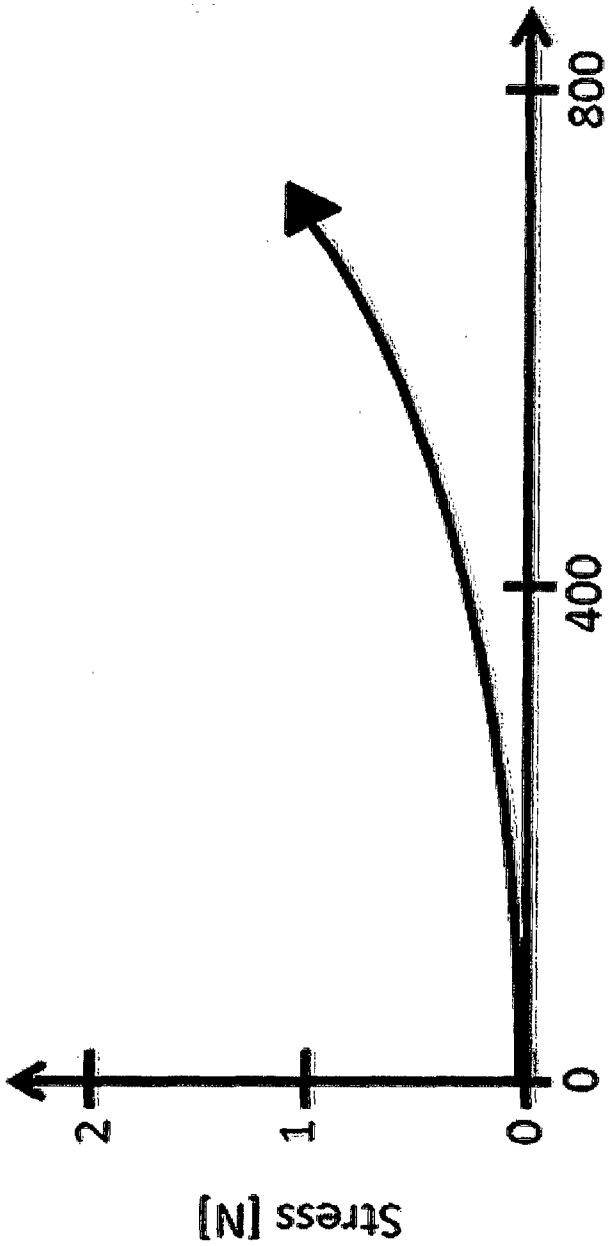


FIG. 2C

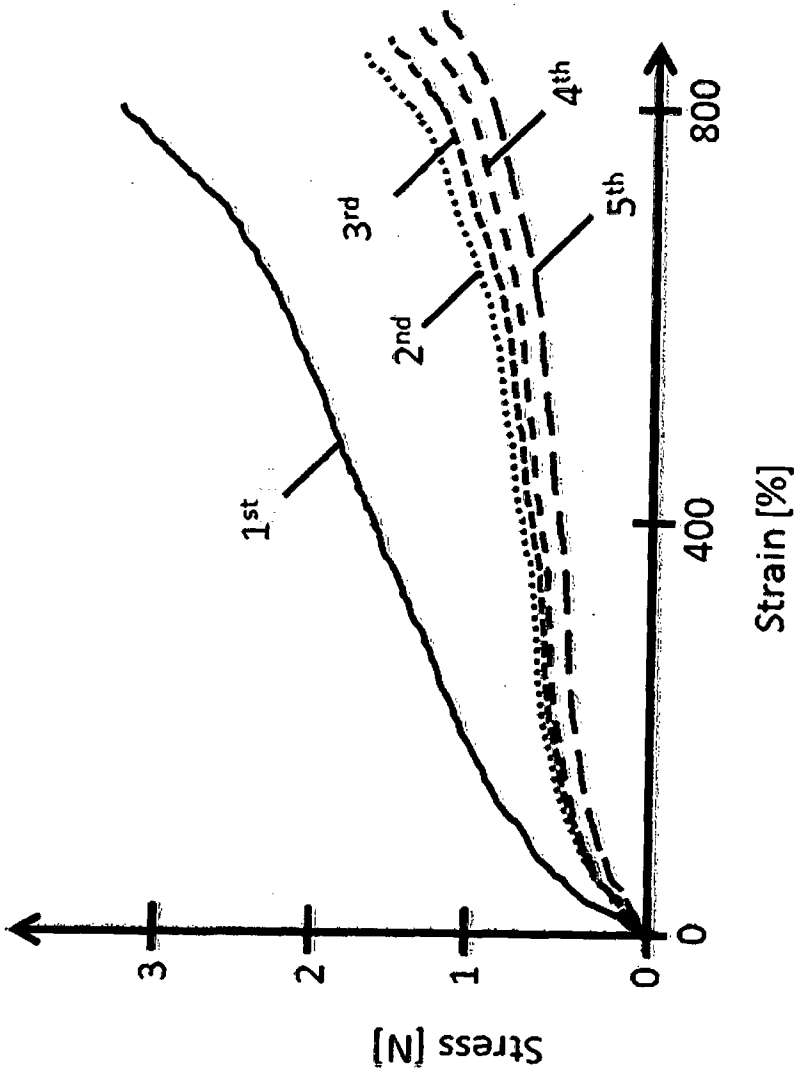


FIG. 2D

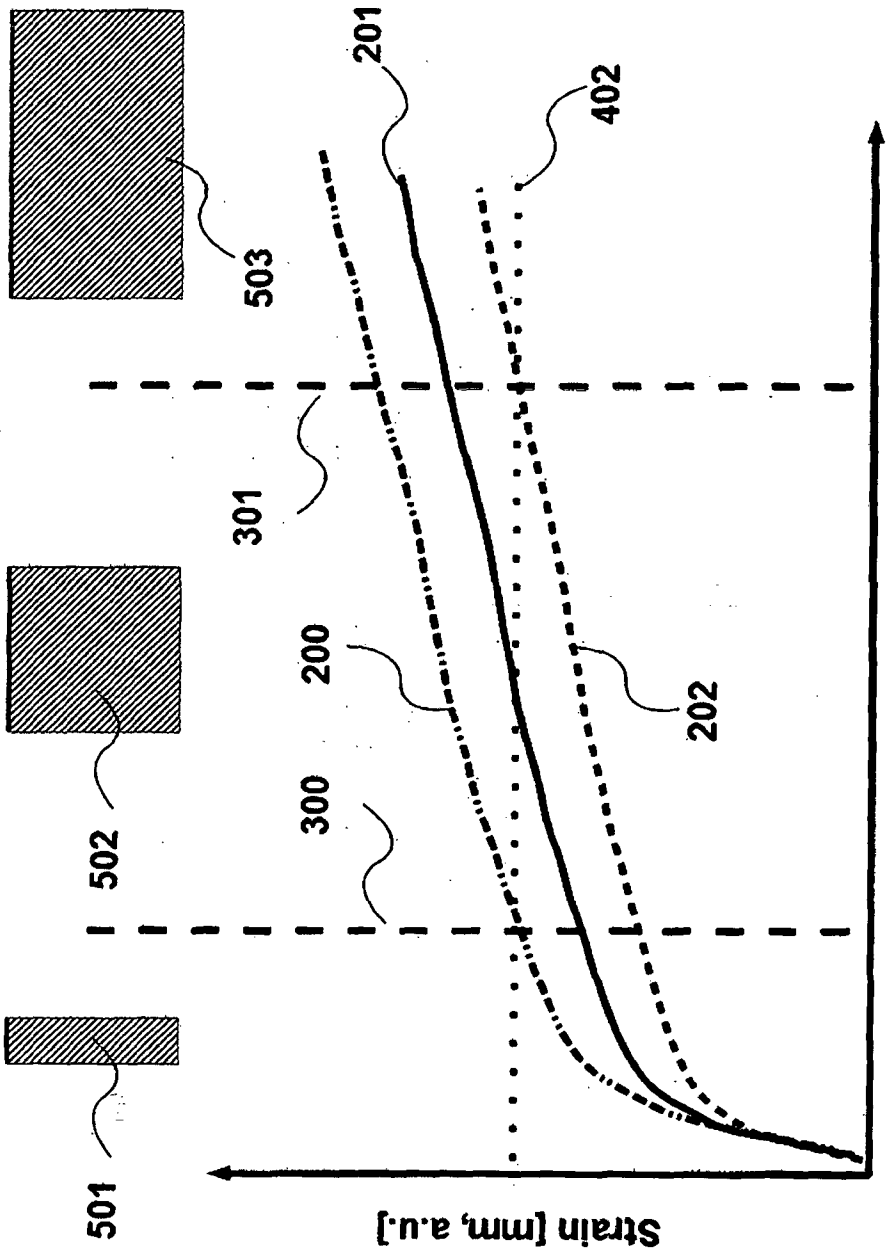


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/077427

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61F13/00 A61L15/18
ADD.

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)
A61L A61F

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 practicable, search terms used)
EPO-Internal, BIOSIS, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FR 2 499 416 A1 (THUASNE & CIE [FR]) 13 August 1982 (1982-08-13) page 1, lines 1, 2, 21, 22, 42 page 2, line 1 - line 14 page 3, line 21 - line 39 figures 1, 7, 8	1-22
A	US 2007/203442 A1 (BECHERT THORSTEN [DE] ET AL) 30 August 2007 (2007-08-30) page 1, paragraphs 12, 15 page 3, paragraphs 25, 26, 29 page 5, paragraphs 51, 56 figures 1, 2	1-22
Y	US 2011/064785 A1 (DANIELS R HUGH [US] ET AL) 17 March 2011 (2011-03-17) the whole document	1-22

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 February 2014	19/02/2014

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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