Bulletproof stabbed prevention dress with liquid stage material

Abstract

translated from

The invention relates to a soft bulletproof stab-resistant armor made by the single-layer or multi-layer superposition of shear thickening liquid impregnating in the high-intensity fiber fabric; the bulletproof stab-resistant armor is soft under the condition of no external force, and the hard nanometer particles in the shear thickening liquid aggregate in clusters when impacted by the external force, which hardens the bulletproof stab-resistant materials in order to provide protection. The soft bulletproof stab-resistant armor made of shear thickening bulletproof stab-resistant materials has the advantages of the light weight, the softness and the thinness.

Classifications

machine-classified

The classifications are assigned by a computer and are not a legal conclusion.
Google has not performed a legal analysis and makes no representation as to the accuracy of the classifications listed.

CN101140151A

CN Application

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Other languages

Chinese

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Priority date

The priority date is an assumption and is not a legal conclusion.
Google has not performed a legal analysis and makes no representation as to the accuracy of the date listed.

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Date App/Pub Number Status

The legal status is an assumption and is not a legal conclusion.
Google has not performed a legal analysis and makes no representation as to the accuracy of the status listed.

连接或嵌入的基本样式的各种工作服、特种服装、时装、衬衫、茄克衫、马甲、毛编织服装和皮装；硬质纳米粒子的形状可为球形、块形、片形、不规则形．其中优选球形；硬质纳米球型粒子的材质可为二氧化硅、硅、无机材料、金属、碳酸钙、PVC、塑料、磁性材料、聚合物. 其中优选二氧化硅、硅；剪切增稠液体的分散介质可为非蒸发性的乙二醇液体、聚乙二醇液体、水和甘油混合液、乙醇和甘油混合液、异丙醇液体、仲丁醇液体. 其中优选乙二醇液体、聚乙二�Object of the present invention is to provide a liquid material is light and thin anti-ballistic armor, comprising: a stab and ballistic resistant material, which is made with a hard nanoparticle suspension having a shear thickening properties shear thickening liquid immersion made of a high strength fiber woven fabric, a knitted fabric, a nonwoven fabric made of single or multiple superposed; housing, the inside or interlayer may stab and ballistic resistant material connected to or embedded in the base style variety of uniforms, special clothing, fashion, shirts, jackets, vests, garments woven wool and leather; shape of the hard nanoparticles may be spherical, block-shaped, plate-shaped, irregular-shaped, wherein preferably spherical; hard nano spherical particles may be made of silicon dioxide, silicon, an inorganic material, a metal, calcium carbonate, PVC, plastic, magnetic material, a polymer, which is preferably silicon dioxide, silicon; the dispersion medium may be non-shear thickening liquid evaporation of liquid glycol, liquid polyethylene glycol, a mixture of glycerol and water, a mixture of ethanol and glycerol, liquid isopropanol, sec-butanol liquid, wherein the liquid ethylene glycol, polyethylene 液体：高强度纤维是指强度较高的纤维．如：芳纶纤维、高强度高密度聚乙烯纤维、碳纤维、玄武岩纤维、高强度尼龙、高强度漆纶等高强度纤维．其中优选芳纶纤维、高强度聚乙烯纤维；外罩用粘扣粘连和钮扣挂接方式可将防弹防刺材料连接在外罩的内侧．或者外罩的夹层中可将防弹防刺材料嵌入。 Liquid; high strength fiber means a high strength fibers, such as: aramid fiber, high strength and high density polyethylene fibers, carbon fibers, basalt fibers, high strength nylons, high strength nylon paint high strength fibers, preferably aramid fiber where , high-strength polyethylene fibers; blocking cover with Velcro hook and buttons embodiment stab proof material may be attached to the inside of the housing, or the housing may be embedded in the interlayer stab proof material. 本专利解决其技术问题所采用的技术方案是：配制剪切增稠浸渍液．一种配方如下（重量比）：纳米级球形二氧化硅粒子30-60% 聚乙二醇20-50% 乙二醇10-20% 乙醇10-50% 将高强度纤维织物浸渍在剪切增稠浸渍液中．使高强度纤维织物充分吸收剪切增稠浸渍液．浸渍后将溶剂乙醇烘出．即制成液态性防弹防刺材料． This patent solve the technical problem The technical solution adopted is: shear thickening immersion liquid formulation A formulation is as follows (weight ratio): nano-sized spherical silica particles 30-60% polyethylene glycol, 20-50% B ethanol 10-20% 10-50% the impregnated fabric of high strength in shear thickening diol impregnating solution, the high-strength fabric impregnated sufficiently absorb shear thickening fluid, dipping ethanol solvent after bake-out, i.e., Ltd. stab proof of liquid into the material. 将液态性材料按样板裁剪成片．用单片或多片缝合在一起制成防弹防刺片．装入内胆罩中密封．再装入已制好的外罩中即制成液态性材料的防弹防刺服。 The liquid material is cut into pieces by a model with a single piece or multiple pieces sewn together to make Stab proof sheet, sealing the cover liner was charged, and then into ready-made enclosure Pat i.e., to prepare a liquid material stab proof clothing. 本专利的有益效果是：1、剪切增稠液体在常温状态时不显现特别防护性能．防弹防刺材料平时非常柔软贴身．服用 Advantageous effects of the

（重量比）：纳米级球形二氧化硅粒子50% 聚乙二醇15% 乙二醇20% 乙醇15% 将高强度高密度聚乙烯纤维机织布浸渍在剪切增稠浸渍液中，使其充分吸收剪切增稠浸渍 Example 3: preparation shear thickening immersion fluid, formulated as follows (weight ratio): nano-sized spherical silica particles of 50% ethylene glycol 15% Polyethylene glycol 20% ethanol 15% the high strength and high density polyethylene fiber woven fabric was immersed in the impregnating solution shear thickening, shear thickening sufficiently absorb impregnation

液，浸渍后将溶剂乙醇烘出，即制成液态性防弹防刺材料。 Solution, ethanol solvent after impregnation bake-out, i.e., made of a liquid Stab proof material. 将液态性材料按样板裁剪成片，用8片缝合在一起制成防弹防刺片，装入内胆罩中密封，再将内胆在风衣内侧用纽扣挂接方式和其连接即制成时装款式的液态性材料的防弹防刺服。 The liquid material is cut into pieces by a model, using 8 stitched together to make Stab proof sheet, sealing the cover liner was charged, and then coat the inner liner in a manner and with a button which is connected articulated fashion i.e. made stab proof clothing styles liquid material. 实施例4:配制剪切增稠浸渍液，配方如下（重量比）：纳米级块形硬质塑料粒子40% 甘油20% 水20% 乙醇10% 将芳纶1414纤维和高强度高密度聚乙烯纤维混合制成的针刺毡浸渍在剪切增稠浸渍液中，使其充分吸收剪切增稠浸渍液，浸渍后将溶剂乙醇烘出，即制成液态性防弹防刺材料。 Example 4: Shear thickening immersion liquid formulation, the following formulation (weight ratio): block-shaped nano-rigid plastic particles 40% Glycerin 20% Water 20% Ethanol 10% aramid fibers and high strength 1414-density polyethylene needled felt fibers impregnated with a blend of the impregnating solution at a shear thickening, shear thickening sufficiently absorb the impregnation solution, the impregnation solvent of ethanol after bake-out, i.e., made of a liquid stab proof material. 将液态性材料按样板裁剪成片，用3片缝合在一起制成防弹防刺片，装入内胆罩中密封，再将内胆在茄克衫内侧和其连接即制成时装款式液态性材料的防弹防刺服。 The liquid material is cut into pieces by a model, with three sewn together to make Stab proof sheet, sealing the cover liner was charged, and then the inner liner in the jacket which is connected i.e. a liquid material made of fashions the stab and bulletproof clothing. 实施例5:配制剪切增稠浸渍液，配方如下（重量比）：纳米级片形金属粒子55% 聚乙二醇25% 甘油10% 乙醇20% 将高强度高密度聚乙烯纤维制成的3维缝编织物（也称3D布）浸渍在剪切增稠浸渍液中，使其充分吸收剪切增稠浸渍液，浸渍后将溶剂乙醇烘出，即制成液态件防弹防刺材料。 Example 5: preparation shear thickening immersion fluid, formulated as follows (weight ratio): sheet-shaped metal nano-particles 55% 25% Polyethylene glycol 10% ethanol twenty oil 20% The fibers made of high strength and high density polyethylene the 3-dimensional stitchbonded fabric (also called 3D fabric) was immersed in the impregnating solution shear thickening, shear thickening sufficiently absorb the impregnation solution, the impregnation solvent of ethanol after bake-out, i.e., made liquid member stab proof material . 将液态性材料按样板裁剪成片，用1片装入内胆罩中密封，再将内胆在毛衣内侧用粘扣粘连方式连接即制成时装款式液态性材料的防弹防刺服。 The liquid material is cut into pieces by a model, with the sealing cap interior a load, and then connected to liner adhesions manner inside the fastener i.e. a sweater made Stab proof clothing fashions liquid material. 实施例6:配制剪切增稠浸渍液，配方如下（重量比）

4、 根据权利要求1所述的剪切增稠液体，其特征在于，剪切增稠液体的分散介质可为非蒸发性的乙二醇液体、聚乙二醇液体、水和甘油混合液、乙醇和甘油混合液、异丙醇液体、仲丁醇液体，其中优选乙二醇液体、聚乙一醇液体。 4. The shear thickening fluid according to claim 1, wherein the shear thickening liquid dispersion medium may be non-ethanediyl drunk off evaporable liquid, liquid polyethylene glycols off, water and glycerol mixture solution, a mixture of ethanol and glycerol, liquid isopropanol, sec-butanol liquid, wherein the liquid ethylene glycol, a polyvinyl alcohol liquid.

5、 根据权利要求1所述的高强度纤维，其特征在于，其足指强度较高的纤维，如：芳纶纤维、高强度高密度聚乙烯纤维、碳纤维、玄武岩纤维、卤强度尼龙、高强度涤纶等高强度纤维，其中优选芳纶纤维、高强度聚乙烯纤维。 5. The high-strength fiber according to claim 1, characterized in that the toe of which high strength fibers, such as: aramid fiber, high strength and high density polyethylene fibers, carbon fibers, basalt fibers, nylon Xie strength, high strength polyester high-strength fiber, wherein preferably aramid fibers, high strength polyethylene fibers.

6、 根据权利要求1所述的外罩，其特征在于，用粘扣粘连和钮扣挂接方式可将防弹防刺材料连接在外罩的内侧，或者外罩的夹层中可将防弹防刺材料嵌入。 6. The housing as claimed in claim 1, characterized in that, with the buttons and the blocking hook Velcro ways to connect Stab proof material on the inside of the housing, or the housing may be embedded in the interlayer Stab proof material.

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Publication number Priority date Publication date Assignee Title

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CN101871748A * 2010-04-20 2010-10-27 深圳航天科技创新研究院 Soft stab-proof/bulletproof material

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US8080486B1 2011-12-20 Ballistic shield composites with enhanced fragment resistance

Priority And Related Applications

Priority Applications (1)

Application Priority date Filing date Title

CN 200710122028 2007-09-20 2007-09-20 Bulletproof stabbed prevention dress with liquid stage material

Applications Claiming Priority (1)

Application Filing date Title

CN 200710122028 2007-09-20 Bulletproof stabbed prevention dress with liquid stage material

Legal Events

Date Code Title Description

2008-03-12 C06 Publication

2008-05-07 C10 Request of examination as to substance

2011-02-02 C02 Deemed withdrawal of patent application after publication (patent law 2001)

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Laminate materials and dilatant compounds for ballistic shielding

Abstract

translated from

In various embodiments, laminate materials having a first layer, second layer and third layer are described herein. The first layer includes a dilatant compound. The second layer is a ceramic material. The third layer includes a strike face material. The second layer is interposed between the first layer and the third layer. In some embodiments, nanomaterials such as HALLOYSITE nanotubes are mixed in the dilatant compound and are cross-linked thereto. Laminate materials of the present disclosure have beneficial properties for ballistic shielding for both persons and equipment. Dilatant compounds formed from a silicone fluid and a nanomaterial functionalized with at least one silane coupling agent are also described herein.

Classifications

machine-classified

The classifications are assigned by a computer and are not a legal conclusion.
Google has not performed a legal analysis and makes no representation as to the accuracy of the classifications listed.

F MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; BLASTING

F41 WEAPONS

F41H ARMOUR; ARMOURED TURRETS; ARMOURED OR ARMED VEHICLES; MEANS OF ATTACK OR DEFENCE, e.g. CAMOUFLAGE, IN GENERAL

F41H5/00 Armour; Armour plates

F41H5/007 Reactive armour; Dynamic armour

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B15/00 Layered products comprising a layer of metal

B32B15/04 Layered products comprising a layer of metal comprising metal as the main or only constituent of a layer, which is next to another layer of the same or of a different material

B32B15/046 Layered products comprising a layer of metal comprising metal as the main or only constituent of a layer, which is next to another layer of the same or of a different material of foam

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B15/00 Layered products comprising a layer of metal

characterised by a particular shape of the outline of the cross-section of a continuous layer; characterised by a layer with cavities or internal voids ; characterised by an apertured layer

B32B3/266 Layered products comprising a layer with external or internal discontinuities or unevennesses, or a layer of non-planar form ; Layered products having particular features of form characterised by a particular shape of the outline of the cross-section of a continuous layer; characterised by a layer with cavities or internal voids ; characterised by an apertured layer characterised by an apertured layer, the apertures going through the whole thickness of the layer, e.g. expanded metal, perforated layer, slit layer regular cells B32B3/12

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B5/00 Layered products characterised by the non- homogeneity or physical structure, i.e. comprising a fibrous, filamentary, particulate or foam layer; Layered products characterised by having a layer differing constitutionally or physically in different parts

B32B5/02 Layered products characterised by the non- homogeneity or physical structure, i.e. comprising a fibrous, filamentary, particulate or foam layer; Layered products characterised by having a layer differing constitutionally or physically in different parts characterised by structural features of a fibrous or filamentary layer

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B5/00 Layered products characterised by the non- homogeneity or physical structure, i.e. comprising a fibrous, filamentary, particulate or foam layer; Layered products characterised by having a layer differing constitutionally or physically in different parts

B32B5/18 Layered products characterised by the non- homogeneity or physical structure, i.e. comprising a fibrous, filamentary, particulate or foam layer; Layered products characterised by having a layer differing constitutionally or physically in different parts characterised by features of a layer of foamed material

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B9/00 Layered products comprising a particular substance not covered by groups B32B11/00 - B32B29/00

B32B9/005 Layered products comprising a particular substance not covered by groups B32B11/00 - B32B29/00 comprising one layer of ceramic material, e.g. porcelain, ceramic tile

B PERFORMING OPERATIONS; TRANSPORTING

F41H ARMOUR; ARMOURED TURRETS; ARMOURED OR ARMED VEHICLES; MEANS OF ATTACK OR DEFENCE, e.g. CAMOUFLAGE, IN GENERAL

F41H5/00 Armour; Armour plates

F41H5/02 Plate construction

F41H5/04 Plate construction composed of more than one layer

F41H5/0414 Layered armour containing ceramic material

F41H5/0428 Ceramic layers in combination with additional layers made of fibres, fabrics or plastics

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B2255/00 Coating on the layer surface

B32B2255/02 Coating on the layer surface on fibrous or filamentary layer

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B2255/00 Coating on the layer surface

B32B2255/06 Coating on the layer surface on metal layer

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B2255/00 Coating on the layer surface

B32B2255/26 Polymeric coating

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B2262/00 Composition of fibres which form a fibrous or filamentary layer or are present as additives

B32B2262/02 Synthetic macromolecular fibres

B32B2262/0253 Polyolefin fibres

B32B2307/70 Other properties

B32B2307/71 Resistive to light or to UV

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B2307/00 Properties of the layers or laminate

B32B2307/70 Other properties

B32B2307/714 Inert, i.e. inert to chemical degradation, corrosion

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B2307/00 Properties of the layers or laminate

B32B2307/70 Other properties

B32B2307/718 Weight, e.g. weight per square meter

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B2307/00 Properties of the layers or laminate

B32B2307/70 Other properties

B32B2307/72 Density

B PERFORMING OPERATIONS; TRANSPORTING

B32 LAYERED PRODUCTS

B32B LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM

B32B2571/00 Protective equipment

B32B2571/02 Protective equipment defensive, e.g. armour plates, anti-ballistic clothing

Y GENERAL TAGGING OF NEW TECHNOLOGICAL DEVELOPMENTS; GENERAL TAGGING OF CROSS-SECTIONAL TECHNOLOGIES SPANNING OVER SEVERAL SECTIONS OF THE IPC; TECHNICAL SUBJECTS COVERED BY FORMER USPC CROSS-REFERENCE ART COLLECTIONS [XRACs] AND DIGESTS

Y10 TECHNICAL SUBJECTS COVERED BY FORMER USPC

Info

Patent citations (16)

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Description

translated from

LAMINATE MATERIALS AND DILATANT COMPOUNDS FOR BALLISTIC SHIELDING CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to United States provisional patent application 61/144,360, filed January 13, 2009, which is incorporated by reference herein in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

[0002] Not applicable.

BACKGROUND

[0003] Enhanced ballistic protection is important for protecting lives in many fields including, for example, military applications and law enforcement. Although modern body armor and ground vehicle armor have saved countless lives, there still remains a need for enhanced armor providing either improved user protection, lighter weight, or a combination thereof. For example, some forms of modern body armor may have significant weight that can encumber a soldier or law enforcement officer in the field. Furthermore, susceptibility of body and vehicle armor to armor-piercing artillery is an ongoing shortcoming as well.

[0004] As an example of the importance of enhanced ballistics protection, the United States military began replacing standard Small Arms Protective Insert (SAPI) plates in protective armor with Enhanced Small Arms Protective Insert (ESAPI) plates in 2005. State-of-the-art ESAPI plates now provide some protection from armor-piercing bullets but at a significantly higher monetary cost than standard SAPI plates. A call for a next generation plate capable of stopping even higher velocity ballistic threats has been issued by the United States military. The military's call to action has specifically noted the need for flexible systems capable of greater protective coverage without a significant increase in weight.

DETAILED DESCRIPTION

[0017] In the following description, certain details are set forth such as specific quantities, sizes, etc. so as to provide a thorough understanding of the present embodiments disclosed herein. However, it will be evident to those of ordinary skill in the art that the present disclosure may be practiced without such specific details. In many cases, details concerning such considerations and the like have been omitted inasmuch as such details are not necessary to obtain a complete understanding of the present disclosure and are within the skills of persons of ordinary skill in the relevant art.

[0018] Referring to the drawings in general, it will be understood that the illustrations are for the purpose of describing particular embodiments of the disclosure and are not intended to be limiting thereto. Drawings are not necessarily to scale.

[0019] While most of the terms used herein will be recognizable to those of ordinary skill in the art, it should be understood, however, that when not explicitly defined, terms should be interpreted as adopting a meaning presently accepted by those of ordinary skill in the art. In cases where the construction of a term would render it meaningless or essentially meaningless, the definition should be taken from Webster's Dictionary, 3rd Edition, 2009. Definitions and/or interpretations should not be incorporated from other patent applications, patents, or publications, related or not, unless specifically stated in this specification or if the incorporation is necessary for maintaining validity.

[0020] As used herein, the term "dilatant compound" will refer to, for example, a fluid whose viscosity is temporarily or permanently increased upon application of a shear force. In some embodiments herein, the term "dilatant compound" may be used synonymously with the term "shear thickening fluid."

[0021] In various embodiments, laminate materials having a first layer of a dilatant compound, a second layer of a ceramic material and a third layer of a strike face material are described herein. The second layer is between the first layer and the third layer.

[0022] The laminate materials of the present disclosure advantageously rectify many of the perceived shortcomings present in many current materials used for ballistics protection, namely improved impact resistance and reduced weight. Furthermore, the laminate materials of the present disclosure are constructed largely from commercially available components and offer the potential to be produced at a significantly reduced cost compared to presently used ESAPI plates.

[0023] In some embodiments, the laminate materials of the present disclosure include one or more polymer layers binding the first layer, second layer and third layer to one another. In some embodiments, the first layer, second layer and third layer may include sub- layers bound together by one or more polymer layers. In some embodiments the polymer layers further include a nanomaterial filler such as, for example, a nanoclay (e.g., HALLOYSITE nanotubes, described in further detail hereinbelow) or carbon nanotubes (e.g., single-wall carbon nanotube, multi-wall carbon nanotubes, and combinations thereof. In other embodiments, the polymer layers do not include nanomaterial additives. In some embodiments, the polymers of the aforementioned polymer layers are thermoplastic polyurethanes. In some embodiments, the polymers of the polymer layers are si lane functionalized with at least one silane coupling agent.

[0024] In various embodiments of the present disclosure, silane coupling agents typically are silanol species having a general formula HO-Si(R^1)(R^2)(R^3). Typically, the hydroxyl group reacts with an organic or inorganic substrate of interest, and any combination of R , R , and R may contain functionality suitable for cross-linking with another material. For example, in various embodiments,

[0030] In various embodiments, the ceramic material is treated with a silane coupling agent. In various embodiments, the ceramic material is silane functionalized with at least one silane coupling agent. Without being bound by theory or mechanism, Applicant believes that silane functionalization not only increases compatibility by bonding to the other layers of the laminate material or thermoplastic polyurethane layers, but such functionalization also increases strength of the ceramic material by healing Griffith's flaws therein and reducing susceptibility to cracking. Conventional armor using silicon carbide or boron nitride is typically assayed in the field by X- ray to verify that the ceramic material is still functioning as intended and maintaining structural integrity. Silane functional ization may advantageously improve the field durability of the ceramic material in the present laminate materials or other armor applications. Other embodiments described herein may also improve the durability of the ceramic material by protecting it from fracturing. For example, laminating the ceramic material to the dilatant compound of the first layer may also improve the field durability of the ceramic material.

[0031] In some embodiments of the laminate materials, the first layer further includes polymer fibers. Illustrative polymer fibers suitable for forming the laminate materials of the present disclosure include, for example, ultra-high molecular weight polyethylene. Commercial sources of ultra-high weight polyethylene fibers include, for example, SPECTRA available from Honeywell and DYNEEMA available from Royal DSM (The Netherlands). However, one of ordinary skill in the art will recognize that other high performance polymers such as, for example, KEVLAR may form the polymer fibers in the laminate materials of the present disclosure.

[0032] Ultra-high molecular weight polyethylene fibers have been conventionally used in aerospace and high-performance consumer applications due to their high strength and low weight. Table 1 presents a summary of physical properties of SPECTRA 2000, an ultra-high molecular weight polyethylene fiber available from Honeywell, in comparison to KEVLAR, another polymer conventionally used in armor applications. Ultra-high molecular weight polyethylene fibers are particularly advantageous in these and in many other applications due to their resistance to chemicals, water, UV light and flex fatigue. Furthermore, their low dielectric constant makes them virtually transparent to radar. The SPECTRA 2000 fibers are produced by a gel-spinning process, followed by drawing steps which extend the polymer chains. Without being bound by theory or mechanism, it is believed that the linear, highly dense structure of ultra-high molecular weight polyethylene confers its superior mechanical properties. In contrast, low molecular weight polyethylene is a highly branched polymer, which may lead to relatively poor mechanical and thermal performance. Table 1: Properties of Ultra-High Molecular Weight Polyethylene (SPECTRA 2000) Compared to KEVLAR

[0036] Dilatant compounds generally contain colloidal particles of less than about 100 µm in diameter dispersed within a continuous fluid. However, Applicant has developed a dilatant compound that does not contain such colloidal particles. Applicant's dilatant compound is a siloxane fluid cross-linked with silane coupling agents. This dilatant compound is described in PCT/US09/47500, filed June 16, 2009, which is incorporated by reference herein in its entirety. In some embodiments of the present disclosure, the dilatant compound is a silicone fluid cross- linked with at least one silane coupling agent.

[0037] In some embodiments of the present disclosure, however, dilatant compounds may contain the above-described colloidal particles. For example, in some embodiments, dilatant compounds may contain nanomaterials. Illustrative nanomaterials include, for example, HALLOYSITE nanotubes and carbon nanotubes.

[0038] In some embodiments, dilatant compounds of the present disclosure may include a nanoclay material. Nanoclays have been studied extensively in polymer composites, but Applicant believes that their use as a component in dilatant compounds is presently unknown. In polymer composites, nanoclays are known to improve gas permeability, increase stiffness, provide better scratch resistance and improve thermo-mechanical response. Montmorillonite is an illustrative nanoclay material that has been used in making nanoclay polymer composites, particularly for those having improved flame retardancy. However, montmorillonite has significant limitations for making polymer composites such as, for example, a high cation exchange capacity and difficulty in exfoliation, that limit its compatibility with some polymer systems. Embodiments described herein present an alternative nanoclay material whose properties are more compatible with silicone fluids being used as dilatant compounds in some embodiments of the present disclosure.

[0039] In various embodiments of the present disclosure, the dilatant compound of the first layer further includes a nanomaterial. For example, in some embodiments, the nanomaterial may be HALLOYSITE nanotubes, a phyllosilicate material available from NaturalNano. FIGURE 2 shows an illustrative electron micrograph of HALLOYSITE nanotubes. In other various embodiments, the nanomaterial may be, without limitation, Laponite synthetic silicates or carbon nanotube materials. In some embodiments, the HALLOYSITE nanotubes are further modified with at least one silane coupling agent. In some embodiments, the HALLOYSITE nanotubes are covalently bonded to the dilatant compound through the silane coupling agent.

[0040] In some embodiments of the present disclosure, the dilatant compound includes a silicone fluid cross-linked with at least one silane coupling agent. In some embodiments, the dilatant compound of the first layer further includes a nanomaterial, which may be dispersed therein in an embodiment. In some embodiments, the silane coupling agent covalently bonds the nanomaterial to the dilatant compound. In some embodiments, the nanomaterial is HALLOYSITE nanotubes. In some embodiments, the HALLOYSITE nanotubes are bonded to the at least one silane coupling agent.

[0041] Halloysite is a mineral naturally occurring in cylindrical form, as shown in FIGURE 2. HALLOYSITE nanotubes are a phyllosilicate material from the kaolin clay group and have an empirical formula of $Al_2O_3Si_2O_4$-4(H_2O). HALLOYSITE nanotubes are hollow cylinders having a lumen size of about 20 nm and outer diameters of less than about 100 nm. Their lengths typically range from about 0.5 µm to about 5 µm. HALLOYSITE nanotubes have many of the same properties as carbon nanotubes such as, for example, strengthening and toughening of polymers, but without the cost prohibition of the latter. For example, HALLOYSITE nanotubes may be used to increase the impact strength of an epoxy nanocomposite by up to four times without impacting the modulus, strength, or thermal stability.

[0048] In various embodiments, the at least one metal underlayer, the polymer material, the nanomaterial or a combination thereof may be treated with one or more silane coupling agents and functionalized therewith. Such treatment advantageously increases the interaction between the metal underlayer, the polymer material and/or the nanomaterial filler. In some embodiments, the at least one metal underlayer, the polymer material, and the nanomaterial are silane functionalized with at least one silane coupling agent. [0049] In some embodiments, the at least one metal underlayer is formed from a metal alloy. For example, in some embodiments, the metal underlayer is $TiAl_6V_4$. In some embodiments, the metal underlayer is Ti_4V_6. In some embodiments, the metal underlayer is Ti_4Al_6.

[0050] Applicant has found that strike faces of the present disclosure advantageously change the shape trajectory and rheology of a ballistic threat. Without being bound by theory or mechanism, Applicant has found that the holes in the metal underlayer act as a cutting edge that turns and yaws the projectile. Further, the polymer material and its dispersed nanoparticles provide a tough surface that increase dwell time of the projectile to allow the strike face to fracture the projectile more efficiently. Strike faces of the present disclosure are further reinforced by the ceramic material of the second layer. Still without being bound by theory or mechanism, Applicant believes that the tough ceramic material forces the nanoparticles of the strike face to displace energy outward toward the ballistic threat. As a result, the projectile's own kinetic energy is used against itself when impacting the laminate materials of the present disclosure. Laminate materials of the present disclosure typically divide traditional lead core projectiles and armor-piercing projectiles into several flattened pieces before being stopped at or before the ceramic material of the second layer. The dilatant compound of the third layer provides additional protective material. The strike faces of the present disclosure are particularly advantageous for stopping armor-piercing projectiles, since they result in shedding of the penetrating tip of the projectile. Once the penetrating tip has been removed, only an ordinary projectile (i.e., a bullet) remains, which is much easier to stop as its kinetic energy begins to spread out over a wider area upon passing through the laminate materials.

[0051] The strike faces of the present disclosure are distinguished from strike faces used in conventional protective armor not only in their composition but in the way in which they repel a ballistic threat. Conventional strike faces have typically sought to provide ballistic protection by using a thick, dense strike layer (e.g., a solid metal or ceramic material) to repel a ballistic threat, followed by layers of high-performance shielding underneath to stop the fragments of the initial impact. For example, current ESAPI armor plates employ a ceramic strike face made from boron carbide or silicon carbide backed by layers of KEVLAR or other high-performance polymer. These conventional strike faces make no attempt to change the trajectory of the projectile, however. In contrast, strike faces of the present disclosure advantageously change the trajectory of the projectile as it impacts the strike face, resulting in cutting of the projectile and yawing as the impact fragments are stopped within subsequent layers of the laminate material. Furthermore, the fact that the strike faces are not required to be thick and dense in the present embodiments results in the realization of advantageous reductions in weight.

[0052] In other various embodiments of the strike faces of the present disclosure, a metal foam may be placed behind the metal underlayer. In some embodiments, the metal foam may be coated with a polymer and/or a nanomaterial prior to being placed behind the metal underlayer. In such embodiments, exceptional shock mitigation is observed, along with increased projectile dwell time, yaw and fracture.

[0053] In addition to enhanced ballistic projection provided by HALLOYSITE nanotubes, other beneficial property enhancements may also be realized by having these nanomaterials included as a

polyurethane layer 50. Thermoplastic polyurethane layer 53 laminates the metal underlayer/thermoset layer combination together within strike face 1. Strike face 1 is laminated to ceramic layer 2 through thermoplastic polyurethane layer 56. In the example shown, the ceramic layer 2 is cubic boron nitride. Ceramic layer 2 is further laminated to shear thickening layer 3 through thermoplastic polyurethane layer 57. Shear thickening layer 3 includes high-molecular weight polyethylene layers 58 and 60 laminated to one another with thermoplastic polyurethane layer 59. The exterior of shear thickening layer is coated with thermoplastic polyurethane layer 61. Dilatant compound 62 is dispersed on high-molecular weight polyethylene layers 58 and 60 throughout shear thickening layer 3. As noted above, any or all components may be treated with silane coupling agents in order to increase compatibilization and bonding to one another. Each of the thermoplastic polyurethane layers contain HALLOYSITE nanotubes.

[0059] FIGURES 6A - 6D show illustrative images of a laminate material of the present disclosure following ballistics testing. FIGURE 6A shows the impact zone in the thermoplastic polyurethane/HALLO YSITE layer 50 on the exterior of the strike face. FIGURE 6B shows the impact zone in the thermoplastic polyurethane layer 53 on the interior of the strike face. FIGURE 6C shows the impact zone at the metal underlayer 54 of the strike face. FIGURE 6D shows the impact of the projectile in the high-molecular weight polyethylene layers 58 and 60 after yawing. The impact shots are from a 7.62 AP M2 projectile, a 30 caliber armor-piercing round traveling at 2800 feet per second. The images show the yaw and spread of the projectile as it passes through the laminate material. Rather than piercing the laminate material in a pin hole and reaching the wearer, the armor piercing material of the projecting is removed and the impact force is dissipated over a wider area in the laminate material. Impact fragments do not penetrate completely through the laminate material, thereby providing protection to the wearer.

[0060] From the foregoing description, one of ordinary skill in the art can easily ascertain the essential characteristics of this disclosure, and without departing from the spirit and scope thereof, can make various changes and modifications to adapt the disclosure to various usages and conditions. The embodiments described hereinabove are meant to be illustrative only and should not be taken as limiting of the scope of the disclosure, which is defined in the following claims.

Claims ()

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CLAIMSWhat is claimed is the following:

1. A laminate material comprising: a first layer comprising a dilatant compound; a second layer comprising a ceramic material; and a third layer comprising a strike face material; wherein the second layer is interposed between the first layer and the third layer.

2. The laminate material of claim 1 , wherein the dilatant compound, the ceramic material, and the strike face material are all silane functionalized with at least one silane coupling agent.

3. The laminate material of claim 1, wherein the first layer further comprises polymer fibers.

4. The laminate material of claim 3, wherein the polymer fibers are arranged in a plurality of sub-layers within the first layer.

5. The laminate material of claim 4, wherein each of the plurality of sub-layers within the first layer are laminated to one another through a plurality of thermoplastic polyurethane sub -layers.

25. The laminate material of claim 24, wherein at least the metal underlayer, the polymer material, the nanomaterial, and the ceramic material are silane functionalized.

26. The laminate material of claim 25, wherein the first layer further comprises HALLOYSITE nanotubes dispersed in the dilatant compound; wherein the dilatant compound comprises a silicone fluid cross-linked with at least one si lane coupling agent; and wherein the HALLOYSITE nanotubes are silane functionalized with the at least one silane coupling agent.

27. A dilatant compound comprising: a silicone fluid; and a nanomaterial dispersed in the silicone fluid; wherein the nanomaterial is functionalized with at least one silane coupling agent.

28. The dilatant compound of claim 27, wherein the nanomaterial is cross-linked to the silicone fluid through the at least one silane coupling agent.

29. The dilatant compound of claim 27, wherein the nanomaterial comprises HALLOYSITE nanotubes.

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Priority And Related Applications

Priority Applications (2)

Application Priority date Filing date Title

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Legal Events