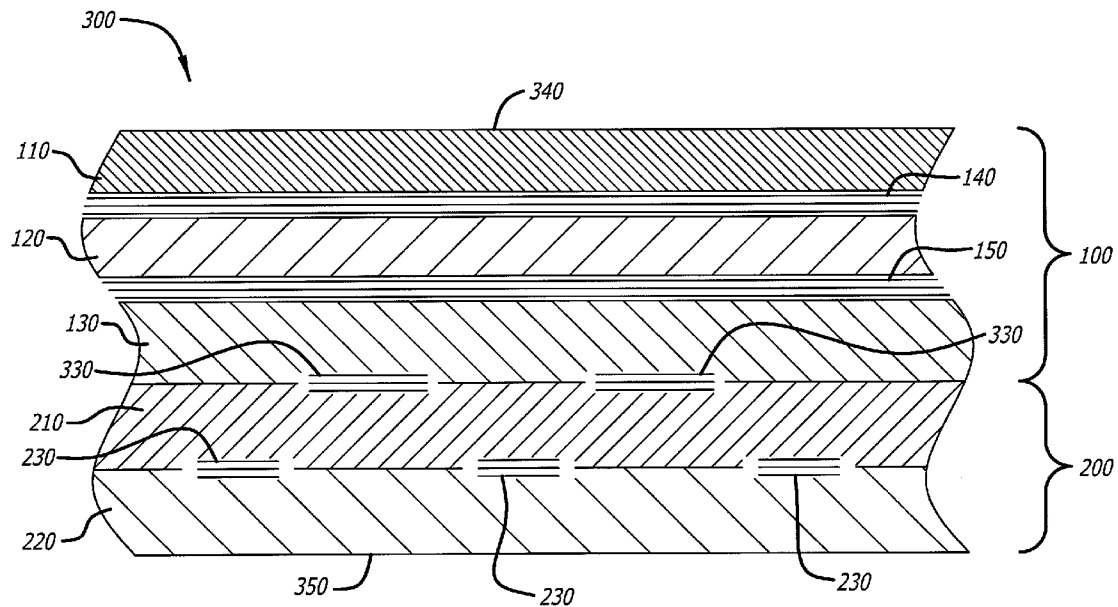


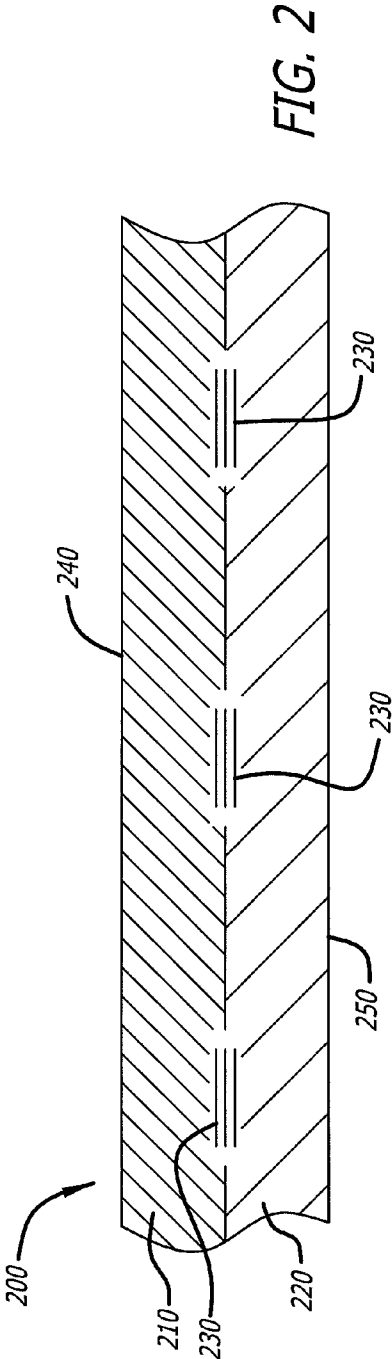
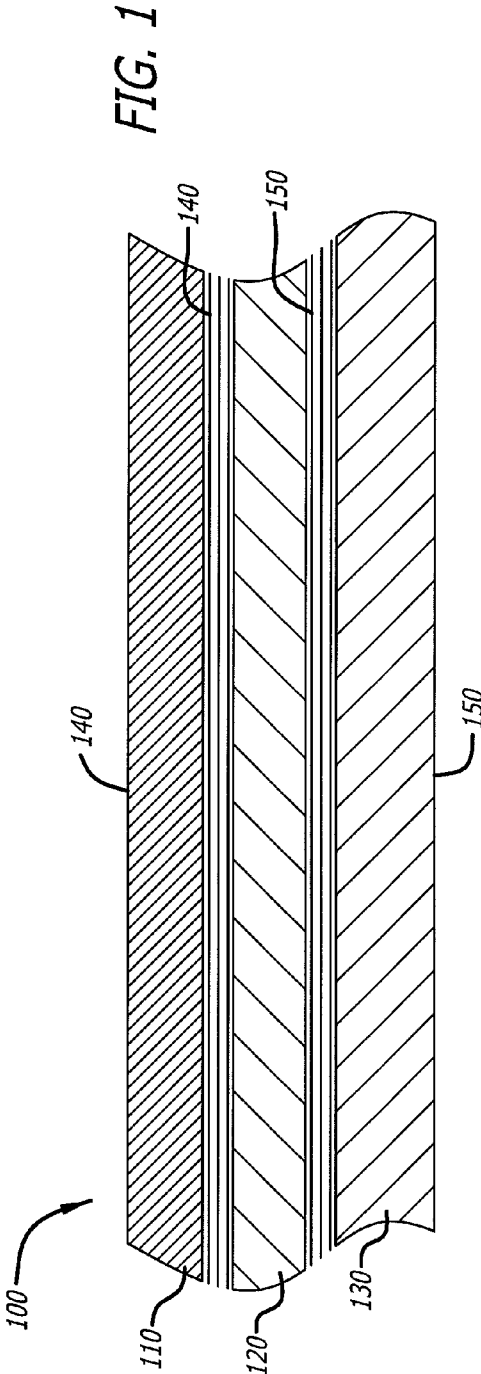


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BRAIEWA et al.(10) **Pub. No.: US 2012/0186433 A1**(43) **Pub. Date: Jul. 26, 2012**(54) **PROTECTIVE SHIELD MATERIAL****Publication Classification**(75) Inventors: **Robert Joseph BRAIEWA**,
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89/915; 89/918(73) Assignee: **SCAPA NORTH AMERICA**,
Windsor, CT (US)(21) Appl. No.: **12/749,035**(22) Filed: **Mar. 29, 2010****Related U.S. Application Data**(60) Provisional application No. 61/167,141, filed on Apr.
6, 2009, provisional application No. 61/256,828, filed
on Oct. 30, 2009.(57) **ABSTRACT**

A ballistics shield material comprises an armor structure formed from armor material components. The armor structure is substantially imperforable by armor-piercing fire. The armor structure comprises at least multiple layers of high tensile material layers of para-aramid fabric, and an adhesive material for bonding components together. There is a visco elastic foam bonded with the adhesive. The foam can be acrylic foam is bonded with nitrile phenolic adhesive.





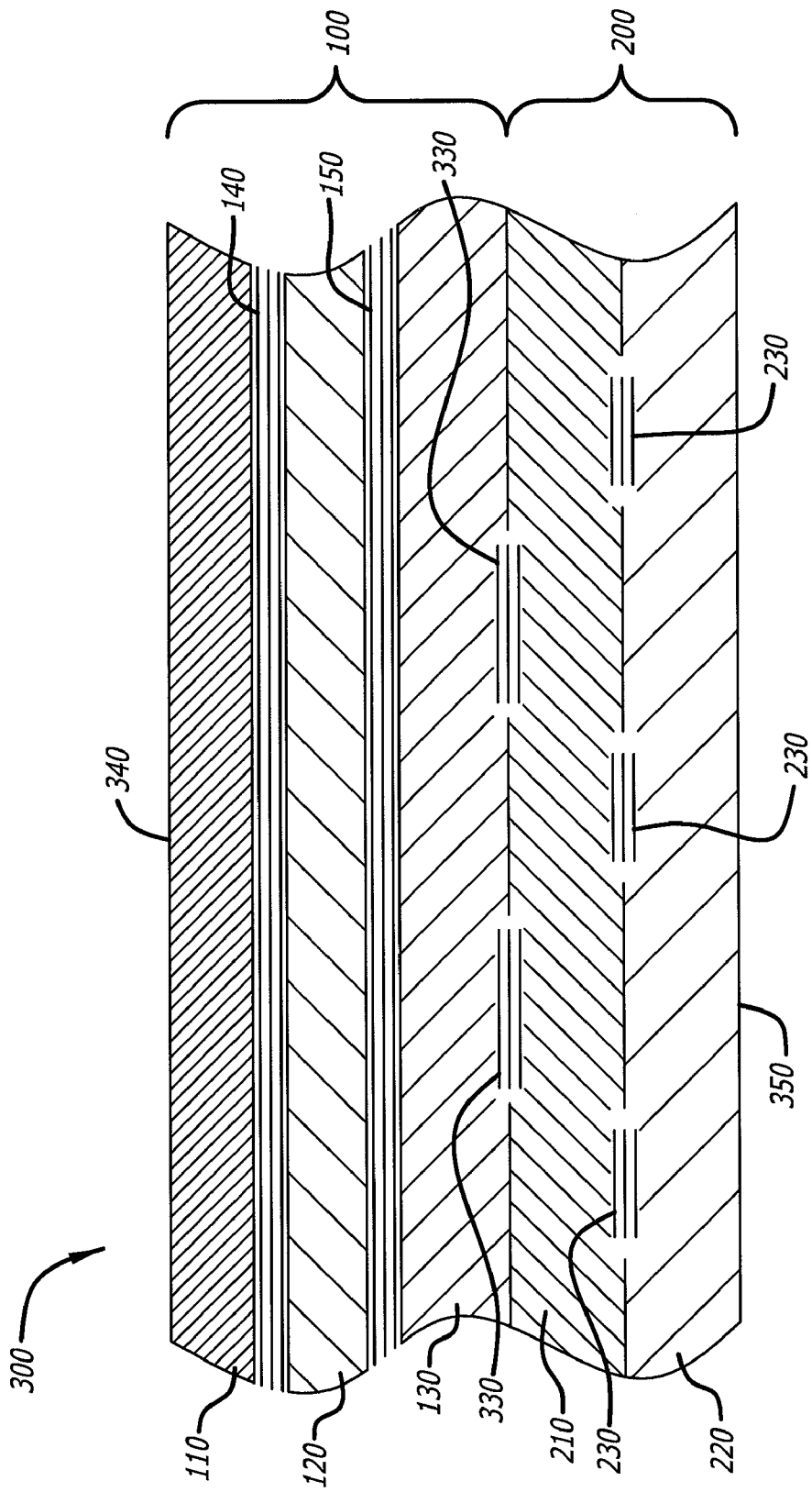


FIG. 3

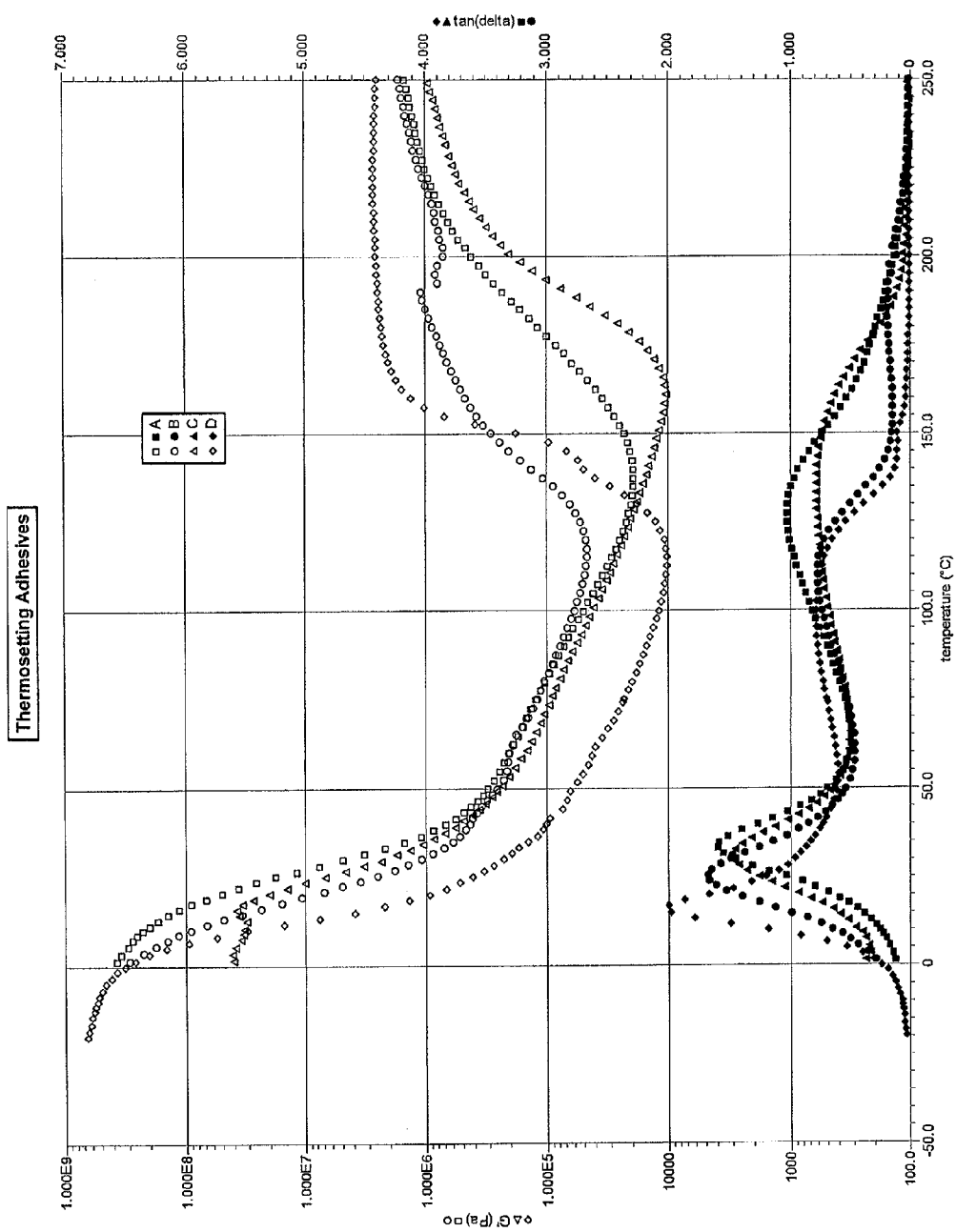


FIG. 4

PROTECTIVE SHIELD MATERIAL

RELATED APPLICATION

[0001] This application is related to U.S. Provisional Application Ser. No. 61/167,141, filed Apr. 6, 2009 and U.S. Provisional Application Ser. No. 61/256,828, filed Oct. 30, 2009, the contents of which are incorporated by reference herein in its entirety.

BACKGROUND

[0002] This disclosure concerns protective shield material. In particular it is concerned with body armor which can include hard and soft armor. Hard armor can be made strong, but is more rigid for some applications, whereas soft armor is generally weaker than hard armor, but may have other benefits.

[0003] An objective of this disclosure is to provide a shield product which has the benefits of both such armors and thereby provide an effective shield material.

SUMMARY

[0004] The shield material structure has an outward side and an inner side. The armor structure is formed from a high tensile strength fabric material, for instance a KEVLAR™ like material. The material can be a high tensile material scrim bonded together with a heat seal or epoxy or other adhesive and for use as body armor so as to reduce trauma from ballistic impact.

[0005] MICROLAM™ is a scrim that can be with a chopped fiber lay-up composite or with KEVLAR™ bonded together with heat seal adhesive for trauma reduction in a protective vest. The materials form a product which includes the adhesive as a composite blend of soft and hard areas within adhesive layer. The adhesive may have a backing or embedded layers between the adhesive layers consisting of shock absorbing materials such as foam, gels or porous laminates. The structure of the foam could include PU, PVC, Acrylic, Silicone, PE or microsphere filled thermoplastic foams. The films could be PU, PE, etc. The structure may be simply a heat seal or transfer adhesive consisting of hard and soft regions. These regions are created during by combination of material cure as well as adding particles that could act as hard or soft regions.

[0006] The structure of the vest including the weave, the angle of weave and denier and layers of high tensile material, such as KEVLAR™ enhance the performance of the shield material.

[0007] In some cases acrylic foam or other visco elastic or energy dissipative structures such as foams or layered porous film structures is bonded with adhesive for the body armor. as materials in protective armor. In other cases the shield may be without foam or film or damping elements.

[0008] Acrylic foam with nitrile phenolic adhesive, as a tape product, a film or intermediate layer can be used.

[0009] There is also an adhesive material such as a tape which may be activatable adhesive, typically for instance, a thermosetting adhesive. The thermoplastic adhesives consists of polyolefin, polyamide, polyester or copolymers containing elastomers and thermoplastic segments etc. or could be a blend of these polymers. The thermosetting materials include epoxides, urethanes, cyanate esters, bismaleimides, phenolics, including nitrile phenolics, and any combinations

thereof. Suitable nitrile phenolic materials include those made by including butadiene-nitrile elastomers in phenolic resin-based materials.

[0010] The shield material permits for an armor structure sufficiently strong to defeat rifle fire or NIJ ballistic testing protocol.

DRAWINGS

[0011] The present disclosure will become more apparent with reference to the following description taken in conjunction with the accompanying drawings wherein like reference numerals denote like elements and in which:

[0012] FIG. 1 is a schematic sectional view of one example of an armor structure.

[0013] FIG. 2 is a schematic sectional view of another example of an armor structure.

[0014] FIG. 3 is a schematic sectional view of another example of an armor structure.

[0015] FIG. 4 is a graph showing the rheological characteristics of various adhesives.

DETAILED DESCRIPTION

[0016] A lightweight protective shield material for a vest, body armor, panel or element is for resisting ballistic impacts from bullets, shrapnel, and like objects. These shields and armor elements possess an effective stiffness and favorable strength-to-weight ratios, and for resisting destruction and penetration by ballistic objects such as bullets and shrapnel, or for resisting deformation from high force/low speed attack by objects such as battering rams, knives, cutting tools, and pry-bars.

[0017] A flexible, high-tensile strength fabric may be a woven or non-woven material, preferably made of a high-tensile fiber material such as aramid fiber, ultra-high molecular weight polyethylene fiber, or PBO fiber. Each of the sheets of flexible, high-tensile strength fabric should have a tensile breaking strength not less than about 100 pounds per inch of fabric width for every ounce per square yard of material.

[0018] A ballistics shield material comprises an armor structure formed from an armor material components. The armor structure is substantially imperforable by armor-piercing fire; and the armor structure comprises at least multiple layers of high tensile material layers such as para-aramid fabric. An adhesive material for bonding components together is used, and the adhesive material comprises an activatable adhesive. The shield can also include a visco elastic foam, for instance an acrylic foam bonded with adhesive. The visco elastic damping material composition consists of typically polymeric materials in the form of foam, sheet or porous structures containing acrylic, polyurethane, plasticized PVC, silicone, polyethylene, copolymers of vinyl acetate or elastomers. The heat activatable adhesives can be thermoplastic adhesives and thermosetting adhesives. The thermoplastic adhesives include polyolefin based adhesives, polyester type, polyamide type etc, and any of those that come from blending of those adhesive materials. The thermosetting adhesives include epoxides, urethanes, cyanate esters, bismaleimides, phenolics, including nitrile phenolics, and any combinations thereof. Suitable nitrile phenolic adhesives include those made by including butadiene-nitrile elastomers in phenolic resin-based materials.

[0019] The ballistics shield material can have a visco elastic foam like material, for instance an acrylic foam bonded with nitrile phenolic adhesive.

[0020] In another form there is a ballistics shield material which comprises an armor structure formed from an armor material components. The armor structure is substantially imperforable by armor-piercing fire; and the armor structure comprises at least multiple layers of high tensile material layers of para-aramid fabric. There is an adhesive material for bonding components together. The adhesive material comprises opposite first and second major sides, each of the first and second major sides having an adhesive layer. The adhesive layers define adhesive surfaces on both major sides of the adhesive material, and each of the adhesive layers and (i) the pressure sensitive adhesive comprises a pressure sensitive adhesive, (ii) an activatable adhesive comprises an epoxy resin, or both (i) and (ii).

[0021] FIG. 1 illustrates an armor structure 100 which comprises a layered construction of a first section 110, second section 120 and third section 130. The armor structure 100 is configured to be worn, mounted or otherwise used such that the first section 110 is located closest to a threat (e.g., incoming gunfire) and the third section 130 is located closest to the wearer, vehicle, aircraft, building, etc. to be protected by the armor structure 100.

[0022] The first, second and third sections 110, 120, 130 is formed from an armor material. In some cases, the first section 110 comprises an aramid, for instance such as ZYLON™, namely PBO (poly(p-phenylene-2,6-benzobisoxazole)) material or fabric, the second section 120 comprises KEVLAR™ or other high tensile material which can be a para-aramid material or fabric formed such a material. The third section 130 can be KEVLAR™.

[0023] In other such examples, any one or more of the first, second and third sections 110, 120, 130 may comprise woven aramid, for instance ZYLON™ or woven KEVLAR™, or multiple layers of woven aramid, for instance ZYLON™ or woven KEVLAR™.

[0024] In one example, the first section 110 includes multiple layers of an aramid, for instance ZYLON-530 (i.e., ZYLON™ similar to style no. 530 available from Hexcel Schwebel of Anderson, S.C.), the second section 120 includes multiple layers of KEVLAR-704 (i.e., KEVLAR™ similar to style no. 704 available from Hexcel Schwebel), and the third section 130 comprises multiple layers of KEVLAR-726 (i.e., KEVLAR™ similar to style no. 726 available from Hexcel Schwebel). In addition, if desired, the layers of the third section 130 may be laminated to improve resistance to deformation.

[0025] In further example of the armor structure 100, the first section 110 comprises multiple layers of an aramid, for instance ZYLON-530, the second section 120 comprises multiple layers of KEVLAR-704, and the third section 130 comprises multiple layers of KEVLAR-726.

[0026] In certain of these examples, one or more layers of soft armor material other than an aramid, for instance ZYLON-530, KEVLAR-704 and KEVLAR-726 may be employed in the first, second or third layers 110, 120, 130, respectively, in addition to the layers specified above.

[0027] In some cases the nitrile phenolic based bondable layers are commercially available in film form include those available from Scapa North America (Scapa), Windsor, Conn., USA, under the trade name of H153U, H212U and H193U.

[0028] An example foam material is VHB 4910 which a clear acrylic foam tape having an average tape thickness of 1.10 mm and a red film liner with a thickness of 0.08 mm. The foam density averages 960 kg/m³. The 90 degree peel adhesion to steel at RT with 72 hr dwell time has a common value of 26 N/10 mm.

[0029] An example foam material is Scapa AS1179W which an acrylic foam tape having an average tape thickness of 1.1 mm and a red film. The foam density averages 860 kg/m³. The 90 degree peel adhesion to steel at RT with 72 hr dwell time has a common value of 50 N/25 mm.

[0030] The second acrylic foam material is Scapa AS1130TP, which is a clear acrylic foam tape having an average tape thickness of 0.6 mm. The foam density averages 860 kg/m³. The 90 degree peel adhesion to steel at RT with 72 hr dwell time has a common value of 60 N/25 mm.

[0031] The third acrylic foam material is Scapa AS1179GHS, which is a grey acrylic foam tape with a pressure sensitive adhesive on one side and a heat activatable adhesive on the other side of the foam core layer. It has 1.1 mm total thickness and foam density around 850 kg/m³.

[0032] Polyurethane (PU) foam material is Scapa 3909 adhesive tape with acrylic pressure sensitive adhesive coated on one side of the PU foam. It has 2 mm thickness and 10 N/25 mm Peel Adhesion under 10 minute dwell and 180 degree per Scapa Test Method F10.

[0033] Polyvinyl Chloride (PVC) foam material is Scapa 3509 adhesive tape with acrylic pressure sensitive adhesive coated on one side of an elastic PVC foam. It has 1.5 mm thickness and 5 N/25 mm Peel Adhesion under 10 minute dwell and 180 degree per Scapa Test Method F10.

[0034] Elastic EVA foam material is Scapa SA416V that is an adhesive tape have an elastic EVA foam. The EVA foam is two-side coated with acrylic adhesive. SA416V has 1.6 mm thickness and 15 N/25 mm Peel Adhesion under 10 minute dwell and 180 degree per Scapa Test Method F10.

[0035] Silicone based elastic materials include RTV silicone materials, foamed silicone materials and adhesives. Scapa RX1267P is a silicone pressure sensitive adhesive coated on elastic polyester film in total thickness of 0.2 mm. The silicone adhesive side provides 1 N/25 mm Peel Adhesion under 1 minute dwell and 180 degree per Scapa Test Method F10.

[0036] FIG. 2 depicts another example of an armor structure 200 which comprises a layered construction of a first section 210 and a second section 220. The armor structure 200 is configured to be worn, mounted or otherwise employed such that the first section 210 is located closest to a threat (e.g., incoming gunfire) and the second section 220 is located closest to the wearer, vehicle, aircraft, building, etc. to be protected by the armor structure 200.

[0037] In some examples, both of the first and second sections 210, 220, are formed from soft armor material. In certain such examples, the first section 210 comprises an aramid, for instance ZYLON™ and the second section 220 comprises KEVLAR™. In other such examples, one or both of the first and second sections 210, 220 may comprise woven ZYLON™ or woven KEVLAR™, or multiple layers of woven aramid, for instance ZYLON™ or woven KEVLAR™.

[0038] In one example, the first section 210 comprises multiple layers of an aramid, for instance ZYLON-530 and the second section 220 comprises multiple layers of KEVLAR-

726. In addition, if desired, the layers of the second section **220** may be laminated to improve resistance to deformation.

[0039] In further type IIIa-compliant examples of the armor structure **200**, the first section **210** comprises multiple layers of an aramid, for instance ZYLON-530, and the second section **220** comprises multiple layers of KEVLAR-726. In these examples, one or more layers of armor material other than an aramid, for instance ZYLON-530 or KEVLAR-726 may be employed in the first or second layers **210**, **220**, respectively.

[0040] FIG. 3 depicts another example of an armor structure **300** which comprises a first armor structure comprising any of the examples of the armor structure **100**, positioned adjacent a second armor substructure comprising any of the examples disclosed herein of the armor structure **200**. The various examples of the armor structure **300** defeat handgun fire and various threats as discussed above, and achieve NIJ type IIIa protection.

[0041] In some examples, different sections are formed from soft armor material. In different examples, the first section can include an aramid, for instance ZYLON and the second section **620** can include SPECTRASHIELD PLUS™, namely ultra-high molecular weight polyethylene or fabric. In other such examples, one or both of the first and second sections can include comprise woven aramid, for instance ZYLON™ or woven SPECTRASHIELD PLUS™, or multiple layers of woven aramid, for instance ZYLON™ or woven SPECTRASHIELD PLUS™.

[0042] There can be layers of an aramid, for instance ZYLON-530 and layers of SPECTRASHIELD PLUS-902 (i.e., SPECTRASHIELD PLUS similar to style no. 902 available from Hexcel Schwebel of Anderson, S.C., or from Honeywell Corp. of Morristown, N.J.).

[0043] In further type III-compliant examples of the armor structure **600**, the first section **610** comprises 100 or more layers of an aramid, for instance ZYLON-530, and the second section **220** comprises 135 or more layers of SPECTRASHIELD PLUS-902. In these examples, one or more layers of armor material other than an aramid, for instance ZYLON-530 or SPECTRASHIELD PLUS-902 may be employed in the first or second layers **610**, **620**, respectively, in addition to the layers specified above.

[0044] Any of the examples of the soft armor structures **100**, **200**, and **300** may be employed to construct any of a variety of armored equipment. For example, the disclosed armor structures may be employed to construct soft body armor, such as a bulletproof vest. Such a vest can be entirely constructed from one or a combination of the armor structures, providing ballistic protection of a given type that “wraps” completely around a torso of a wearer. Any of the armor structures **100**, **200**, **300** may also be employed to form armor panels for use in vehicles, either on or against the vehicle “skin” or in critical locations like seats, cockpits, fuel tanks, hydraulic lines, ammunition stores, helmets or armor panels for buildings.

[0045] The armor structures and/or armored articles may have each of the layers of armor material laser-cut into the desired perimeter shape. The layers can be cut individually or in groups of 2 or more. Laser cutting has proven advantageous in that it prevents fraying of woven armor materials as the laser heat tends to “heat-seal” the edges of the cut material. In some cases adhesive tape, such as a polymer tape, can be used over some or all of the perimeter edges of the “sandwich” of layers. The tape can be stitched to the layers.

[0046] Specifications for various materials discussed above are as set out.

[0047] ZYLON-530: SPECIFICATIONS Yarn Type Warp Yarn Zylon AS, 500 denier Fill Yarn Zylon AS, 500 denier Fabric Weight 4.00 oz/yd.2 136 g/m² Weave Style Plain Nominal Construction Warp Count 30 (yarns/inch) Fill Count 30 Fabric Thickness 8.0 mils 0.20 mm Breaking Strength 1080 lbf/in 1020 lbf/in.

[0048] KEVLAR-704: SPECIFICATIONS Yarn Type Warp Yarn Kevlar 129, 840 denier Fill Yarn Kevlar 129, 840 denier Fabric Weight 7.0 oz/yd² 237 g/m² Weave Style Plain Nominal Construction Warp Count 31 (yarns/inch) Fill Count 31 Fabric Thickness 12.0 mils 0.3 mm Breaking Strength 900 lbf/in 950 lbf/in.

[0049] KEVLAR-724: SPECIFICATIONS Yarn Type Warp Yarn Kevlar 129, 1000 denier Fill Yarn Kevlar 129, 1000 denier Fabric Weight 6.5 oz/yd² 220 g/m² Weave Style Plain Nominal Construction Warp Count 24 (yarns/inch) Fill Count 24 Fabric Thickness 11.0 mils 0.28 mm Breaking Strength 763 lbf/in 776 lbf/in.

[0050] KEVLAR-726: SPECIFICATIONS Yarn Type Warp Yarn Kevlar 129, 840 denier Fill Yarn Kevlar 129, 840 denier Fabric Weight 6.0 oz/yd² 203 g/m² Weave Style Plain Nominal Construction Warp Count 26 (yarns/inch) Fill Count 26 Fabric Thickness 10.0 mils 0.25 mm Breaking Strength 760 lbf/in 770 lbf/in.

[0051] SPECTRASHIELD PLUS-902: SPECIFICATIONS Yarn Type Warp Yarn Spectra 900, 1200 denier Fill Yarn Spectra 900, 1200 denier Fabric Weight 5.5 oz/yd² 187 g/m² Weave Style Plain Nominal Construction Warp Count 17 (yarns/inch) Fill Count 17 Fabric Thickness 18.0 mils 0.46 mm Breaking Strength 900 lbf/in 850 lbf/in.

[0052] The shield also uses an adhesive tape or film **140**, **150**, **230** and **330** which is used is a barrier layer. The barrier layer may be non-perforated, namely extend as a continuous layer throughout the adhesive tape or may be perforated, namely extend discontinuously along one or both orthogonal axes that are parallel to the major surface of the adhesive tape or film. On both opposite major sides of the layer, where there is an adhesive tape or film **140**, **150**, **230** and **330** there is an adhesive layer defining adhesive surfaces on both major sides of the adhesive tape or film.

[0053] A pressure sensitive adhesive can provide a tacky surface so that the tape or film can adhere two components together by application of pressure. Typically, the pressure sensitive adhesive will be tacky and capable of adhering components together in a temperature range of 5 to 200 degrees C., typically between 10 and 150 degrees C. An activatable adhesive when activated will provide the final bond strength of the components that are bonded together by the adhesive tape. During activation, there may be an overlap in properties where the pressure sensitive adhesive is decreasing in strength due to activation by for example an increasing temperature and the activatable adhesive is increasing in strength.

[0054] The adhesive can be a nitrile phenolic, epoxy, polyurethane, polyamide, polybutadiene type polymer (thermoplastic or thermoset), or combinations thereof.

[0055] In one exemplary implementation, the adhesive consists of hard and soft polymeric regions. These regions are set depending on the desired rheological or flow characteristics of the adhesive at short and long durations of stress or impact under different temperature conditions. In one embodiment, the adhesive is a nitrile phenolic having regions of hard phenolic and soft nitrile rubber. In some instances, the

hard and soft polymeric region of the adhesive can be compatibilized to be a single phase. The rheology of the adhesive is such that at the time of assembly, the adhesive will be fluid enough under minimal heat to allow adequate bonding to the surface. The adhesive can be post cured by application of heat after the bonding process to improve the rigidity. The activation temperature of the curing process can be adjusted to lower temperatures for easy application. An example of the rheological characteristics of various embodiments of adhesives are shown in FIG. 4.

[0056] In some embodiments, the adhesive can be relatively non-tacky or low tack at room temperature handling conditions. This allows the adhesive to be in the form of a sheet that can be easily applied in a continuous process.

[0057] Not limited to strictly body armor and shield material, the adhesive can be combined with various other types of fiber elements or cloth combinations. The multi-layers and multi-regions created from these combinations provide a range of flexible and rigid structures that can be used in various other applications. For example, the multi-layer combination of the adhesive with cloth materials can be used in wearable clothing, where flexibility is most important. The multi-layer combination of the adhesive and other materials can also be used in a physical structure such as structural partition, where rigidity is most important.

[0058] Furthermore, the adhesive by itself or in combination with fiber elements can be designed to provide products that can be washed and/or handled in different environments. For example, the adhesive may have resistance to diesel and other fluids/solvents when soaked for a finite time.

[0059] The impact resistance improvement that can be obtained with an adhesive tape or film connection with the present disclosure depend on the design. Both major sides of the adhesive tape or film can have an adhesive surface defined by an adhesive layer of the domains of pressure sensitive adhesive and activatable adhesive. The configuration, shape, size and arrangement of the adhesive domains need not be the same on both major sides of the adhesive tape although for convenience in the manufacturing of the adhesive tape, the adhesive surfaces on both major sides should be designed in the same way.

[0060] The thickness of the adhesive layer **140, 150, 230** and **330** is generally between 0.1 mm and 2.0 mm, preferably between 0.3 mm and 1.0 mm. The domains of pressure sensitive adhesive and activatable adhesive composition may be of the same thickness or different thickness.

[0061] An example, of the material is a 16-ounce fabric layers **110, 120, 130, 210, 220** should have a breaking strength not less than 1600 pounds. There should multiple sheets of high-strength fabric. As an assembly, for body armor, the panel or element is preferably not less than 0.25 inches thick, and not greater than 2 inches thick.

[0062] The sheets of thermal-fusible film adhesive **140, 150, 230** and **330** may be made of an ionic copolymer, epoxy, polyurethane, or other thermoplastic material. The thermal-fusible film adhesive is used in a quantity sufficient to consolidate the panel and provide good structural strength and fatigue resistance, without sacrificing the ballistic resistance provided by the sheets of high-tensile strength fabric.

[0063] A cushioning material may be selected from an aramid material, a polyurethane foam material, or other cushioning materials. The sheet of cushioning material, for instance could have a density not less than 3 pounds per cubic foot to a substantially higher level density.

[0064] The structure provides structural strength to assist in flattening ballistic projectiles, thereby improving the ballistic resistance of the panel. Suitable materials include unidirectional glass fibers or fiberglass woven materials impregnated with a phenolic resin. These are preferably not less than 0.01 inches thick, and not greater than 0.10 inches thick. The tensile strength is 40,000 pounds per square inch, or higher.

[0065] Fabric layers **110, 120, 130, 210, 220** may be any suitable high-tensile strength fabric such as are known for making ballistic resistant vests and the like. Various different suitable fabrics are commercially available, including fabrics made from aramid fibers such as KEVLAR™, fabrics made from ultra-high molecular weight polyethylene fibers such as Spectra™ and Dyneema, and fabrics made from polyphenebenzobisoxazole (PBO) fibers such as ZYLON™. Various cost and performance parameters may be considered in the selection of fabrics, but for purposes of a lightweight structural elements, aramid fibers provide a favorable cost/performance ratio.

[0066] Suitable aramid fabrics for layers **110, 120, 130, 210, 220** include, but are not limited to: Kevlar KM-2, 850 denier, 31 count plain weave style 705, 6.8 oz/yd² (breaking strength 880 lbf/in); Kevlar 29, 3000 denier, 17 count plain weave style 745, 14.0 oz/yd² (breaking strength 1600 lbf/in); and Kevlar 29, 3000 denier, 21 count 4×4 basket weave style 755, 16.5 oz/yd² (breaking strength 2000 lbf/in). These and similar high-tensile strength fabrics are available from numerous commercial vendors as known in the art.

[0067] The number of layers **110, 120, 130, 210, 220** of high-tensile fabric material should be selected in proportion to the weight, breaking strength, and dynamic performance of the individual layers. For example, layers of 2000 lbf/in fabric would provide comparable ballistic resistance to several layers of 1600 lbf/in fabric or to several layers of 880 lbf/in fabric.

[0068] The adhesive for adhering fabric layers together within body armor element or panel should be selected to permit flexure of the fabric layers when struck by a ballistic object, without failure of the adhesive layers. The matrix of fabric layers **110, 120, 130, 210, 220** and adhesive layers should be flexible and resilient to enable the fabric to deform and flex upon impact, thereby dissipating the kinetic energy of the projectile.

[0069] Various thermal-fusible materials may be used for film adhesive, including thermal-fusible ionic copolymer (ionomer) film, Surlyn™ Ionomers are ethylene acid copolymers, in which the acid groups are partially neutralized with either zinc or sodium ions. Ionic bonding between the polymer chains provides outstanding melt strength and toughness, which are particularly desirable properties for laminating the layers of high-tensile strength fabric. Other high-strength, flexible thermoplastic, thermoset, or epoxy adhesives are also suitable, and in particular, polyurethane materials.

[0070] The adhesive layer is a film having a thickness between about 0.5 and 6 mil, and all of the adhesive films are preferably selected to have the same thickness. The thickness of the film layers should be selected based on the weight and thickness of the surrounding fabric layers. For example, for use with an aramid fabric having a weight of 6.8 oz/yd² and a thickness of 12 mil, film layer may be about 1 to 2 mil thick, and for an aramid fabric having a weight of 16.5 oz/yd² and a thickness of 30 mil, film layer may be about 3 to 6 mil thick.

[0071] The interleaved fabric **110, 120, 130, 210, 220** and film layers **140, 150, 230** and **330** in the aggregate can be

about 14-27 percent ionomer resin by weight. A resin content in this range permits a high degree of consolidation of the panel core, thereby achieving a high degree of structural integrity and fatigue endurance without sacrificing ballistic resistance.

[0072] A cushioning layer is provided adjacent to the fabric **110, 120, 130, 210, 220** and resin layers. The cushioning layer permits internal flexure of the ballistic-resistant layers **110, 120, 130, 210, 220** for greater ballistic resistance while preserving the stability of the faces.

[0073] Suitable cushioning materials include aramid and honeycomb materials and foams. The cushioning material has a density between about 3 to 8 pounds per cubic foot, and a thickness from about 0.125 to 1.75 inches. The body armor can include both cushioning and fabric layers **110, 120, 130, 210, 220** is preferably about 0.25 to 2.0 inches thick.

[0074] High-tensile strength fabric layers **110, 120, 130, 210, 220** may be consolidated together with the film adhesive layers in an initial step. Then the consolidated fabric/film layers are consolidated with the remaining layers of the panel. The fabric layers, namely the high-tensile strength fabric **110, 120, 130, 210, 220** and film adhesive are cut to the desired panel size. If aramid (e.g., KEVLAR™ fabric) is used, it should be oven dried at about 150 degrees F. to remove any absorbed moisture. The desired number of layers are stacked on top of one another. A layer of release film should be placed at the top and bottom of the stack. The stack may then be consolidated using a vacuum bag and oven at 275 degrees F. to 300 degrees F. under 12-14 psi pressure for 2-3 hours, or using a heat press at 275 degrees F. to 300 degrees F. under 12-40 psi pressure for 20 minutes to 1 hour. The stack should be cooled down to about 120 degrees F. to 150 degrees F. before releasing pressure.

[0075] If an aramid material is used for the cushioning layer, it should be oven dried as described above. The stack should be surrounded by sheets of release film and placed between two sheets in a heat press. The heat press should be preheated to about 275 degrees F. to 300 degrees F.

[0076] Contact pressure of less than 3 psi should be applied for 1 to 2 minutes and the press opened. The procedure should be repeated 3 to 5 times at 1 to 2 minute intervals to release gas generated by the phenolic resin. The press should then be closed and the panel consolidated at 275 degrees F. to 300 degrees F. under 25 to 50 psi for 1 to 2 hours. The stack should then be cooled to about 120 degrees F. to 150 degrees F. before releasing pressure to complete the consolidation process, although the pressure may be released while the press is hot if the phenolic resin is formulated to permit "hot-in, hot-out" handling.

[0077] Different objects and advantages of the disclosure are described. It is understood that not necessarily all such objects or advantages may be achieved in accordance with any particular example of the disclosure. Those skilled in the art will recognize that the disclosure may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other objects or advantages as may be taught or suggested.

[0078] While the product and method have been described in terms of what are presently considered to be the most practical and preferred examples, it is to be understood that the disclosure need not be limited to the disclosed examples. It is intended to cover various modifications and similar arrangements included within the spirit and scope of the

claims, the scope of which should be accorded the broadest interpretation so as to encompass all such modifications and similar structures. The present disclosure includes any and all examples of the following claims.

1. A ballistics shield material comprising an armor structure formed from armor material components; the armor structure being substantially imperforable by armor-piercing fire; wherein the armor structure comprises at least multiple layers of high tensile material layers of para-aramid fabric, and an adhesive material for bonding components together, the adhesive material selectively being heat sensitive or other adhesive, and a visco elastic foam-like material.

2. A ballistics shield material as claimed in claim 1 wherein the material is an acrylic foam bonded with a heat sensitive adhesive.

3. A ballistics shield material as claimed in claim 1 wherein the material is an polyurethane foam bonded with a heat sensitive adhesive.

4. A ballistics shield material as claimed in claim 1 wherein visco elastic material is PVC foam bonded with a heat sensitive adhesive.

5. A ballistics shield material as claimed in claim 1 wherein the visco elastic material is EVA foam bonded with a heat sensitive adhesive.

6. A ballistics shield material as claimed in claim 1 wherein the visco elastic material is silicone bonded with a heat sensitive adhesive.

7. A ballistics shield material as claimed in claim 2 wherein the heat sensitive adhesive is nitrile phenolic adhesive.

8. A ballistics shield material comprising an armor structure formed from an armor material components; the armor structure being substantially imperforable by armor-piercing fire; wherein the armor structure comprises at least multiple layers of high tensile material layers of para-aramid fabric, and an adhesive material for bonding components together, the adhesive material comprising opposite first and second major sides, each of the first and second major sides having an adhesive layer thereon, the adhesive layers defining adhesive surfaces on both major sides of the adhesive material, each of the adhesive layers having (i) a pressure sensitive adhesive comprise an acrylic pressure sensitive adhesive, (ii) an activatable adhesive comprise an epoxy resin, or both (i) and (ii).

9. A ballistics shield panel formed from the ballistics shield material of claim 1.

10. A garment comprising at least one of the ballistics shield material of claim 1.

11. A vest comprising at least one of the ballistics shield material of claim 1.

12. A helmet comprising the ballistics shield material of any one of claims 1 to 11.

13. The ballistics shield material of claim 1 wherein the adhesive is a tape for bonding components together, said adhesive tape comprising a layer having opposite first and second major sides, each of the first and second major sides having an adhesive layer thereon, the adhesive layers defining adhesive surfaces on both major sides of the adhesive tape, each of the adhesive layers comprising areas of pressure sensitive adhesive and domains of an activatable adhesive composition, and each of the areas defining a part of the adhesive surface of the adhesive layer.

14. The ballistics shield material of claim 13 wherein the adhesive tape includes an activatable adhesive composition capable of being cross-linked upon exposure to heat.

15. The ballistics shield material of claim **8** wherein (i) the pressure sensitive adhesive comprises an acrylic pressure sensitive adhesive, (ii) the activatable adhesive comprises an epoxy resin, or both (i) and (ii).

16. The ballistics shield material of claim **13** wherein the adhesive tape includes (i) a pressure sensitive adhesive comprising an acrylic pressure sensitive adhesive, (ii) the activatable adhesive comprises an epoxy resin, or both (i) and (ii).

17. An adhesive tape comprising at least two or more polymeric materials and a heat activated curable adhesive and joining the at least two or more polymeric materials, the adhesive having micro regions of hard and soft polymeric materials.

18. The adhesive tape as claimed in claim **17** wherein the adhesive is a nitrile phenolic having regions of hard phenolic and soft nitrile rubber.

19. The adhesive tape as claimed in claim **17** wherein the adhesive is at least one of an epoxy, polyurethane, polyamide, polybutadiene.

20. The adhesive tape as claimed in claim **17** wherein the polymeric material is a film, cloth, foam, metal, foil or combination thereof.

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