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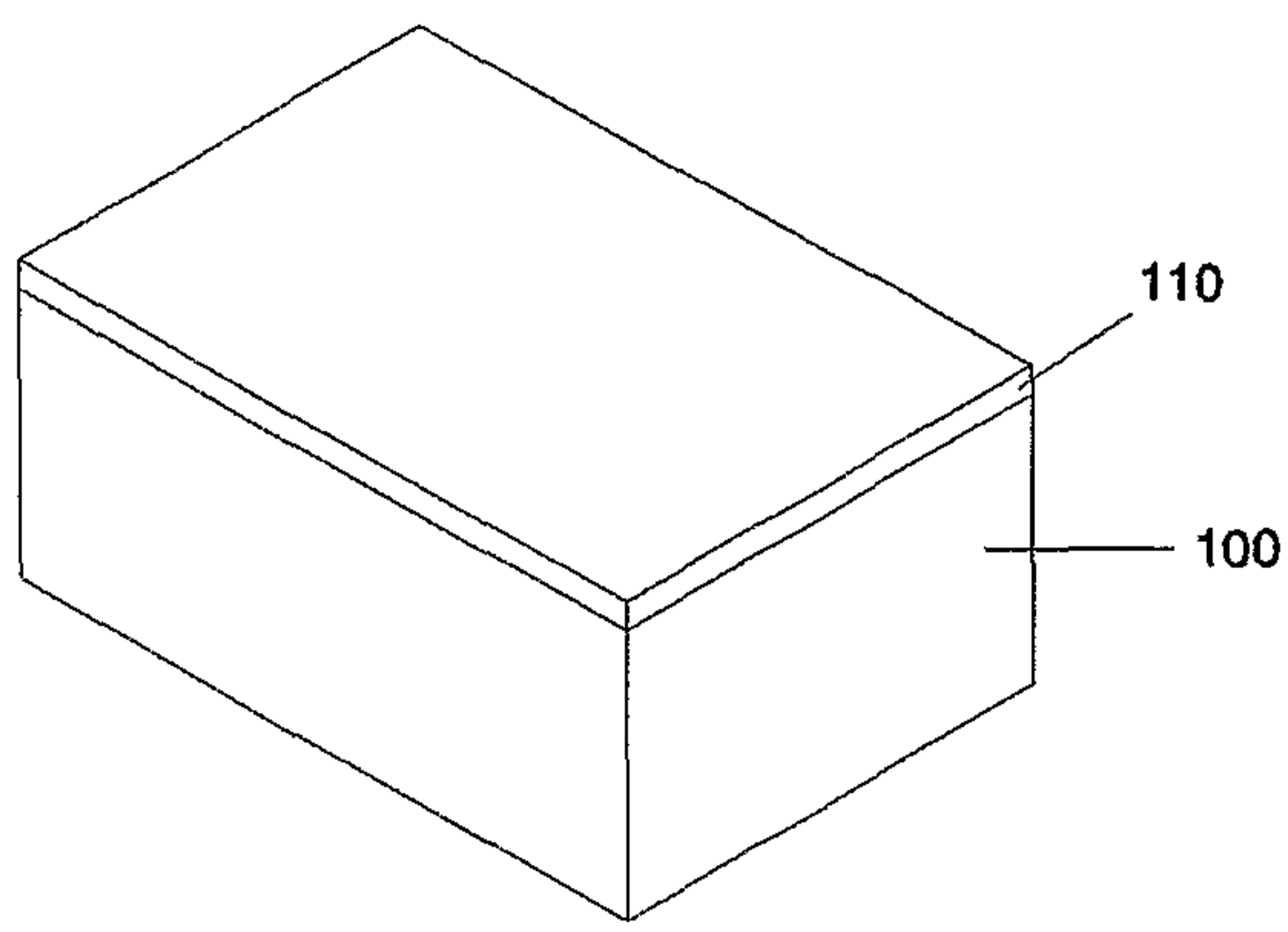
(54) Titre : COMPOSITE DE BLINDAGE A TRANSMISSION OPTIQUE
(54) Title: OPTICALLY TRANSMISSIVE ARMOR COMPOSITE



(57) Abrégé/Abstract:
An exemplary apparatus providing a substantially optically transparent/translucent composite armor material is disclosed as having: a first layer (110) of hard transparent material (i.e., a glass facing layer) adapted for attachment to a second layer (100) of polymer backing (i.e., a kinetic layer) and a layer of elastomeric bonding material disposed between the first (110) and second (100) layers. Disclosed features and specifications may be variously controlled, adapted or otherwise optionally modified to improve and/or modify the performance characteristics of the transparent/translucent armor composite. Exemplary embodiments of the present invention generally provide lightweight transparent/translucent armor for use as, for example, bulletproof windows in vehicles and buildings.

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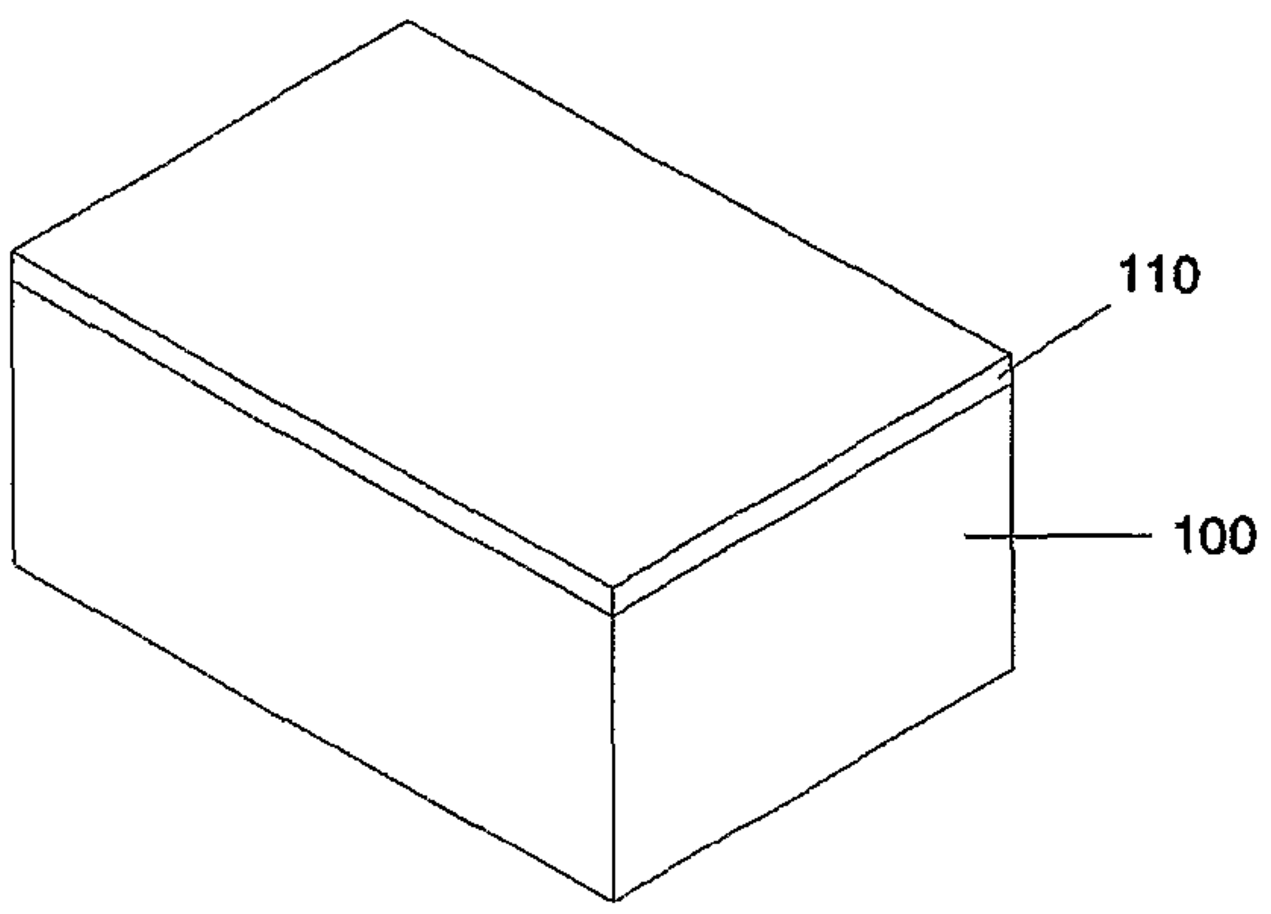
(54) Title: OPTICALLY TRANSMISSIVE ARMOR COMPOSITE



(57) Abstract: An exemplary apparatus providing a substantially optically transparent/translucent composite armor material is disclosed as having: a first layer (110) of hard transparent material (*i.e.,* a glass facing layer) adapted for attachment to a second layer (100) of polymer backing (*i.e.,* a kinetic layer) and a layer of elastomeric bonding material disposed between the first (110) and second (100) layers. Disclosed features and specifications may be variously controlled, adapted or otherwise optionally modified to improve and/or modify the performance characteristics of the transparent/translucent armor composite. Exemplary embodiments of the present invention generally provide lightweight transparent/translucent armor for use as, for example, bulletproof windows in vehicles and buildings.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Utility Patent Application for:

Title: **OPTICALLY TRANSMISSIVE ARMOR COMPOSITE**

Inventor: Richard L. Cook (Flagstaff, AZ, USA)

RELATED APPLICATIONS

[0001] This application claims priority to United States Provisional Patent Application Serial No. 60/633,365 (entitled 'Transparent Armor') filed in the United States Patent and Trademark Office on 12/03/2004 by Richard Cook.

FIELD OF INVENTION

[0002] The present invention generally provides improved systems, compositions and methods for substantially transparent/translucent, breakage-resistant composite structures; and more particularly, representative and exemplary embodiments of the present invention generally relate to bullet-resistant windows and/or ballistic laminate materials. In one representative aspect, various exemplary embodiments of the present invention relate to ballistic glass and transparent armor useful in military and security vehicle applications. Still other representative embodiments of the present invention relate to architectural and design elements for security purposes in hostile environments.

BACKGROUND

[0003] In recent times, security has become increasingly important. With respect to vehicle structures in general, military vehicles generally require greater than average protection for the occupants. This has given rise to various transparent armor structures for windshields and side windows that are designed to resist the incursion of small arms projectiles and shrapnel.

[0004] In constructing transparent armor, 'bullet-proof glass' sandwiches fabricated from glass are bonded together to form complex composites. The resulting composites are generally transparent and substantially free of optical distortion, while maximizing the ballistic protection from penetrators. In use, the inner and outer layers of the composite will typically be subjected to shock, scratching, abrasion and adverse weather conditions – particularly when a transparent armor composite is used in military applications.

[0005] The various layers used in the composite may be chosen for their different projectile resistance characteristics and functions. For example, glass layers are hard and thus readily erode bullets and are highly abrasion resistant; however, glass layers are also brittle, which generally causes any glass layers opposite a penetration threat to spall, which in turn creates shrapnel fragments. The shrapnel may produce numerous projectiles on the interior surface of the vehicle. The resulting spall (or fragments) may in fact be more dangerous than the original penetrator. Plastic material layers used as part of a composite sandwich provide a means to introduce flexibility into the transparent armor composite. The addition of one more plastic layers to the composite changes the failure mode of the transparent armor so it fails in a more ductile manner rather than spalling. Acrylic-, polyurethane- and polycarbonate-based materials are among the plastic materials which have been shown to have utility in producing transparent armor composites.

[0006] One class of plastics that has proven both useful and reliable in constructing transparent armor composites and architectural bandit type barriers is polycarbonate. Polycarbonate has demonstrated superior characteristics in terms of providing overall protection because it demonstrates the highest spread between brittleness transition temperature and heat distortion temperature. For this reason, polycarbonates are generally preferred materials in transparent armor composites. Unfortunately, polycarbonate and the other plastic materials are also soft and easily abraded by the action of dirt and dust. Furthermore, polycarbonates are frequently adversely affected by solvents and cleaning solutions when used to remove dirt. Thus, the cleaning of surface dirt and grime will inevitably cause scratching. This causes the optical properties to be adversely effected. Scratching can cause the transparency of the armor composite to substantially degrade in under one year. The substantial degradation of transparency generally necessitates replacement of the composite. Since transparent armor composites are expensive, frequent replacement creates a substantial financial burden on maintenance budgets.

[0007] In the conventional art, heavy glass in thicknesses in the vicinity of 0.5 inches have been used to blunt and decelerate bullets where the resulting spall is stopped by a polymeric backing. The attendant peripheral damage, both ballistically and optically, is severe and broad in scope.

SUMMARY OF THE INVENTION

[0008] In representative aspects, the present invention provides systems, devices and methods for providing bullet resistant windows (*e.g.*, ballistic glass) utilizing thin laminate glazing over resilient polymer backing capable of sustaining multiple close proximity hits from a variety of munitions. Advantages of the present invention will be set forth in the Detailed Description which follows and may be apparent from the Detailed Description or may be learned by practice of exemplary embodiments of the invention. Still other advantages of the invention may be realized by means of any of the instrumentalities, methods or combinations particularly disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Representative elements, operational features, applications and/or advantages of the present invention reside in the details of construction and operation as more fully hereafter depicted, described and claimed – reference being made to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout. Other elements, operational features, applications and/or advantages may become apparent in light of certain exemplary embodiments recited in the Detailed Description, wherein:

[0010] FIG. 1 representatively illustrates a three-quarter, isometric view of a substantially optically transmissive armor in accordance with an exemplary embodiment of the present invention;

[0011] FIG. 2 representatively illustrates a three-quarter, isometric view of another substantially optically transmissive armor in accordance with an exemplary embodiment of the present invention;

[0012] FIG. 3 representatively illustrates a three-quarter, isometric view of another substantially optically transmissive armor in accordance with an exemplary embodiment of the present invention;

[0013] FIG. 4 representatively illustrates a three-quarter, isometric view of yet another substantially optically transmissive armor in accordance with an exemplary embodiment of the present invention;

[0014] FIG. 5 representatively illustrates a three-quarter, isometric view of another substantially optically transmissive armor in accordance with an exemplary embodiment of the present invention; and

[0015] FIG. 6 representatively illustrates a three-quarter, isometric view of still another substantially optically transmissive armor in accordance with an exemplary embodiment of the present invention.

[0016] Elements in the Figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the Figures may be exaggerated relative to other elements to help improve understanding of various embodiments of the present invention. Furthermore, the terms “first”, “second”, and the like herein, if any, are generally used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. Moreover, the terms “front”, “back”, “top”, “bottom”, “over”, “under”, and the like, if any, are generally employed for descriptive purposes and not necessarily for comprehensively describing exclusive relative position or order. Any of the preceding terms so used may be interchanged under appropriate circumstances such that various embodiments of the invention described herein, for example, are capable of operation in orientations and environments other than those explicitly illustrated or otherwise described.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0017] The following representative descriptions of the present invention generally relate to exemplary embodiments and the inventor's conception of the best mode, and are not intended to limit the applicability or configuration of the invention in any way. Rather, the following description is intended to provide convenient illustrations for implementing various embodiments of the invention. As will become apparent, changes may be made in the function and/or arrangement of any of the elements described in the disclosed exemplary embodiments without departing from the spirit and scope of the invention.

[0018] In the past, multiple layers of glass in thicknesses in the vicinity of 1/2" were used in ballistic glass applications. The resultant peripheral damage, both ballistically and optically, was severe and broad in scope. Various embodiments of the present invention provide a tough kinetic backing layer with an overlying, relatively thin glass facing. The glass facing, being only of sufficient thickness to spoil the pointedness of the incoming projectile (*e.g.*, 1/8") may be bonded to the kinetic layer with an elastic medium.

[0019] When a projectile strikes the thin glass facing, the facing fractures, but in a much smaller area than that of convention ballistic glass assemblies.

[0020] In accordance with an exemplary embodiment representatively depicted in Figure 1, the present invention provides an improved optically transmissive armor. The optically transmissive armor has a first layer **110** (*e.g.*, a 'facing layer' presenting a surface of first contact to an incoming projectile), a second layer **100** (*e.g.*, a 'kinetic layer' for depleting the projectile's energy), and an optional elastomeric layer at least partially disposed therebetween (*e.g.*, a 'bonding layer' suitably configured for immobilizing facing layer **110** with respect to the disposition of kinetic layer **110**). The bonding layer may be composed of material having high elongation characteristics, or any other suitable material capable of mitigating temperature-rated expansion differentials associated with the kinetic layer **100** and the facing layer **110**. If the bonding layer does not have suitable elongation characteristics over a given temperature range, the bonding layer may become damaged should the first and second layers expand or contract.

[0021] Generally, the thickness ratio of the kinetic layer **100** (*e.g.*, polymeric material) to the facing layer **110** (*e.g.*, glass material) should be at least approximately unity. It will be appreciated, however, that various other thickness ratios may be alternatively, conjunctively or sequentially employed to achieve a substantially similar result. It will also be appreciated that different thickness ratios will produce different armor characteristics that are uniquely adapted for particular threats or operating environments.

[0022] The facing layer **110** may be comprised of a hard, glass-like material that operates to blunt or otherwise deform a bullet or projectile incident to its surface. The facing material may be almost any composition, such as, for example: soda lime; crown; borosilicate; aluminum oxynitride; sapphire; *etc.* Any glass material, whether now known or otherwise hereafter described in the art, may be alternatively, conjunctively or sequentially employed in order to achieve a substantially similar result.

[0023] It should be noted that the term "projectile" may refer to any object that may strike the surface of a optically transmissive armor assembly. These may include projectiles used to attack the integrity of the optically transmissive armor such as ballistic items (bullets, shrapnel, thrown objects such as bricks, stones and other similar objects) and self-propelled items (such as RPGs, missiles, and other rocket-like objects). Projectiles may also include objects used to directly strike the surface of the optically transmissive armor, such as, for example: bricks, bats, metal objects, stones, wooden clubs, *etc*. Finally, projectiles may also include other objects that come into contact with the surface of the optically transmissive armor. For example, if the optically transmissive armor is used as part of a vehicle and that vehicle were to be involved in an accident, portions of other vehicles, the road, buildings or other objects may strike the surface of the optically transmissive armor.

[0024] In the present embodiment, facing layer **110** has a preferable thickness of about 1/8" (± approximately 50%). This is in contrast to the conventional art, in which the principle structure consists of a plurality of thick layers of glass – as conventional glass layers are primarily used as kinetic depletion layers rather than as facing and blunting layers, as representatively disclosed and claimed in the instant application. In the present invention, the glass material generally serves to merely blunt or otherwise deform a projectile that is striking its surface, as opposed to depleting a substantial fraction of the kinetic energy of the projectile. Accordingly, glass facing layers in accordance with the instant invention may be relatively thin compared to those of the conventional art. A thinner layer of glass material is preferable because it significantly reduces the weight of the armor assembly without substantially decreasing penetration impedance, and simultaneously provides improved optical characteristics and retention of localized structural integrity after the armor assembly is struck by a projectile.

[0025] For comparable stopping power, the present invention weighs considerably less than that of conventional transparent armor alternatives. Optical clarity after a projectile strike (*i.e.*, hit proximity performance) is also improved. As the thickness of the glass facing material decreases, the damaged area (*i.e.*, hit radius) and glass loss also decreases. For example, the glass loss in a 1/8" facing is only about 1" diameter; however, with 1/4" glass, this area extends out to roughly 3" in diameter or greater. Accordingly, after a hit on a thinner layer of glass, less of the material's optical characteristics will have been compromised.

[0026] By way of comparison, the optical occlusion of conventional transparent armor extends out over a 6" radius from any given hit. Various exemplary embodiments of the present invention present an occluded area of only about 1.5" radius under similar conditions. Second hit capability (*i.e.*, the ability of the optically transmissive armor assembly to stop a projectile that strikes its surface in close proximity to the location of a prior hit) is substantially improved due to the minimized glass loss that results from use of thinner layers of glass facing. Generally, the glass loss area after a first hit is greatly weakened and will not provide much protection against a second hit. Accordingly, it is preferable to employ a thinner layer of glass material in the facing layer **110**, thereby minimizing the amount of glass loss.

[0027] Present performance specifications for transparent armor generally can require successful stoppage in a close hit pattern. The disconcerting issue is that realistic threats are likely to greatly exceed the specification requirement. The present invention operates to overcome many problems associated with the conventional art by providing a hit (and stoppage) capability in as low as 3/4" spacing in all directions.

[0028] The kinetic layer **100** of the optically transmissive armor generally comprises a tough, semi-rigid material having a high cut and puncture resistance capable of catching the blunted projectile by depleting its kinetic energy. For example, a single casting of a clean, hard urethane polymer is an exemplary material that may be employed in accordance with various embodiments of the present invention. Hard urethane has demonstrated ease of casting and superb close hit capability. Other materials having similar characteristics (*e.g.*, polycarbonate and acrylic), whether now known or otherwise hereafter described in the art, may be alternatively, conjunctively or sequentially employed to achieve a substantially similar result.

[0029] In accordance with another exemplary embodiment, as generally depicted in Figure 2 for example, interspersed kinetic layers **200**, **220**, **240** may comprise 1/4" polycarbonate optionally interleaved with relatively thin layers of urethane **210**, **230**. Of course, significant benefit may be derived from an optically transmissive armor substantially comprising polymer and elastomeric layers having various other thickness dimensions in combination with a relatively thin, hard facing layer **250**. The layers' dimensions may be altered by up to approximately ± 50% and still provide significant performance improvement over the conventional art. Additionally, the ratio of the facing:kinetic thickness dimensions may be significantly, which may be alternatively, conjunctively or sequentially employed to achieve a substantial benefit over the conventional art. It will also be appreciated that different thickness ratios will produce different armor characteristics that are uniquely adapted for particular threats or operating environments.

[0030] In accordance with another exemplary embodiment, as generally depicted in Figure 3 for example, the facing may comprise more than one sheet of material **310, 320, 330** overlying a relatively thicker kinetic layer **300**. Suitable configurations of the facing may comprise two sheets of glass material **310, 320**; or the facing may comprise more than two sheets of glass material **310, 320, 330**. It will be understood that although specific dimensions for the facing material have been provided *vide supra*, significant benefit may be derived from the use of other dimensions as well. For example, the thicknesses of glass facing material may be significantly altered and still provide substantial benefit over the conventional art.

[0031] In accordance with still another exemplary embodiment, as generally depicted in Figure 4 for example, a first layer **410** may be substantially articulated. Facing layer **410** may be articulated with a plurality of tile elements **420**. Tile elements **420** may comprise different shapes, including, for example: discrete tiles (as generally depicted in Figure 4); spheres; polyhedra; cylinders; and/or regular solids. Marbles (*e.g.*, spheres) have been demonstrated as an efficient tile element material (with net area density calculated in the range of 10-12 lbs/ft^2); however, even plate glass (1/4" to 1/2" thick) mosaics have demonstrated themselves to be quite efficient with densities in the 14 lbs/ft^2 range. Various tiles **420** may be coupled together with any suitable polymer matrix; however, in some applications, an important consideration may involve matching the indices of refraction of the optically transmissive tile elements **420** with that of the polymer matrix to eliminate or otherwise reduce optical distortions.

[0032] An exemplary glass/polymer composite embodiment comprises borosilicate glass (having a refractive index of about 1.48) and a low modulus, low temperature curing urethane. By addition of low R1 plasticizers, the index of refraction match can be nearly perfect (within a given temperature range). This limit of temperature range may preclude the use of sphere tile elements, but flat mosaics may be useful under similar conditions. Although it is generally preferable to match the indices of refraction for certain applications, substantial benefit may be derived from an optically transmissive armor where the indices of refraction are dissimilar. For example, even with mis-matched indices of refraction, optically transmissive armor would still function well under a variety of conditions in diverse operating environments. Articulation of the facing layer **410** has demonstrated minimization of the glass loss that results after a projectile strikes the surface of the first layer **410** by *inter alia* localizing fracture expansion to a single tile (or nearest-neighbors) regime. Accordingly, the loss of facing material will generally be confined to the particular tile or tiles **420** that were struck by the projectile.

[0033] In accordance with yet another exemplary embodiment, as generally depicted in Figure **5** for example, the facing may comprise more than one layer of substantially articulated glass material **510, 530, 540**. The articulation may be accomplished via a plurality of tile elements **520**. Tile elements **520** may comprise different shapes, including, for example: discrete tiles (as generally depicted in Figure 5); spheres; polyhedra; cylinders; and/or regular solids. In the representative embodiment illustrated in Figure 5, boundaries **525** of tile elements **520** in the sheets of glass facing **540, 530, 510** may be suitably configured so as not to substantially overlap. Such a configuration may find particular utility in specific applications where the boundaries **525** of tiles **520** are generally less able to blunt or deform a projectile than the normal substantially unitary surface of tiles **520** themselves. Accordingly, should a projectile strike a boundary **525** of a tile **520**, the projectile may not be sufficiently blunted such that the kinetic layer **500** can effectively stop or otherwise impede the projectile. By offsetting overlap of boundaries **525**, it will be unlikely that a projectile could have sufficient kinetic energy and angle-of-attack to pass through a substantial linear distance of kinetic material having first squarely struck any given boundary **525** of facing tiles **520**.

[0034] Substantial benefit may be derived for configurations of the facing layer(s) where some sheets of facing material are substantially articulated and others are not. For example, the first layer of facing material **540** presented to a projectile may not be articulated, but the other sheets of facing material may be articulated – thereby minimizing glass loss within those layers, as well as reducing construction complexity and fabrication costs.

[0035] In accordance with yet another exemplary embodiment, as generally depicted in Figure **6** for example, the facing may comprise more than one layer of glass material **610, 620, 630**. Overlying facing layer **630** may be substantially contiguous, so as to prevent or otherwise impede dirt and/or other materials from lodging in the interstitial regions between the tile elements of articulated layers **610, 620**. Tile elements may comprise different shapes, including, for example: discrete tiles/blocks (as generally depicted in Figure 6); spheres; polyhedra; cylinders; and/or regular solids. In the representative embodiment illustrated in Figure **6**, the boundary edges between the tile elements in the articulated sheets of glass facing **610, 620** may be suitably configured so as to substantially overlap. Such a configuration may find particular utility in specific applications where optically clarity is to be maximized – especially where the indices of refraction between the tile elements (as well as between overlying and underlying layers) can be well-matched.

[0036] Optically transmissive armor composite assemblies, in accordance with various embodiments disclosed herein, may be constructed using vacuum and autoclave processes of laminate stack-ups. The stacks may comprise a combination of multi-layered thick glass, polymeric inner-layers and polymeric backing. The composite laminate assembly may then be heated and cooled under pressure. Various other embodiments of the present invention may also be cast with conventional equipment.

[0037] In the foregoing specification, the invention has been described with reference to specific exemplary embodiments; however, it will be appreciated that various modifications and changes may be made without departing from the scope of the present invention as set forth herein. The specification and Figures are to be regarded in an illustrative manner, rather than a restrictive one and all such modifications are intended to be included within the scope of the present invention. Accordingly, the scope of the invention should be determined by the claims and their legal equivalents rather than by merely the examples described above.

[0038] For example, the steps recited in any method or process claim may be executed in any order and are not limited to the specific order presented in the claims. Additionally, the components and/or elements recited in any apparatus embodiment may be assembled or otherwise operationally configured in a variety of permutations to produce substantially the same result as the present invention and are accordingly not limited to the specific configuration recited in the claims.

[0039] Benefits, other advantages and solutions to problems have been described above with regard to particular embodiments; however, any benefit, advantage, solution to problem or any element that may cause any particular benefit, advantage or solution to occur or to become more pronounced are not to be construed as critical, required or essential features or components of the invention.

[0040] As used herein, the terms “comprising”, “having”, “including” or any variation thereof, are intended to reference a non-exclusive inclusion, such that a process, method, article, composition or apparatus that comprises a list of elements does not include only those elements recited, but may also include other elements not expressly listed or inherent to such process, method, article, composition or apparatus. Other combinations and/or modifications of the above-described structures, arrangements, applications, proportions, elements, materials or components used in the practice of the present invention, in addition to those not specifically recited, may be varied or otherwise particularly adapted to specific environments, manufacturing specifications, design parameters or other operating requirements without departing from the general principles of the same.

CLAIMS

We claim:

1. A substantially optically transmissive armor composite, said composite comprising:

a facing layer (**110**) having a first thickness, said facing layer (**110**) comprising an at least partially at least one of transparent and translucent glass material;

a kinetic layer (**100**) having a second thickness, said kinetic layer (**100**) comprising an at least partially at least one of transparent and translucent polymeric material suitably configured for attachment to said first layer (**110**); and

an optional layer of an elastomeric material, said optional layer at least partially disposed between said first layer (**110**) and said second layer (**100**); and

wherein the ratio of said second thickness to said first thickness is at least about unity.

2. The armor composite of claim **1**, wherein said ratio of the kinetic layer (**100**) thickness to the facing layer (**110**) thickness is about 1.625.

3. The armor composite of claim **1**, wherein said facing layer (**110**) is suitably configured to at least one of: substantially blunt a projectile striking the facing layer's (**110**) surface; at least partially remove a coaxial portion of a projectile striking the facing layer's (**110**) surface; at least partially diminish the structural integrity of a coaxial portion of a projectile striking the facing layer's (**110**) surface; and at least partially deform the shape of a projectile striking the facing layer's (**110**) surface.

4. The armor composite of claim **1**, where said kinetic layer (**100**) is suitably configured to at least partially reduce the kinetic energy of a projectile penetrating at least partially into said kinetic layer (**100**).

5. The armor composite of claim **1**, wherein said facing layer (**410**) is substantially articulated.

6. The armor composite of claim **5**, wherein said facing layer (**410**) comprises a plurality of at least one of discrete tiles (**420**), spheres, marbles, polyhedra, cylinders and regular solids.

7. The armor composite of claim **1**, wherein the indices of refraction of the facing layer (**110**) and the kinetic layer (**100**) are substantially equivalent for a pre-determined temperature range.

8. The armor composite of claim **1**, wherein said facing layer (**110**) comprises a plurality of hard facing sub-layers (**310**, **320**, **330**).

9. The armor composite of claim **8**, wherein at least one of said facing sub-layers (**510**, **530**, **540**) is substantially articulated with a plurality of at least one of discrete tiles (**520**), spheres, marbles, polyhedra, cylinders and regular solids.

10. The armor composite of claim **9**, wherein the articulation boundaries (**525**) of at least two articulated facing sub-layers (**510**, **530**, **540**) are configured in at least one of a substantially staggered geometry and a substantially offset geometry.

11. The armor composite of claim **1**, wherein said facing layer (**110**) comprises at least one of an amorphous glass material and a crystalline glass material.

12. The armor composite of claim **1**, wherein said kinetic layer (**100**) comprises a plurality of kinetic sub-layers (**200**, **220**, **240**).

13. The armor composite of claim **12**, wherein the kinetic layers (**200**, **220**, **240**) comprise layers of at least one of polycarbonate, acrylic and urethane interspersed with layers of elastomeric polymer (**210**, **230**).

14. A method for protecting an object from projectile damage behind an at least partially optically transmissive barrier, said method comprising the steps of:

providing a facing layer **(110)** having a first thickness, said facing layer **(110)** comprising an at least partially at least one of transparent and translucent glass material;

providing a kinetic layer **(100)** having a second thickness, said kinetic layer **(100)** comprising an at least partially at least one of transparent and translucent polymeric material suitably configured for attachment to said first layer **(110)**; and

providing an optional layer of an elastomeric material, said optional layer at least partially disposed between said first layer **(110)** and said second layer **(100)**; and

wherein the ratio of said second thickness to said first thickness is at least about unity.

15. The method of claim **14**, wherein said ratio of the kinetic layer **(100)** thickness to the facing layer **(110)** thickness is about 1.625.

16. A substantially optically transmissive armor composite, said composite comprising:

a facing layer (**110**) having a first thickness, said facing layer (**110**) comprising an at least partially at least one of transparent and translucent glass material;

a kinetic layer (**100**) having a second thickness, said kinetic layer (**100**) comprising an at least partially at least one of transparent and translucent polymer material suitably configured for attachment to said first layer (**110**); and

an elastomeric layer comprising at least one polymer material, said elastomeric layer disposed between said first layer (**110**) and said second layer (**100**); and

wherein the ratio of said second thickness to said first thickness is at least about unity.

17. The armor composite of claim **16**, wherein said facing layer (**110**) comprises at least one of: two sheets of glass dimensioned with approximate thicknesses of 3/32" and 1/8" respectively; two sheets of glass dimensioned with approximate thicknesses of 3/32"; and two sheets of glass dimensioned with approximate thickness of 1/8".

18. The armor composite of claim **16**, wherein said facing layer (**110**) comprises at least one sheet of glass dimensioned with an approximate thickness of 1/8" bonded to a polymer layer, wherein said polymer layer is suitably dimensioned to contain spall generated when a projectile strikes the surface of said facing layer (**110**).

19. The armor composite of claim **16**, wherein said kinetic layer (**100**) comprises a plurality of semi-rigid polymer layers (**200, 220, 240**) interspersed with layers (**210, 230**) of elastomeric polymer.

20. The armor composite of claim **16**, wherein said kinetic layer (**100**) comprises a plurality of semi-rigid polymer layers (**200**, **220**, **240**) having an approximate thickness of about 1/4" interspersed with layers (**210**, **230**) of elastomeric polymer having an approximate thickness of up to about 0.05".

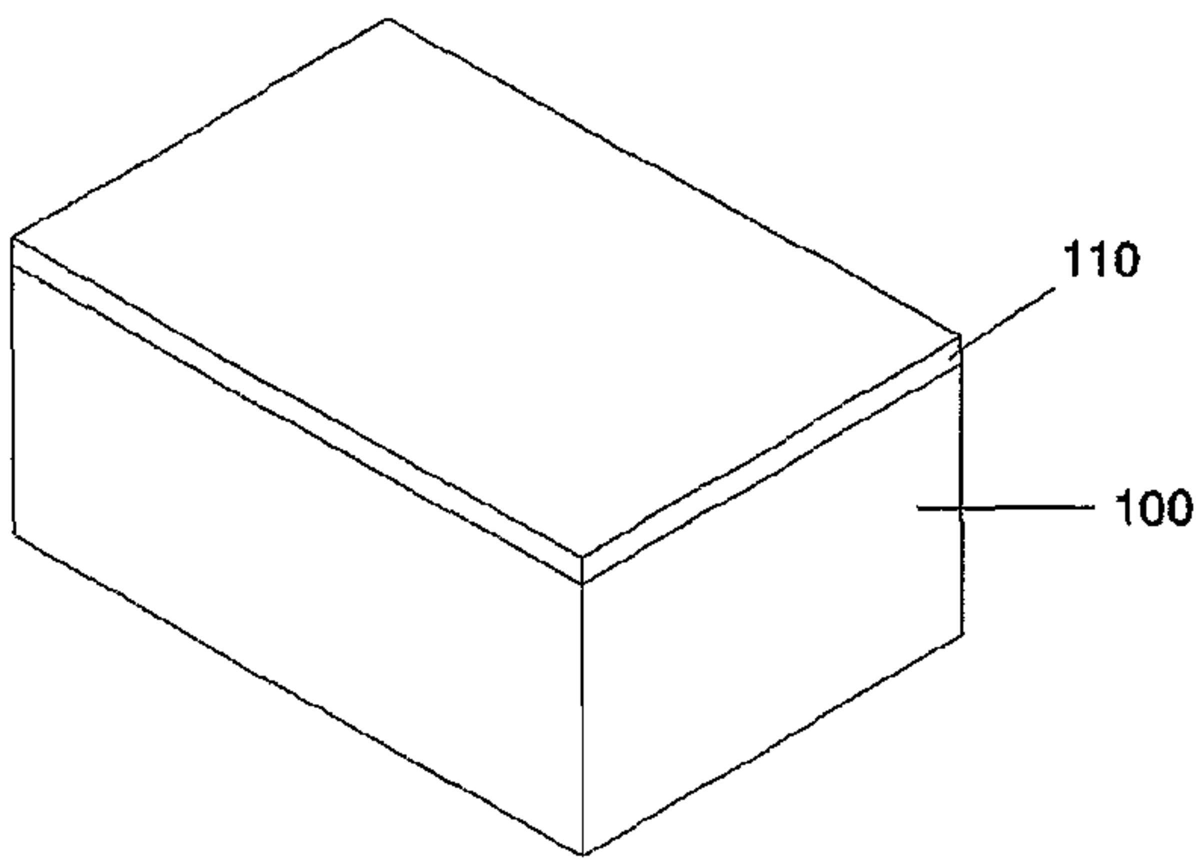


FIG. 1

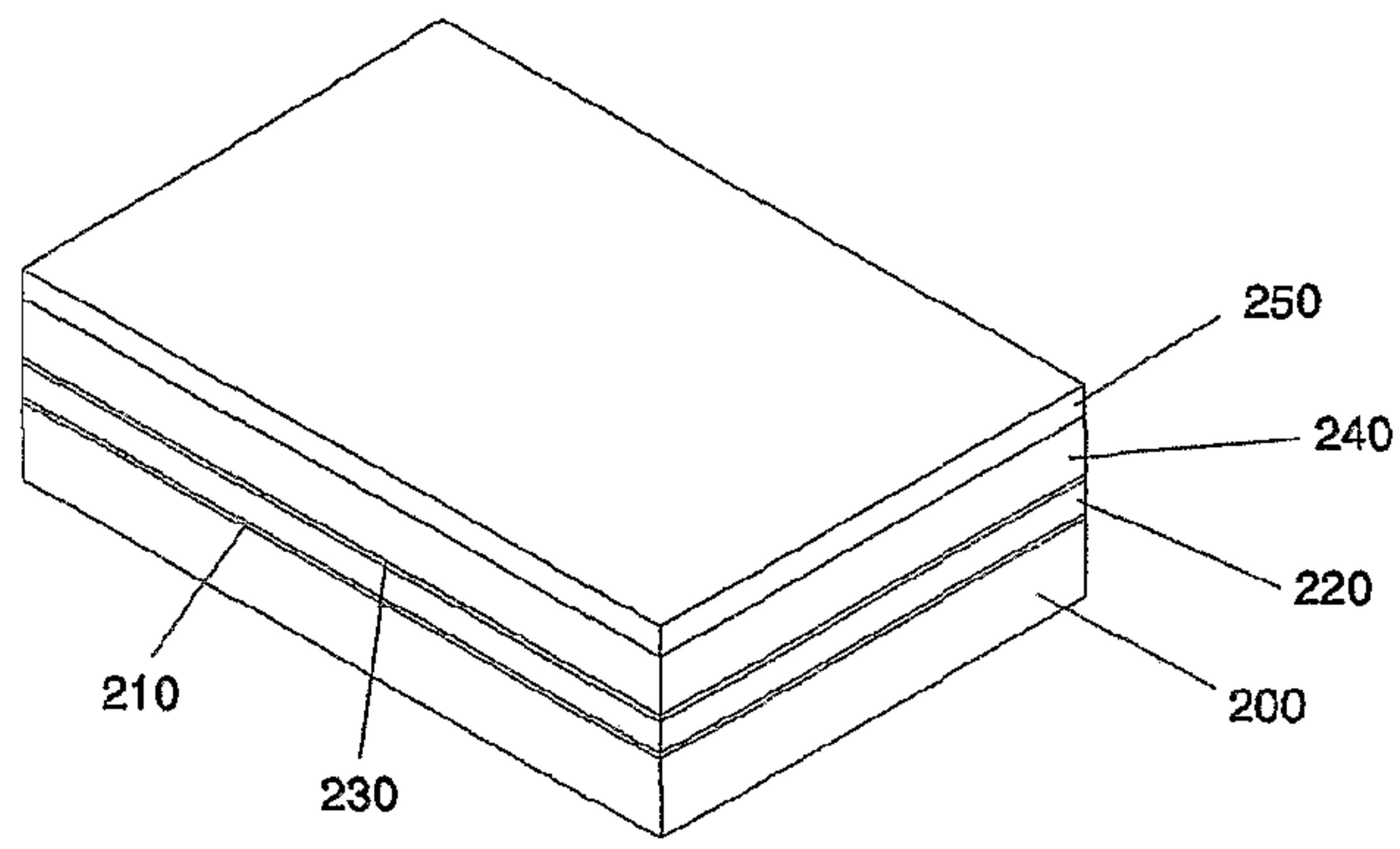


FIG. 2

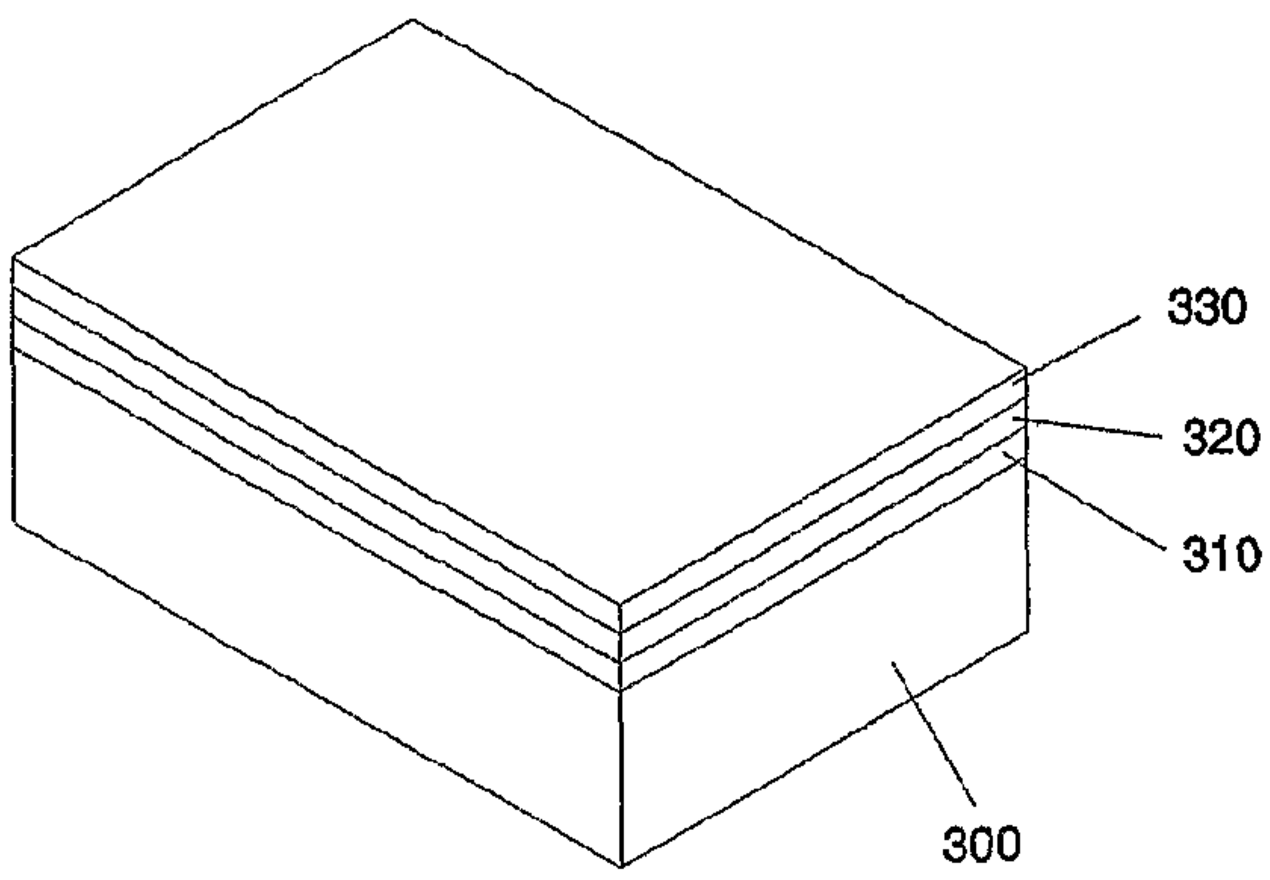


FIG. 3

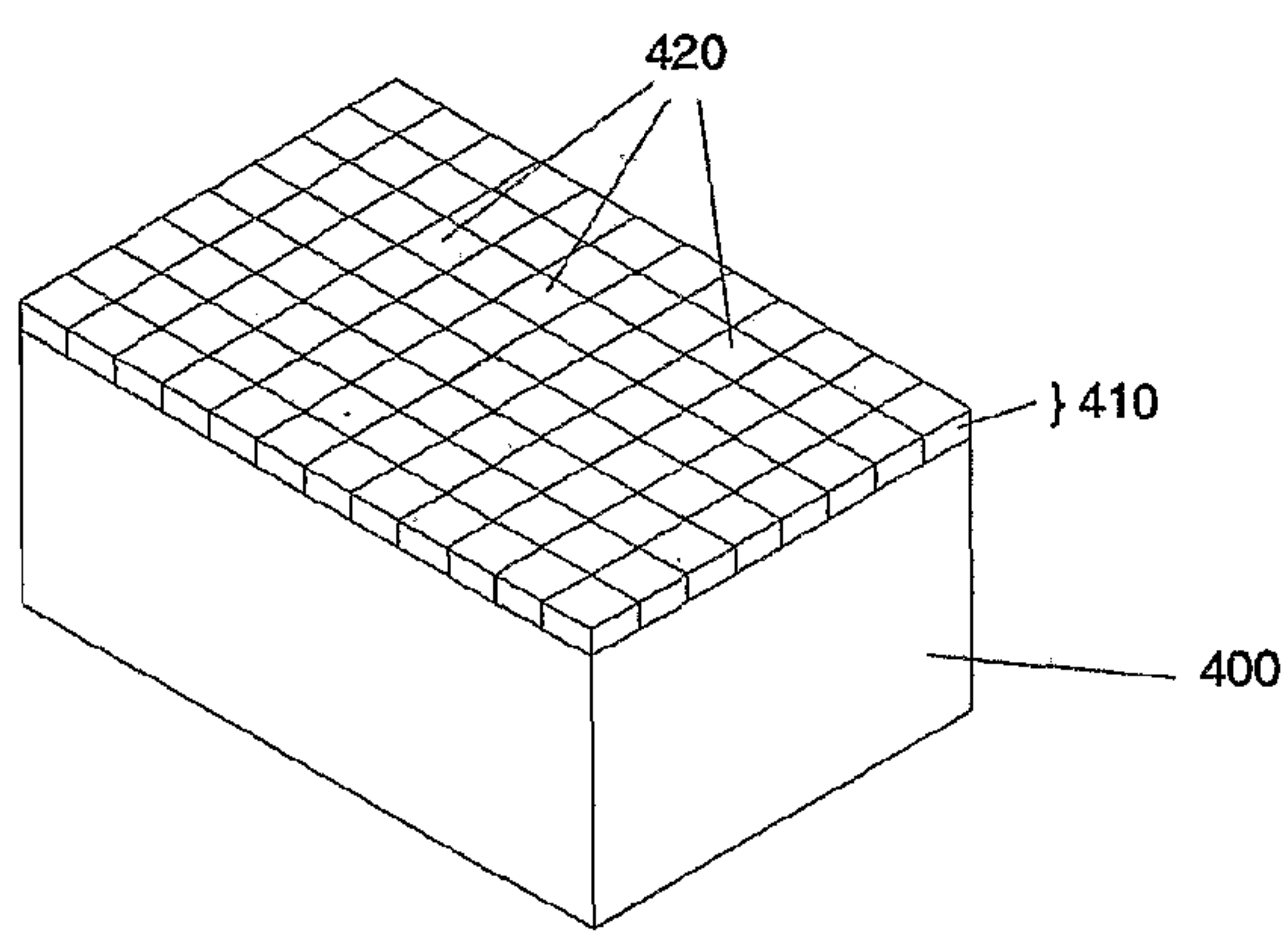


FIG. 4

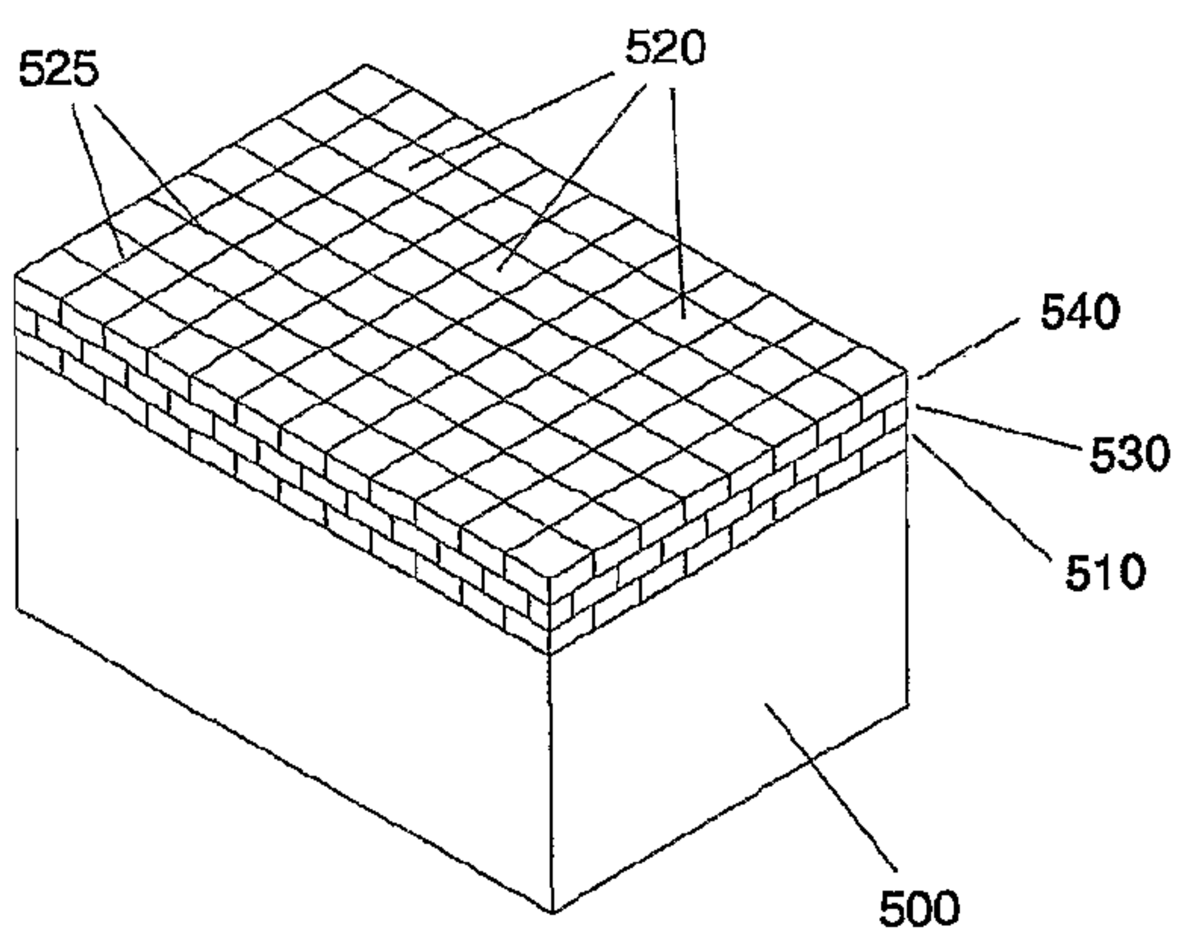


FIG. 5

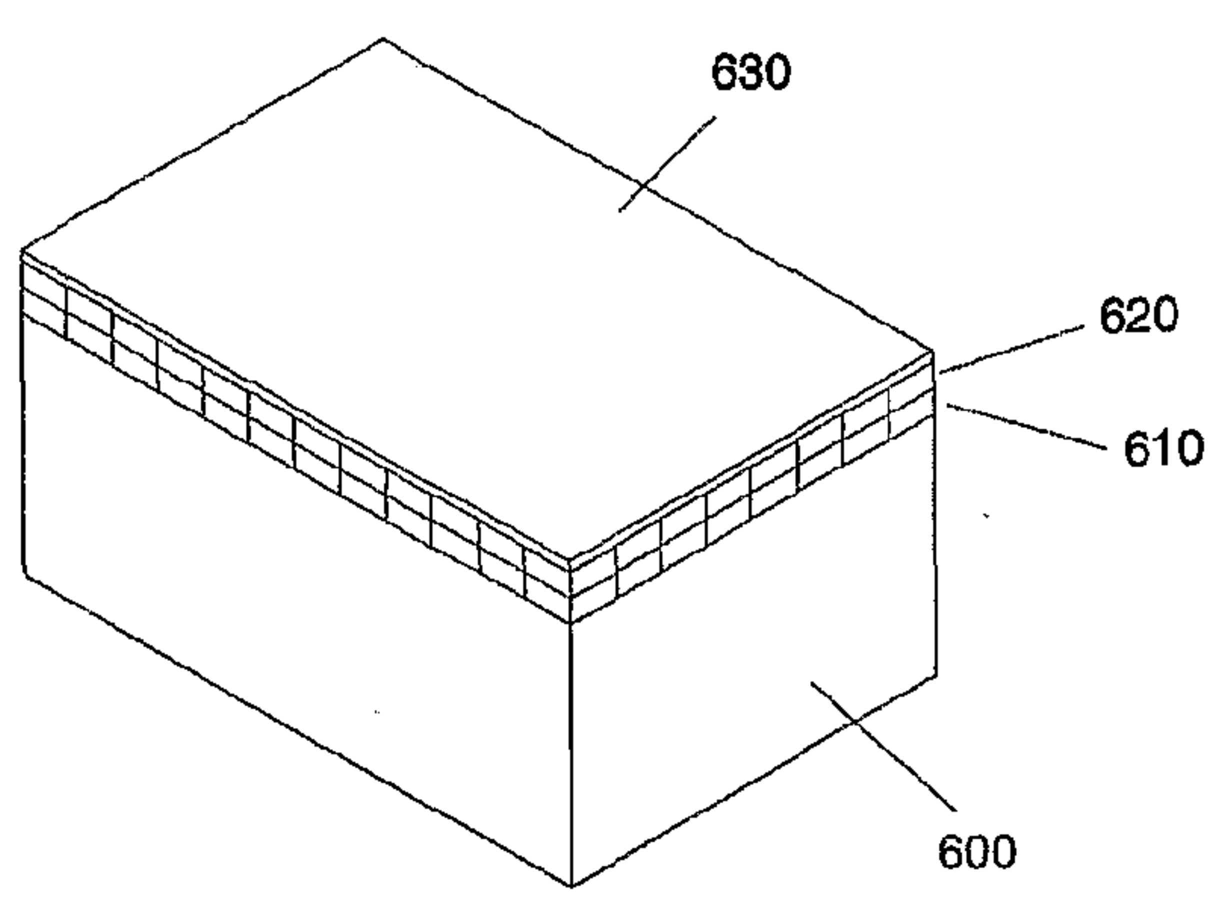
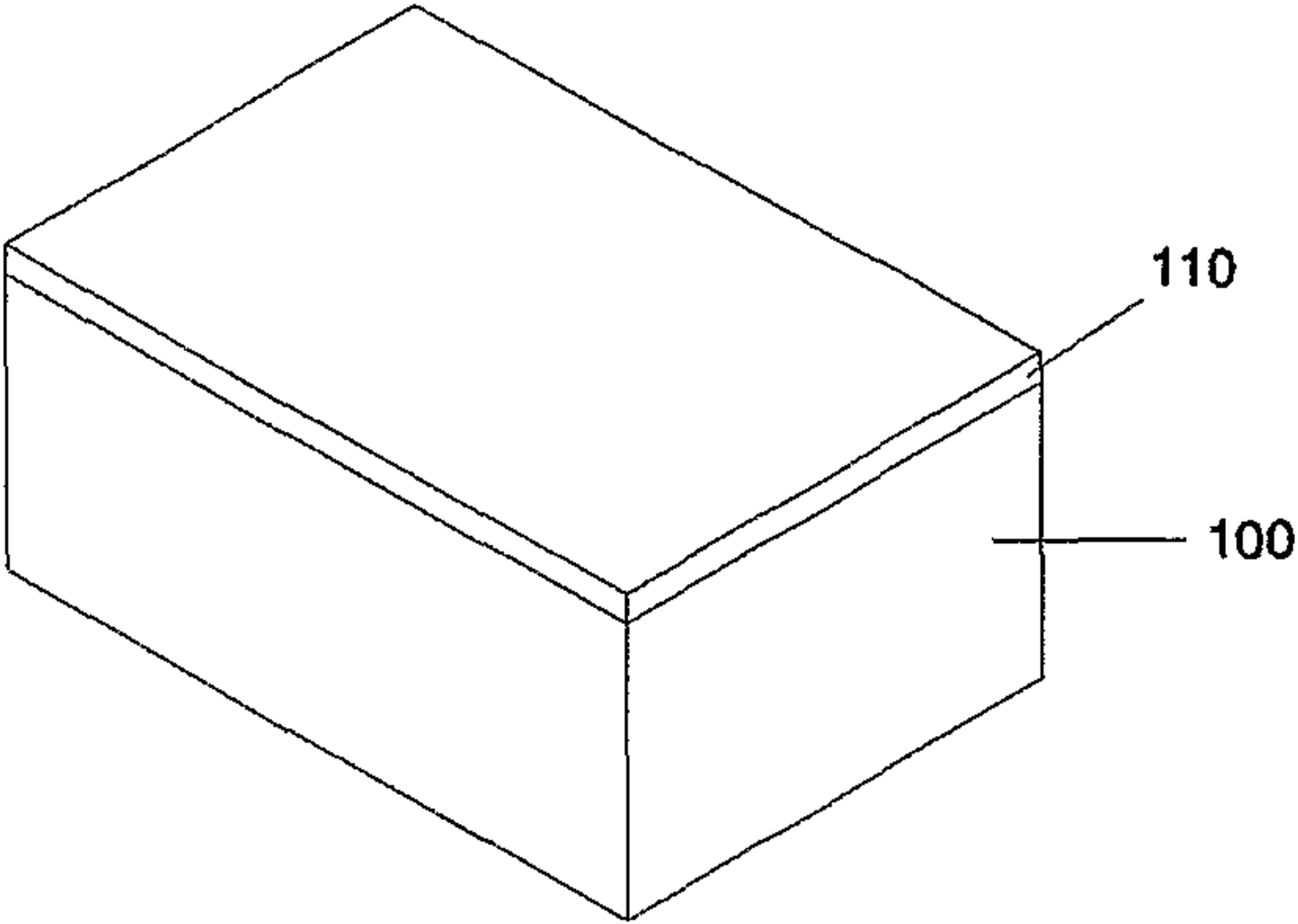


FIG. 6


110
100