



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
01.06.2011 Bulletin 2011/22

(51) Int Cl.:
F41H 5/04 (2006.01)

(21) Application number: **09252112.9**

(22) Date of filing: **02.09.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

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(54) **Improvements relating to armour**

(57) There is disclosed armour material comprising a plurality of ceramic portions and polymer material ar-

ranged to separate the ceramic portions. Body armour in which the armour material can be applied is also disclosed.

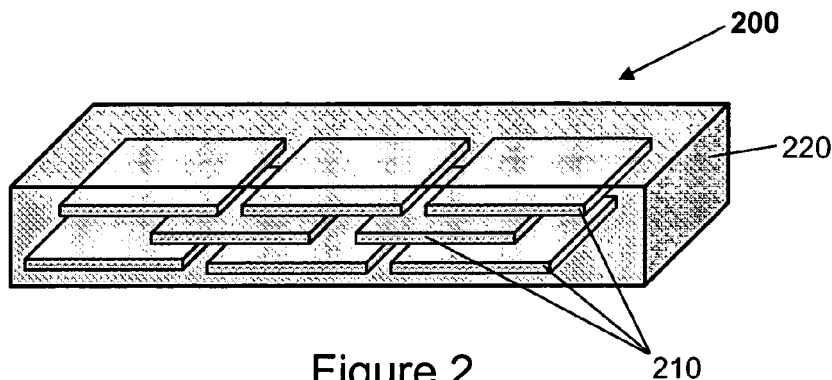


Figure 2

Description

Field of the invention

[0001] This invention relates to improvements concerning armour. In particular, the invention relates to improvements concerning body armour intended to mitigate against injury caused by ballistic projectiles, knife or other spike penetration.

Background

[0002] Body armour systems for personal protection have been developed in order to provide protection from ballistic projectile impacts in addition to knife and spike penetration. Materials which have been used to provide protection against such threats include metal, ceramics, and synthetic fibres. Many current armour systems which provide protection from high velocity projectiles (such as a 9mm or 7.62mm full metal jacketed bullet NIG level IIIA and III threat projectiles respectively) are based upon a jacket with pouches into which ceramic plates can be inserted. These monolithic ceramic plates cover a large area of the torso, protecting vital organs. The ceramic plate inserted into the jacket is selected with consideration of the expected threat to be defeated, thus providing a tailorable system. In addition to the ceramic plates spall liners are used behind the plate and in some cases in front of the plate. These spall liners capture fragments of the ceramic plate and projectile produced on interception of a high velocity projectile.

[0003] Although monolithic ceramic plates can provide protection against high velocity rounds this protection has a cost. The plates are heavy, bulky and also their rigidity all bears a burden upon the wearer and impede manoeuvrability. Additionally, ceramics are hard materials with a crystalline or glassy structure and upon impact a large area of the plate can break up limiting its effectiveness in defeating subsequent impacts. Consequently, a new lighter, more flexible armour system with increased comfort to the wearer is required which offers equivalent or enhanced protection to that offered by current monolithic plate armour.

[0004] United States patent, publication number US 6,745,661 and published United States patent application, publication number US2001015157, disclose armour comprising a plurality of ceramic discus-shaped disks, individually wrapped in a containment wrap. The wrapped disks are laid out in an imbricated pattern and adhered in place between a pair of fibrous layers. It is suggested to use an elastomer layer to seal the resulting panel to prevent degradation from exposure to environmental factors.

Summary of the invention

[0005] In accordance with a first aspect of the present invention, there is provided armour material comprising

a plurality of ceramic portions and polymer material arranged to separate the ceramic portions. In comparison to prior known armour systems, using monolithic ceramic plates, armour material in accordance with the present invention is lighter, since there is less ceramic material, and more flexible. Furthermore, the armour can be made in a variety of shapes so as to conform to human physiology, resulting in an increased level of comfort. Moreover, because a potentially large number of separate ceramic portions are included in the armour material, it is expected that the tolerance of the armour material to multiple impacts should be increased in comparison to prior known monolithic systems, since one impact should only damage a relatively small number of the ceramic portions.

[0006] The polymer material may be an elastomer. Use of an elastomer provides enhanced flexibility to the armour, and also increases the efficiency of dissipation of impact energy. Moreover, the elastomer protects the ceramic portions from damage as a result of general handling of the armour, since small shocks resulting from low energy impacts will be dissipated in the elastomer. Thus the armour material of the present invention is expected to exhibit improved damage tolerance in comparison to prior-known armour systems using monolithic ceramic plates.

[0007] In several embodiments of the invention described herein, the ceramic portions are generally tile-shaped. Alternatively, the ceramic portions may be generally pellet-shaped.

[0008] In some exemplary embodiments, the ceramic portions are arranged in an imbricated pattern. In this way, it is ensured that, in use, all parts of the body protected by the armour are covered by some ceramic material, since the individual ceramic portions overlap.

[0009] The polymer material may be provided as a plurality of tile-shaped portions, and the ceramic and material portions may be arranged alternately in a stack-like configuration. Such configurations are convenient to manufacture.

[0010] The polymer material may be a matrix material in which the ceramic portions are embedded.

[0011] A plurality of layers of ceramic portions may be provided. The ceramic portions in each layer may be arranged in a generally regular array, in which case the arrays in adjacent layers may be translated relative to one another. This ensures that the armour provides good coverage of ceramic material, to reduce the risk of a projectile penetrating between individual ceramic portions.

[0012] The polymer material may be a shear-thickening material. Shear thickening materials are thought to provide enhanced protection against knife attack.

[0013] The ceramic portions are formed from one of silicon carbide, boron carbide, and alumina.

[0014] The invention extends to body armour comprising clothing provided with a number of pockets into which armour material as described above is inserted. Because of the increased flexibility of the present armour material

in comparison to prior known monolithic ceramic armours, and because the present armour material can be made to better conform to the wearer's shape, it is expected that the present armour material will find application primarily in body armour. However, it is also envisaged to apply the armour material in other protective systems. For example, it could be used for vehicle armour.

Brief Description of the Drawings

[0015] The invention may be performed in various ways, and, by way of example only, embodiments thereof will now be described, with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of armour in accordance with a first embodiment of the invention;

Figure 2 is a schematic illustration of an insert to the first embodiment of the invention illustrated in Figure 1; and

Figures 3, 4, 5, 6, and 7 are schematic illustrations of alternative insert in accordance with a further embodiment of the invention.

Detailed Description of Exemplary Embodiments

[0016]

Figure 1 is a schematic illustration of body armour 100 in accordance with a first embodiment of the present invention. Body armour 100 is the front portion of a vest, and comprises a fabric portion 110 that is provided with a number of pouches 120. Armour inserts, as described below, are inserted into the pouches 120 in order to protect the wearer from hostile fire. It will be appreciated that, in use, a back portion to the armour, as well as further portions to protect further areas of the body, will also be provided.

Figure 2 is a schematic illustration of an insert 200 for an armoured jacket in accordance with a second embodiment of the present invention. Insert 200 comprises a plurality of ceramic portions 210 embedded within an elastomeric matrix 220. Portions 210 are each generally rectangular or tile-like in shape, and are arranged in three layers of substantially planar arrays. Each layer is translated relative to those immediately above and below it (as shown in Figure 2) such that, when viewed from above, the portions in a first layer extend over gaps between the portions in a second layer. Any gaps between portions in the first layer not covered by portions in a second layer are covered by portions in a third layer. In the present embodiment, three such layers of ceramic portions are provided.

[0017] Each ceramic portion 210 is surrounded by the elastomeric matrix material, such that each portion is separated from the others by elastomer. By including elastomer between the ceramic portions, the performance of the armour against multiple strikes is improved, since the shock transferred to ceramic components adjacent to those in the impacted area is reduced as a result of the behaviour of the elastomeric material. Similarly, the ceramic portions are protected against low force impacts caused by general handling of the insert by dissipation of the energy from such impacts within the elastomeric matrix material. The insert 200 is encased in a ballistic fabric, such as the polyaramid poly(phenylene diamine terephthalamide) fabric, sold by Du Pont under the registered name of Kevlar®. Many layers of fabric can be used. On impact of a projectile onto the armour, such fabrics capture fragments of the ceramic portions and fragments of the projectile that are created as a result of the impact.

[0018] Inserts 200 are fabricated in layers in moulds. Elastomer is poured into the mould, and then a first layer of the ceramic portions is arranged on the elastomer. Then, further elastomer is added onto the first layer of tiles, and a second layer of ceramic portions is arranged on the further elastomer. A third layer is added in a similar manner. The thickness of the elastomer layers is preferably in the range between approximately 0.5 mm to approximately 5 mm, and in the present embodiment is approximately 1 mm. The ceramic portions are, in the present embodiment, 4.4 mm thick 25 mm square tiles fabricated from Sintox FA, a 95% alumina ceramic produced by Morgan Metroc limited. The elastomer is a silicon rubber.

[0019] Figure 3 is a schematic illustration of an insert 300 for an armoured vest in accordance with a third embodiment of the invention. The second embodiment is similar to the first embodiment except in that the ceramic portions are arranged differently in the elastomeric matrix material. Rather than arranging the tiles in layered arrays, the tiles are arranged vertically in the elastomeric material. By arranging the tiles vertically, additional flexibility is given to the armour insert. Figures 4 and 5 illustrate further inserts 400 and 500 in which further different arrangements are provided for the ceramic portions within the elastomer. In inserts 400 and 500, the portions are arranged at varying angles to the vertical. These arrangements maintain the flexibility of the insert 300, but offer additional protection to the wearer since, in the case of insert 300, there is a small possibility that an incident projectile may penetrate between the ceramic portions. By angling the ceramic portions relative to the vertical, it will be appreciated that the risk of such penetration is reduced.

[0020] Figure 6 is a schematic illustration of an insert 600 for an armoured jacket in accordance with a further embodiment of the invention. Insert 600 comprises a stack of alternate ceramic and elastomer tiles. The tiles are held together by adhesive, and, as in the case of the

above-described inserts, provided with spall liner at the front and back of the insert. As in the above-described embodiments, the ceramic tiles are of alumina, and the elastomer tiles are of a silicon rubber.

[0021] An insert 700 in accordance with a further embodiment of the invention is illustrated schematically in Figure 7. The insert 700 is similar to insert 600, except in that the tiles are stacked at a slight angle to the vertical. This alternative stack arrangement is intended to mitigate against the risk of penetration between ceramic portions.

[0022] Having described various specific embodiments of the invention, it is noted that those skilled in the art will recognise that variations and modifications to the above-described embodiments are possible without departing from the spirit and scope of the invention, which is defined in the accompanying claims. Such variations and modifications will be readily apparent to those skilled in the art. For example, it will be clearly understood that the ceramic portions could be of varying shapes and sizes. Instead of using the above described tile-shaped portions, it may alternatively be desirable to use smaller, pellet shaped ceramic portions embedded in an elastomer matrix. It may also be desirable to use ceramic portions of similar shape to those described above, but of smaller size.

[0023] Furthermore, those skilled in the art will appreciate that many other commonly known ceramic materials, such as barium titanate, strontium titanate, calcium zirconate, magnesium zirconate, silicon carbide or boron carbide, could be used in place of the alumina described in the above embodiments. It will of course be appreciated that it will in general be preferable to select lower cost, more common ceramic materials, such as silicon carbide, boron carbide, or alumina as described above.

[0024] It will also be possible to use a large number of suitable elastomers. Those skilled in the art will appreciate that it may be desirable to use a shear-thickening material in the spall liners so as to provide additional protection against knife or spike attack. It may be desirable to replace the elastomer matrix with a shear-thickening material. Those skilled in the art will readily appreciate that a number of different shear-thickening materials could be used for the purpose, including, for example, that described in published patent application, publication number US 2007/0029690.

[0025] Moreover, whilst it has been described in the above to encapsulate the elastomer and ceramic composites in a single spall liner, it will be appreciated that it is possible to provide a multi-layered armour insert, comprising a number of layers of the ceramic and elastomer composite separated by ballistic fabrics, or by fabrics impregnated with shear-thickening fluids.

[0026] Finally, it is noted that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments.

Claims

1. Armour material comprising a plurality of ceramic portions and polymer material arranged to separate the ceramic portions.
2. Armour material as claimed in claim 1 wherein the polymer material is an elastomer.
3. Armour material as claimed in claim 1 or claim 2, wherein the ceramic portions are generally tile-shaped.
4. Armour material as claimed in claim 1 or claim 2, wherein the ceramic portions are generally pellet-shaped.
5. Armour material as claimed in claim 3, wherein the ceramic portions are arranged in an imbricated pattern.
6. Armour material as claimed in claim 3 or claim 5, wherein the polymer material is provided as a plurality of tile-shaped portions, and wherein the ceramic and material portions are arranged alternately in a stack-like configuration.
7. Armour material as claimed in any one of claims 1 to 5, wherein the polymer material is a matrix material in which the ceramic portions are embedded.
8. Armour material as claimed any one of claims 1 to 3, comprising a plurality of layers of ceramic portions.
9. Armour material as claimed in claim 8, wherein the ceramic portions in each layer are arranged in a generally regular array, and wherein the arrays in adjacent layers are translated relative to one another.
10. Armour material as claimed in claim 1 wherein the polymer material is a shear-thickening material.
11. Armour material as claimed in any one of the preceding claims, wherein the ceramic portions are formed from one of silicon carbide, boron carbide, and alumina.
12. Armour material substantially as described herein and with reference to Figures 2 to 7 of the accompanying drawings.
13. Body armour comprising clothing provided with a number of pockets into which armour material as claimed in any preceding claim is inserted.

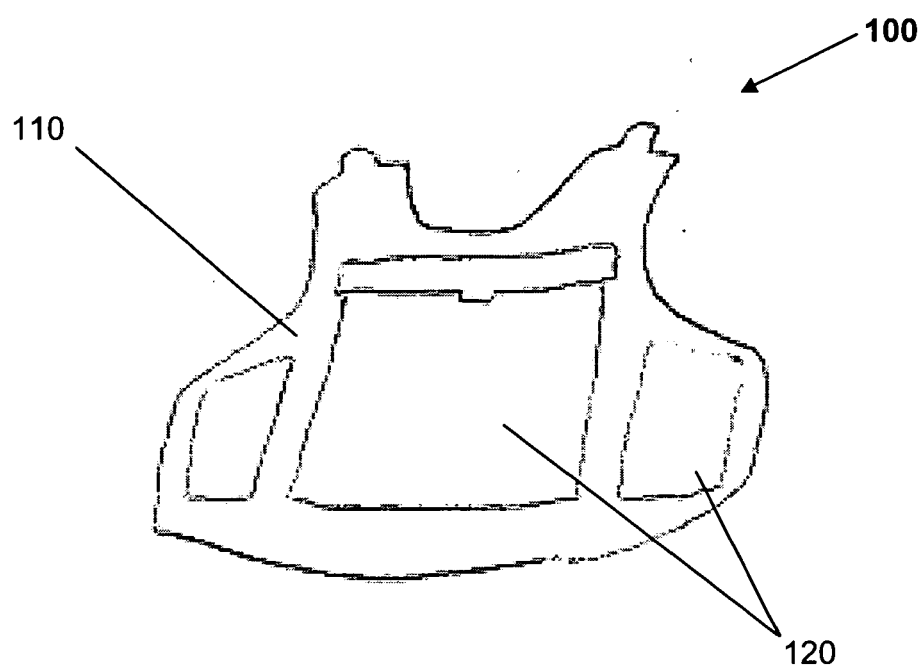
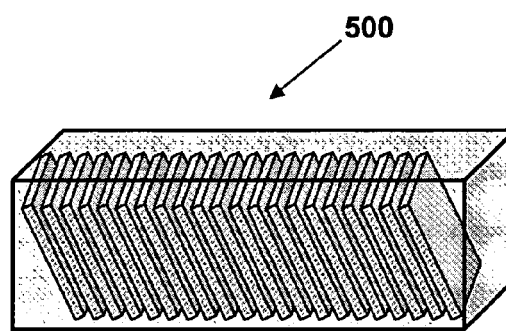
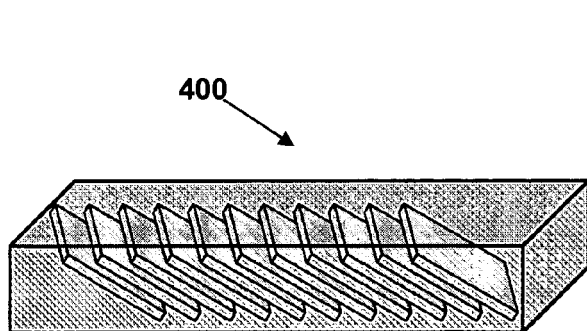
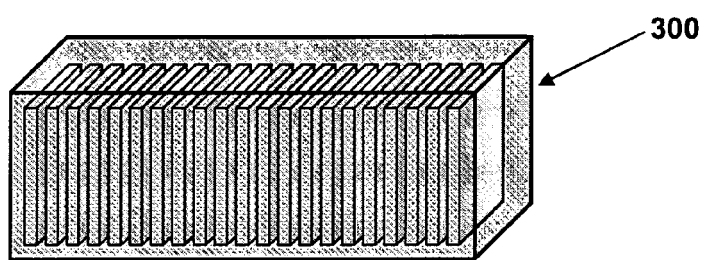
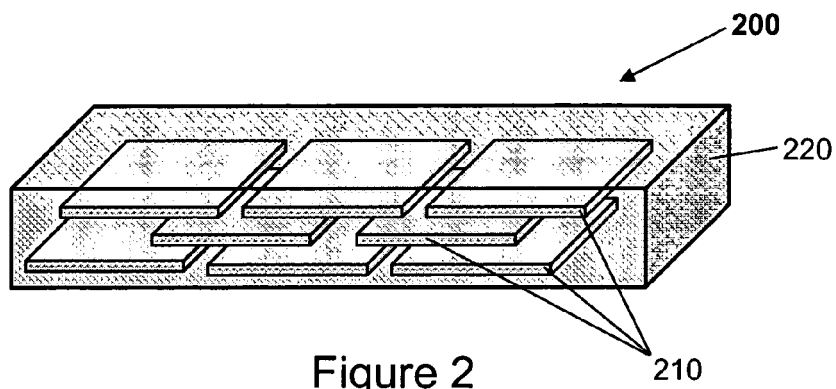


Figure 1



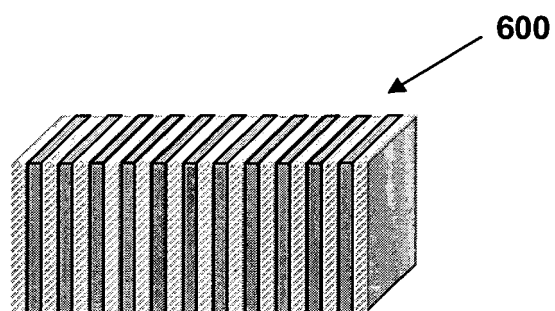


Figure 6

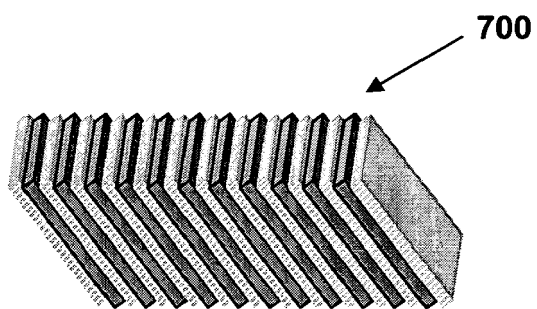


Figure 7

**PARTIAL EUROPEAN SEARCH REPORT**

Application Number

which under Rule 63 of the European Patent Convention EP 09 25 2112 shall be considered, for the purposes of subsequent proceedings, as the European search report

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2005/103363 A (US NAVY [US]; BARSOUM ROSHDY GEORGE S [US]; DUDT PHILIP [US]) 3 November 2005 (2005-11-03)	1-4,7-11	INV. F41H5/04
Y	* page 3, line 1 - page 5, line 30 * * page 6, line 16 - page 7, line 11 * * page 8, lines 6-8 * * figures 1a,1b,3a,3b,6 * -----	13	
Y	EP 0 028 476 A (SACKS MICHAEL) 13 May 1981 (1981-05-13) * page 4, line 19 - page 5, line 28 * -----	13	
X	US 2009/114083 A1 (MOORE III DAN T [US] ET AL) 7 May 2009 (2009-05-07) * paragraphs [0002], [0014], [0036], [0037], [0062], [0063] * * figure 5 * -----	1-7,11	
X	DE 28 15 582 A1 (APPRICH HARRY) 6 March 1980 (1980-03-06) * page 4, lines 1-10 * * page 5, lines 20-24 * * figures 1,2 * -----	1-3,5, 7-9	TECHNICAL FIELDS SEARCHED (IPC)
			F41H
INCOMPLETE SEARCH The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims. Claims searched completely : Claims searched incompletely : Claims not searched : Reason for the limitation of the search: see sheet C			
Place of search The Hague		Date of completion of the search 26 January 2010	Examiner Van Leeuwen, Erik
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04E07)



PARTIAL EUROPEAN SEARCH REPORT

 Application Number
 EP 09 25 2112

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (IPC)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	US 3 431 818 A (KING HARRY A) 11 March 1969 (1969-03-11) * column 2, lines 47-69 * * column 5, lines 69-73 * * figure 1 * -----	1,4,7-9	
			TECHNICAL FIELDS SEARCHED (IPC)



**INCOMPLETE SEARCH
SHEET C**

Application Number

EP 09 25 2112

Claim(s) completely searchable:
1-11,13

Claim(s) not searched:
12

Reason for the limitation of the search:

Contrary to the requirements of Rule 43(6) EPC, the subject-matter of claim 12 solely relies on a reference to the description and the drawings.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 25 2112

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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26-01-2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2005103363 A	03-11-2005	EP 1737653 A2 US 2007093158 A1	03-01-2007 26-04-2007
EP 0028476 A	13-05-1981	DE 3065184 D1 GB 2061089 A IE 50359 B1 ZA 8006455 A	10-11-1983 13-05-1981 02-04-1986 28-10-1981
US 2009114083 A1	07-05-2009	NONE	
DE 2815582 A1	06-03-1980	NONE	
US 3431818 A	11-03-1969	DE 1578324 A1	02-01-1970

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6745661 B [0004]
- US 2001015157 A [0004]
- US 20070029690 A [0024]