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(54) **Title:** LOW COLLATERAL DAMAGE EXPLOSIVE REACTIVE ARMOUR

(57) **Abstract:** An ERA is proposed comprising ceramic or glass plates to reduce the potential for collateral damage.

## LOW COLLATERAL DAMAGE EXPLOSIVE REACTIVE ARMOUR

The present invention relates to the field of explosive reactive armour (ERA), which is a known type of armour used to protect objects from projectiles which  
5 include armour penetrating weapons such as a kinetic energy projectile, hollow charge, shaped charge, high velocity slug, shaped charge jet or shaped charge slug.

ERA typically comprises a stack of 3 plate elements: a backing or inner plate;  
10 an explosive or fast exothermic reacting intermediate plate; and an outer plate. Other plates may be present in the stack in various embodiments of ERA, fulfilling various other purposes such as scratch proofing, waterproofing or providing a textured surface for reasons of camouflage or radar suppression and so on, but these three plates are the common elements in  
15 nearly all ERAs.

The inner plate faces towards, or is attached to, an object to which the ERA is applied, usually with a gap between the inner plate and the object. This gap may be an air gap, or may be or may include an additional plate of some  
20 material which acts to protect the armoured object from the action of the explosive plate and the movement of the inner plate when the ERA is activated.

The intermediate plate is designed to react when the ERA is contacted by a projectile of any type described above. As a result of this reaction, the inner  
25 and outer plates are accelerated in separation, in opposite directions, usually normal to their surface. The translation of the plates actively interacts with the motion of the projectile, by crossing the trajectory thereof and hitting the projectile. The projectile is thus disrupted, leading to a reduction of the subsequent penetration capability of that projectile.

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The problem with existing systems of ERA is that upon activation, there is a high potential for collateral damage. Typically, for example, the armoured object might be a main battle tank which is part of a larger military unit containing infantrymen; the resultant trajectory of outer plates, or fragments

thereof, produced by activated ERA can prove potentially lethal to dismounted troops at significant distances; similarly, in such a scenario, helicopters providing air cover can also be damaged or disabled by flying outer plates or fragments thereof produced by activated ERA.

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Within the prior art are various methods employed to mitigate this problem. Controlled Harm Explosive Reactive Armour (COHERA) employs the use of a fragmentation plate layer as the outer plate, which is designed to shatter into fragments of a pre-determined and controlled size and shape, designed to control the amount of likely collateral damage. The fragmentation layer is composed of tough materials that can be made so as to fragment in a predictable and controllable fashion, usually along deliberately created fault lines in the structure of the fragmentation layer. Such fault lines are created by scoring, shaping, forming, moulding or other production process means.

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Materials used for the fragmentation layer include steel and GRP.

It is the object of the current invention to provide an alternative to a fragmentation layer, that still gives the potential for reduced collateral damage compared to standard steel outer plates, yet performs comparably or even favourably to existing ERA systems.

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Accordingly there is provided an Explosive Reactive Armour (ERA) comprising a stack of plate elements including a backing or inner plate, a fast exothermic reaction intermediate plate, and an outer plate, characterised in that at least one plate in the stack of plate elements comprises a glass or ceramic material that will tend to shatter in a chaotic fashion into uncontrolled but relatively small fragments when the ERA activates, such fragments posing a relatively small risk of collateral damage whilst disrupting an incoming projectile.

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Ceramic or glass materials have not previously been considered as candidates for outer plates of ERAs, as, due to their much more brittle characteristics, they do not fragment in a controllable fashion and it is extremely difficult, if not impossible, to deliberately create fragments of any particular size and shape. The size of fragments produced when a ceramic or

glass plate is fragmented, particularly in the manner envisaged in the field of the current invention, cannot be predicted because such plates will tend to fail from or along unknown flaws or from or along unknown fault lines that are present in the material. Their fragmentation is therefore chaotic and  
5 unpredictable and cannot be predetermined. Hence it may be described as 'uncontrolled', in contrast to prior art forms of ERA that attempt to limit collateral damage.

However, it has surprisingly been found that plates made of such materials  
10 are just as efficient, if not more so, than the plates, or fragments thereof, of prior art ERA at disrupting an incoming projectile, despite the generally much smaller particles and the chaotic distribution patterns of fragments created by using such materials. The great advantage of the fragments created by a ceramic or glass ERA plate after activation of the ERA is that, due to their  
15 much smaller size and weight compared to prior art ERA fragments, they decelerate much more quickly in the air and consequently have much reduced lethality and collateral damage potential. It has been found that the more brittle the material used, the better a result is gained. A further advantage of the use of a brittle ceramic or glass material in this manner is that particular  
20 manufacturing processes typically used in the prior art to create fragmentation plates with controlled fragmentation properties (moulding, scoring, or other means of creating fault lines in the fragmentation layer) are not required – simple flat plates that are easy to manufacture can be used. This results in a potential cost advantage over most forms of prior art ERA, particularly prior art  
25 ERA of the 'controlled fragmentation' type, which use manufacturing methods to control the fragmentation of generally tougher materials, usually either metal or metal composites.

Materials that have been tested and found to give similar or improved  
30 performance as against standard low-carbon steel plates of mass equivalence include an alumina (Sintox FA), a borosilicate glass (Borofloat [TM]), and silicon carbides (EKasic T and PS 5000).

Cemented Carbide materials or 'cermets', such as tungsten carbide, or reaction-bonded ceramics such as reaction bonded silicon carbides are similar hard and brittle composite structure materials which fragment in the same fashion and can be expected to give similar results.

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## Claims

- 1/ An Explosive Reactive Armour (ERA) comprising a stack of plate elements including;
  - a backing or inner plate;
  - a fast exothermic reaction intermediate plate and;
  - an outer plate;characterised in that at least one plate in the stack of plate elements comprises a ceramic or glass material that will tend to shatter in a chaotic fashion into uncontrolled but relatively small fragments when the ERA activates, such fragments posing a relatively small risk of collateral damage whilst disrupting an incoming projectile.
  
- 2/ An ERA according to Claim 1 further characterised in that at least the outer plate in the stack of plate elements comprises the ceramic or glass material.
  
- 3/ An ERA according to Claim 1 further characterised in that at least the outer plate in the stack of plate elements is composed of the ceramic or glass material.
  
- 4/ An ERA according to Claim 1 further characterised in that at least the inner plate in the stack of plate elements comprises the ceramic or glass material.
  
- 5/ An ERA according to Claim 1 further characterised in that at least the inner plate in the stack of plate elements is composed of the ceramic or glass material.
  
- 6/ An ERA according to Claims 1 to 5 further characterised in that the intermediate plate comprises a layer of explosive.
  
- 7/ An ERA according to Claims 1 to 5 further characterised in that the intermediate plate comprises a layer of propellant.

- 8/ An ERA according to any preceding claim in which the ceramic or glass material is a silicon carbide.
- 9/ An ERA according to any of claims 1 to 7 in which the ceramic or glass material is an alumina.
- 10/ An ERA according to any of claims 1 to 7 in which the ceramic or glass material is a borosilicate glass.
- 11/ An ERA according to any of claims 1 to 7 in which the ceramic or glass material is a cemented carbide.
- 12/ An ERA according to any of claims 1 to 7 in which the ceramic or glass material is a reaction-bonded ceramic.
- 13/ An armour system comprising an ERA according to any of the preceding Claims.
- 14/ An object protected by an armour system according to Claim 8.

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A. CLASSIFICATION OF SUBJECT MATTER  
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ADD.  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED  
Minimum documentation searched (classification system followed by classification symbols)  
F41H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/103968 A2 (RAFAEL ARMAMENT DEV AUTHORITY [IL]; MAYSELESS MEIR [IL]) 18 December 2003 (2003-12-18) abstract page 5, lines 22-30 page 6, line 36 - page 7, line 2 page 11, lines 16-19 page 11, line 31 - page 12, line 3 figures 1-2	1-14
X	FR 2 803 379 A1 (FRANCE ETAT [FR]) 6 July 2001 (2001-07-06) page 3, lines 17-19 page 6, lines 4-28 figures 6a,6b,7	1-14

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 981 067 A (KINGERY CHARLES N [US]) 1 January 1991 (1991-01-01) column 1, line 64 - column 2, line 2 column 2, lines 32-37 figure 1	1-9, 11-14
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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			EP 1552239 A2 13-07-2005
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