Transparent ballistic armour ceramics. Recent advances and issues to be overcome

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Transparent armour is a system designed to be optically transparent to support dynamic fragmentation when subjected to the high strain rates produced by ballistic impacts. They are mainly used to protect vehicle occupants from terrorist actions and other hostile conflicts, as visors for non-combat use like riot control or explosive actions, etc. Light weight, small thickness, low optical distortion, compatibility with night vision equipment and multi hit capability are needed to defeat armour piercing ammunitions (AP) threats. These systems consist of a sandwich structure with a hard front layer of transparent ceramic joined to several plies of glass with polymer inter layers and polycarbonate backing. Advances in material science and technology over the last 40 years has made available sub-µm grain size polycrystalline α- Al2O3 aluminium oxynitride (AlON) , magnesium aluminate spinel (MgAl2O4)3 and
single crystal sapphire (Al2O3) as alternative ceramic materials able to satisfy the requirements of transparency and hardness for armours application.

In the present study the following current efforts are shortly exposed: a) the theoretical basis to get high transparency avoiding the light dispersion ; b) the different processing techniques used for preparing these materials, specially for magnesium aluminate spinel (MgAl2O4)3; c) the main results and conclusions of the CERTRANS project supported by the Spanish Ministry of Defence into the framework of the COINCIDENTE programme and finally the existing current commercial products, issues to be overcome and some results on the importance of nanotechnology to get an affordable low cost versus performance transparent ceramic system are shown

The main conclusions to be highlighted are:

-There is a general push to reduce the weight of the systems to increase transportability and flexibility and to reduce the operational costs

-Transparent ceramics offer significant ballistic protection in relation to conventional glass/plastic systems. A few companies produce this kind of products: Surmet (ALON® technology), Armorline (Spinel), Saint Gobain Group (Sapphire), Technology Assessment and Transfer (TA&T) (Spinel). For technology transfer: Fraunhofer Institut (IKTS).

Some issues must be overcome: commercial availability, very high cost raw materials, high investments, complex processing techniques (hot pressing, hot isostatic pressing, Spark Plasma Sintering), machining and polishing costs, large formats and curved shapes, new structural designs for multi hit capability, etc

-Several programs are investigating for cost reduction, new processing ways and scale up of these materials: As strategies are proposed: Conventional pressureless sintering, gel casting, nanotechnology, nanocomposite optical ceramics (NCOCs), etc

-Pressureless sintering of translucent cubic magnesium aluminate spinel (MgAl2O4)3 with a high level of transparency has been obtained in the CERTRANS project supported by the Spanish Ministry of Defence into the framework of the COINCIDENTE programme. Partners: Universidad Rey Juan Carlos, Instituto de Cerámica y Vidrio, INTA, Instituto Tecnológico La Marañosa.

-Other alternative materials are underway (transparent glass-ceramics) to satisfy the requirements of high transparency and hardness, weight reduction, improvement in the ballistic performance for armours application. Polyurethane is also being evaluated as substitution for polycarbonate backing

Figures

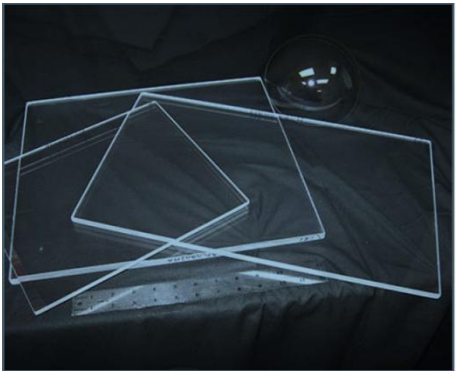

Figure 1: Optical Grade Ceramic Spinel (Armorline)

Figure 2: CERTRANS PROJEC. Pressureless sintering of magnesium aluminate spinel (MgAl2O4)3;

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