Researchers investigate a transparent ceramic material that provides better protection than today’s bulletproof glass at a fraction of the weight and thickness.

Laura L. Lundin
Air Force Research Laboratory
Wright-Patterson Air Force Base
Dayton, Ohio

With the goal of protecting military people who face the threat of armor-piercing weapons on the battlefield, Air Force Research Laboratory (AFRL) engineers are testing a new type of transparent armor that is stronger and lighter than traditional glass materials. In conjunction with the Army Research Laboratory at the Aberdeen Proving Grounds, Maryland, and the University of Dayton Research Institute, Ohio, AFRL is investigating aluminum oxynitride (ALON) as a replacement for the conventional, multilayered glass transparencies in existing ground and air armored vehicles.

The Army is exploring ALON transparent armor as a replacement for ground vehicle windows, while the Air Force is interested in the material for slow low-flying aircraft such as the C-130, the A-10, and helicopters.

Mechanical properties
Aluminum oxynitride ceramic has high compressive strength and durability. When polished, it is the premier transparent armor for armored vehicles. “The substance itself is light-years ahead of glass, and offers higher performance and lighter weight,” asserts Lt. Joseph La Monica, transparent armor subdirection lead for AFRL’s Electronic and Optical Materials Branch.

Whereas traditional transparent armor is made by bonding thick layers of glass together, ALON transparent armor is made by combining the ALON piece on top as a strike plate, a middle section of glass, and a polymer backing. The ALON armor is notably thinner than traditional armor. In addition, ALON is virtually scratch- and impact-resistant, providing better durability and protection against armor-piercing threats at roughly one-half the weight and thickness of traditional glass transparent armor.

Test results
In a demonstration at the U.S. Army’s Team Patriot exercise at Fort Drum, N.Y., in June 2004, ALON test pieces withstood the armor-piercing bullets of both a .30 caliber Russian M-44 sniper rifle and a .50 caliber Browning sniper rifle. While these bullets pierced the demonstrated glass samples, ALON survived the impacts with no penetration, as shown in the photo.

In other tests, ALON has performed consistently well against multiple hits of the .30 caliber armor piercing threats typical of antiaircraft fire. “Tests focusing on multiple hits from .50 caliber threats are in the works,” says Lt. La Monica. He is optimistic about the test results, since the material’s physical properties and design are intended to stop higher-level threats. “The higher the threat, the more savings you’re going to get — because with glass, to get the protection against higher threats, you have to keep building layer
Lighter weight will allow the armor to be more easily integrated into vehicles.

According to Ron Hoffman, UDRI researcher, this ability to establish the necessary level of protection with only a small amount of material is very advantageous. “When looking at higher-level threats, you want the protection, not the weight,” he explains. “Achieving protection at lighter weights will allow the armor to be more easily integrated into vehicles.” Mr. Hoffman also emphasizes the benefit of ALON’s durability: “Eventually, with a conventional glass surface, degradation takes place and results in a loss of transparency. Things such as sand have little or no impact on ALON, and it probably has a life expectancy many times that of glass.”

This scratch-resistant quality will greatly increase the lasting transparency of the armor, enhancing the visual awareness of warfighters on the battlefield. “It all comes down to survivability — being able to see what’s out there and make decisions while having the added protection,” he says.

Though the possibilities of this material seem limitless, researchers must address issues such as manufacturability, size, and cost before they can transition ALON armor to the field.

“Traditional transparent armor costs a little over $3 per square inch; when you look at ALON transparent armor, the cost is $10 to $15 per square inch,” Lt. La Monica explains. “The difficulties arise with heating and polishing processes, which, in turn, lead to higher costs, but we are looking at more cost-effective alternatives.” Experimenting with the polishing process has proven beneficial. “We found that by polishing it a certain way, we increased the strength of the material twofold.”

Currently, size is also a limitation, because the equipment needed for heating larger pieces is expensive. To help lower the costs, researchers are studying design variations that tile smaller pieces of the armor together to form larger windows.

Reducing costs by choosing a commercial grade of the material is also an option, and preliminary results have shown promise. “So far, the difference between the lower-grade material and higher-purity material in ballistic tests is minimal,” Lt. La Monica says. Once manufacturers can produce the material in sufficiently large quantities to meet the military’s needs, costs should come down even further. “It might cost more in the beginning, but it’s going to cost less in the long run because you’re going to have to replace it less frequently.”

For more information: Ms. Laura L. Lundin (Ateon Corporation), of the Air Force Research Laboratory’s Public Affairs Office, wrote this article for the August 2006 issue of the Air Force Research Laboratory Technology Horizons magazine, which may be viewed at www.afrlhorizons.com. It is reprinted here with permission from AFRL. For more information, contact TECH CONNECT at 800/203-6451 or place a request at http://www.afrl.af.mil/techconn_index.asp. Reference document HQ-H-05-26.