



Protection for a New Age

Soldier Mod talks to Diamond Age about their innovative products

Q: Diamond Age are at the innovative edge of protective products for the dismounted soldier, could you talk about how the company evolved to where it is now?

A: We have a design unit and a research unit. The design unit is focused on functional ergonomics, load distribution and managing the trade-offs associated with wearing armor - to mitigate, insofar as possible, the reduced mobility and combat efficacy that all armored soldiers experience.

For that to be most effective, we need to research and develop lighter and more effective armor materials. When Diamond Age was founded, our materials research group was primarily interested in boron nitride. First, in the form of cubic boron nitride ceramic materials for hard armor plates, and, second, as boron nitride nanotubes and nanoplatelets for both reinforcement and density reduction in ceramic and metallic materials.

Cubic boron nitride is a fascinating substance. It's one of the hardest materials on the planet; in fact, it's much harder, and slightly tougher, than all of the armor ceramics in use at present. But, as it turns out, it under-performs as an armor material - and to such an extent that its performance is actually inferior to some of those common armor ceramics. As this started to become apparent to us, we shifted our research efforts to other high-pressure materials, including bulk diamondoid carbon materials, which exhibited astounding levels of performance. Their bulk production has just begun, and we've started producing hard armor plates from those diamondoid carbon materials, which are capable of stopping the 5.56x45mm M855 (SS109) round, at muzzle velocity, at a weight of just 1kg. (Size M SAPI-cut plate.)

Our first successful experiments with bulk high-pressure carbon materials led to experiments with thin carbon films, and other related technologies, which resulted in the Forcefield Multi-Threat soft armor panel.

To answer your question, the story is one of continuing research combined with an experimentalist ethos. We're a small company, but we have excellent analytical and engineering capabilities, and there are huge advantages to being a small team: We can move fast. We can get things done. And for every armor product we've announced, we've run dozens if not hundreds of tests, in many different configurations. We fight for every .1mm of plate thickness, and for every gram of weight - and I mean that quite literally.

Armor science is necessarily the domain of experimentalists, because ballistic armor is not well understood on a theoretical level. It's very easy to make basic errors of reasoning, like: "Ceramic A is harder than Ceramic B, so it has to be a better body armor material on a per-thickness basis," when in truth that conclusion doesn't follow. It's also very easy for materials research to become unhinged, so that the systems it describes are of no practical relevance. The recent articles in the press on composite metal foams for armor purposes, and the dozens of articles on 2-atom thick graphene sheets for armor purposes, definitely fall into this category. The former because, breathless headlines notwithstanding, those metal foams actually perform worse than boring old solid armor materials on both a per-weight and a per-thickness basis. The latter because a 2-atom-thick layer of anything isn't stopping a bullet; even with bulk diamond, the thicknesses



required for meaningful ballistic efficacy are equivalent to millions of atomic layers in total.

Which is not to say that there aren't general scientific principles that can inform the design of better armor. They exist, and we've discovered several. One of them, in particular, is interestingly counter-intuitive. The story of our company is simply one of empiricism, of research, and of subsequent attempts to turn that research into superior and innovative armor products.

At present, we're working on a next generation of carbon and carbon-composite materials for armor purposes, and on new silicon ceramics that perform very well at a much lower cost.

Q: I understand that since the last issue you have a new product line; could we look at the product and the need for it in the defense industry?

A: While we're engaged in hard armor R&D, with only limited product releases, we're heavily involved in soft armor production and distribution.

We have, essentially, two soft armor packages: The Liberator, which is rated to the NIJ's Level II, and the aforementioned Forcefield, a multi-threat panel which is rated to what I like to call "IIIa+."

The difference between regular Level IIIa and Level II is smaller, more marginal, than most people assume: Level IIIa vests are rated to stop the .44 Magnum SJHP at muzzle velocity with less than 44mm backface deformation (BFD); Level II vests are tested against the .357 Magnum instead. That's essentially the entire difference. And I'd add that the vast majority of Level II vests will also stop the .44 Magnum SJHP, but with more than 44mm BFD.

This performance differential is insignificant for all practical intents and purposes. The FBI keeps statistics on police officers murdered in the line of duty, and "Level IIIa" threats like the .44 Magnum and .50 Caliber were used in less than 1% of fatal officer shootings with handguns from 2004-2013. Level II threats or below - Level I or Level IIa threats, for the most part - were encountered by officers over 99 percent of the time. When non-fatal shootings are also taken into consideration, this discrepancy grows even further.

Which brings me to another matter: There has never been a single recorded death due to armor backface deformation. This is true for hard armor, and it's true for soft armor. There have been instances where officers wearing Level IIa vests were shot with heavy rounds, resulting in backface deformation estimated to be in excess of 80-100mm, and those officers all survived, without exception. There was even a case where an officer wearing a Level IIa vest was hit at close range with buckshot from a 12 Gauge shotgun, resulting in an estimated 131mm of backface deformation. That officer survived with minor injuries.

So, clearly, for most police and security personnel, Level IIIa armor is too much. Too thick, too heavy - at root, simply overbuilt for improved BFD performance against a threat that they're very unlikely to ever face.

Level IIIa armor also has serious shortcomings. Most worryingly, handgun rounds that can easily defeat most Level

IIIa armor panels are proliferating. I'm talking about rounds like the solid copper 9mm Fort Defense SCS and the Lehing Defense Xtreme Penetrator series. Sufficiently fast rounds fired from the 7.62x25mm Tokarev, the FN Five-SeveN, and the HK 4.6x30mm will also easily penetrate most soft armor panels that are rated to Level IIIa. The latter two, in particular, were designed specifically to penetrate soft armor.

The Forcefield was designed to address all of the shortcomings of standard Level IIIa armor; it is a soft armor panel that does much more than just stop .44 Magnum hollow-points with less than 44mm BFD. It'll stop fast-moving solid copper handgun rounds, and it'll stop high-penetration submachine gun rounds like the 7.62x25mm Tokarev, the 4.6x30mm FMJ, and the 5.7x28mm FMJ, all at well over submachine gun muzzle velocities - in some cases at over 2500 feet per second. The Forcefield also exceeds, by a significant margin, the US military's most stringent fragmentation requirements for their IOTV Gen III soft armor. Lastly, it offers very good protection against knife and spike threats.

If you need enhanced protection, the Forcefield will do what other IIIa panels can't. And it's not significantly heavier or thicker than other products in its class - at just 6.5mm thick and 5.7 kilograms per square meter. (1.17 pounds per square foot.)

As mentioned previously, this level of protection isn't always needed or warranted, so we created the Liberator to address the daily-wear needs of police and security personnel. It offers unparalleled comfort, concealability, and mobility in daily wear. At just 3.5mm thick, it is the thinnest Level II armor package in the world, and it's as flexible as a regular article of clothing. And, most importantly, it offers a degree of protection that is beyond merely adequate. Level II armor is more than sufficient to stop the ballistic threats that police officers and security personnel face in the streets. Your average street criminal isn't rocking a 5.7x28mm PDW, and isn't going to use fairly exotic solid copper rounds that cost more than \$1 apiece. No, your average street criminal is using the cheapest .38 hollow-points that he can find on the shelves of Wal-Mart - or, in Europe, whatever old rounds turn up on the black market.

So a Level II for daily wear, and a IIIa+ for SWAT, military, and crisis response. I think that with just these two products, which were both designed to be as thin and as light as possible, we've got our soft armor bases covered.

Q: Your products caught the eye at Eurosatory with a very busy stand, has anything evolved from that and where are you with placing product?

A: We're working with a number of partners on interesting projects, and on tenders for various militaries. I can't talk about most of 'em, but I believe I can mention that we're working with the Australian composites experts XTEC on a very interesting project for the USMC. A lot of very innovative products are in the works - to such an extent that I feel confident in the assertion that a revolution in armor is coming. Stay tuned. ■