

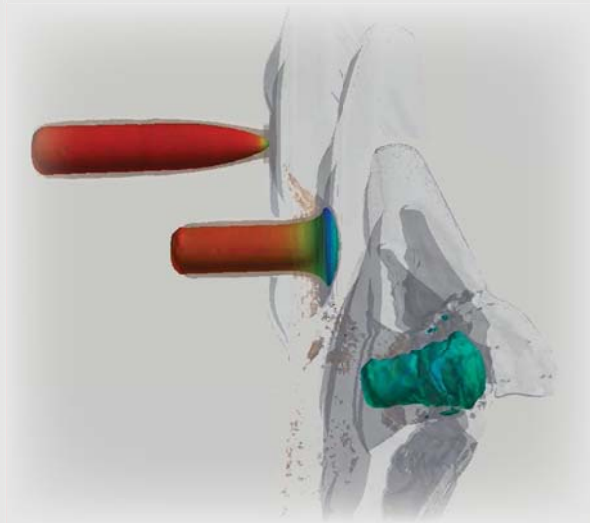
Verco Technology

Why Ceramic Armor?

A ceramic used for ballistic armor? Actually... yes.

A metal is strong, but under ballistic impact, it flows out of the way of the projectile like a liquid.

While they fracture easily, ceramics are hard, they do not plastically deform (flow).



The impacting projectile is forced to dwell on the strike face surface.

It collapses onto itself, mushrooming laterally.

Within the ceramic, a compressive wave propagates to the back, returning as a tensile wave, pulverizing it.

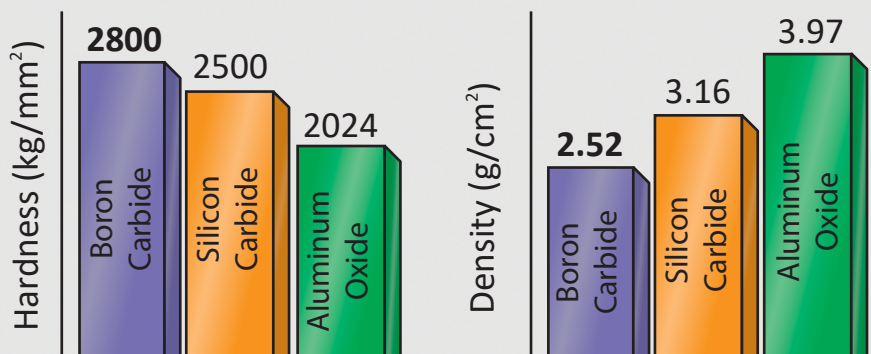
The projectile mass ablates away as it pushes through the abrasive rubble.

Layers of polymeric ballistic fabric backing then catch the fragments.

High-performance ceramics used as strike faces for personal armor plates:

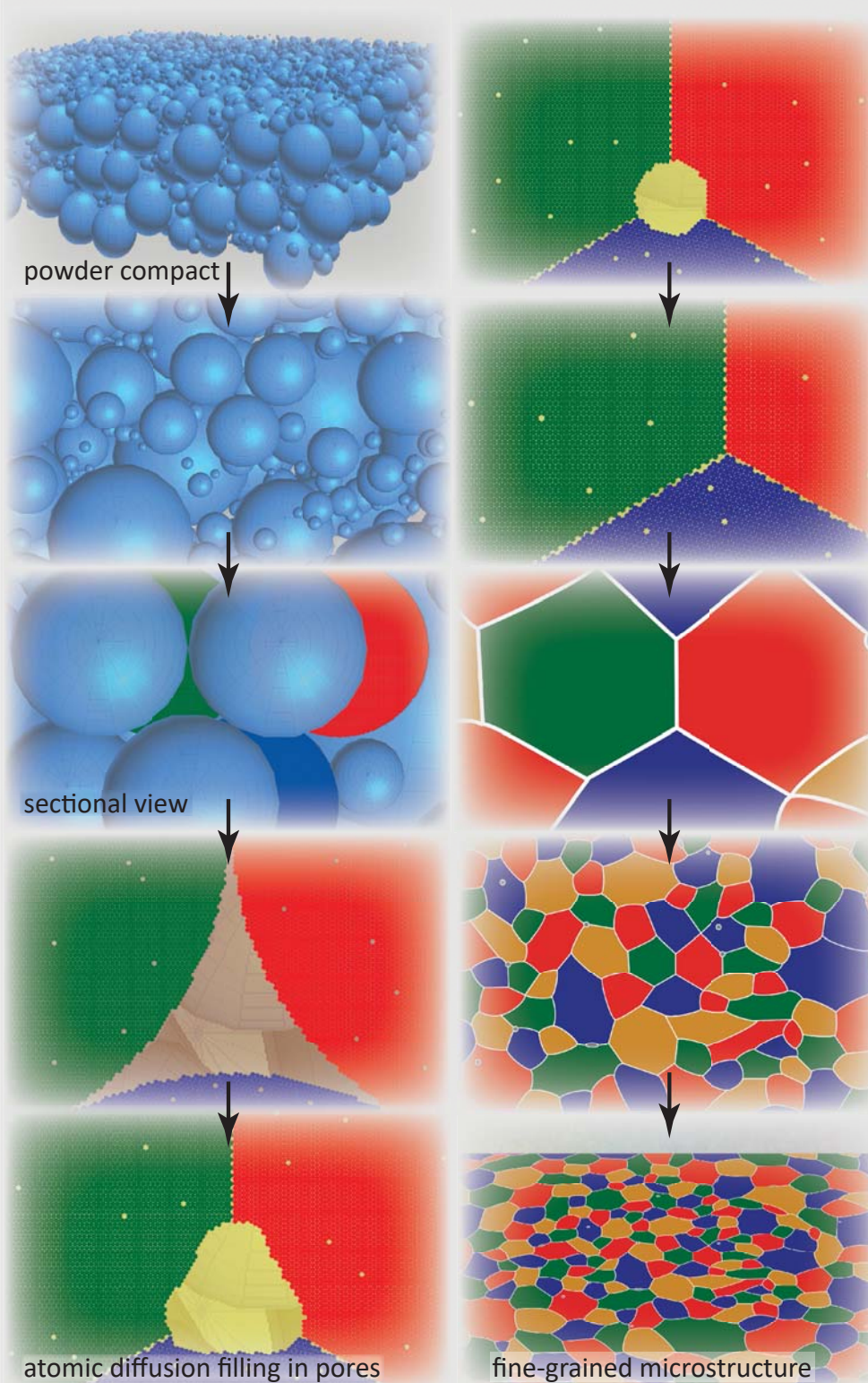
Boron carbide is the hardest, and the lightest.

It will defeat greater threats at lower weights.



However, boron carbide is the most difficult to make, especially in complex shapes.

Sintering Technology



Verco has developed a novel method* of forming boron carbide.

Powder pressed into a compact of a desired shape, is sintered at very high temperatures:

Atoms diffuse so that particles consolidate without ever melting.

Subsequent heating under high-pressure argon gas forms a pore-free sub-micron grained microstructure of extreme hardness.

This VercoB₄C™ process allows for formation of a boron carbide component, without any machining, in any desired shape.



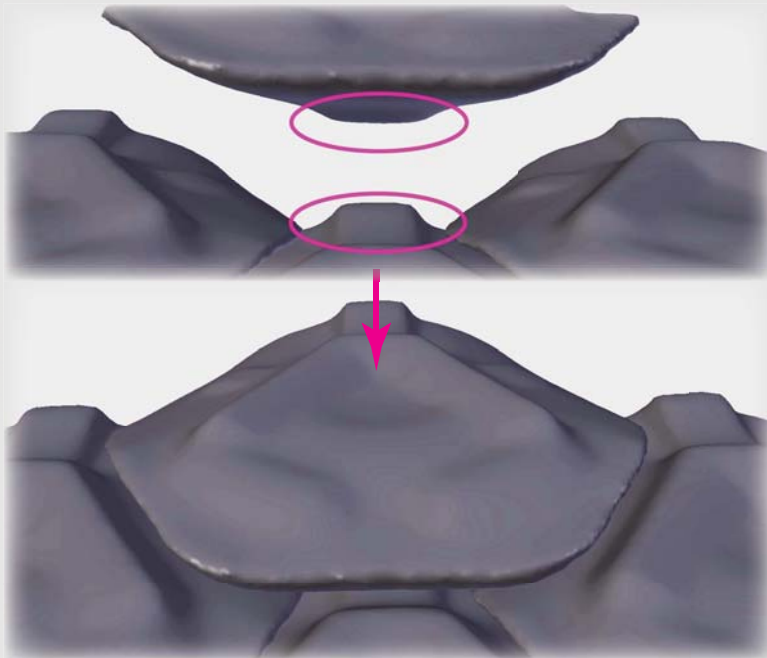
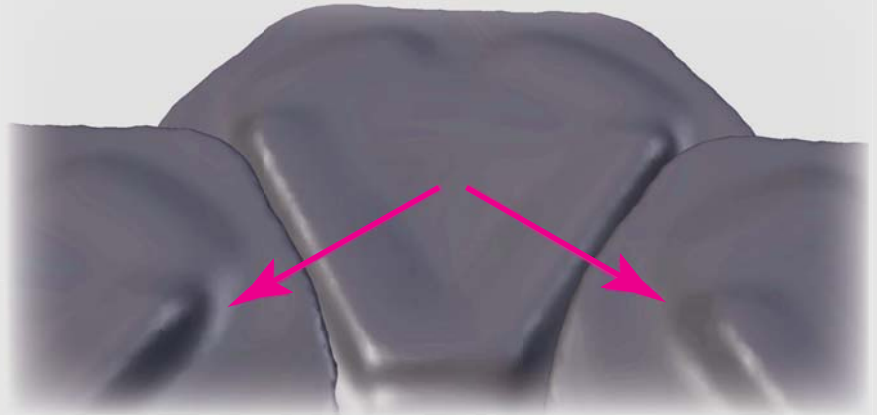
VercoB₄C™ Ballistic Tile

*"Boron Carbide Based Materials and Process for the Fabrication Thereof," **United States Patent** US 9,890,087 B2, February 13, 2018, Assignee: Verco Materials, LLC.

Verco has applied its sintering technology to manufacture a rifle-protection personal armor system based on an imbricated array of VercoB₄C™ tiles.*



The tiles assemble so that the V feature what would otherwise be oblique gaps between the tiles.



The four-tile oblique gap is covered by a tooth on the wear face (underside) of the upper tile mating to a well on the strike face of the lower tile.

Ceramic armor suffers a diminution in ballistic performance near edge regions.

To compensate for this, the imbrication design has all near-edge regions overlap with other tiles.



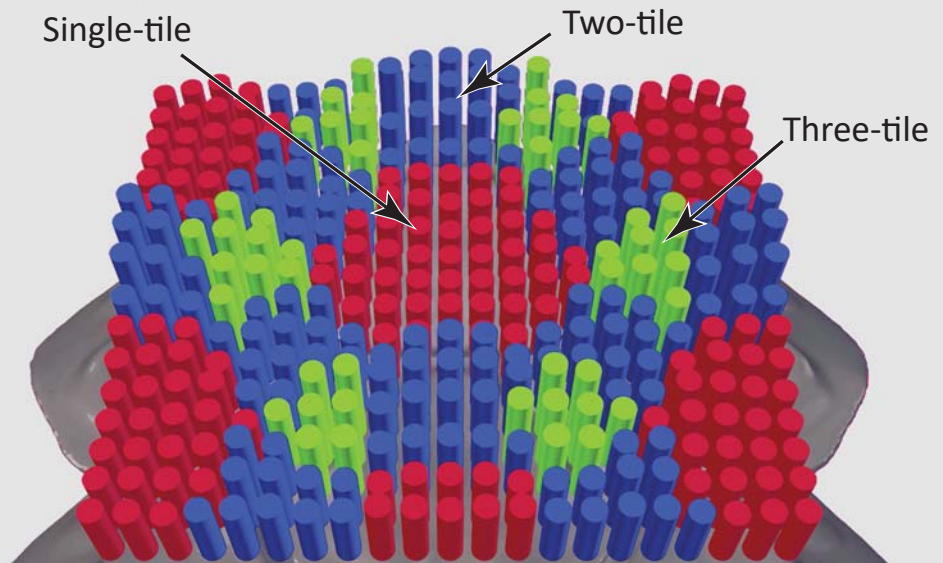
*"Armor Arrangement," **United States Patent** US 8,434,396 B1, May 7, 2013, Assignee: Verco Materials, LLC.

Tile Imbrication

Rod heights indicate total tile thickness.

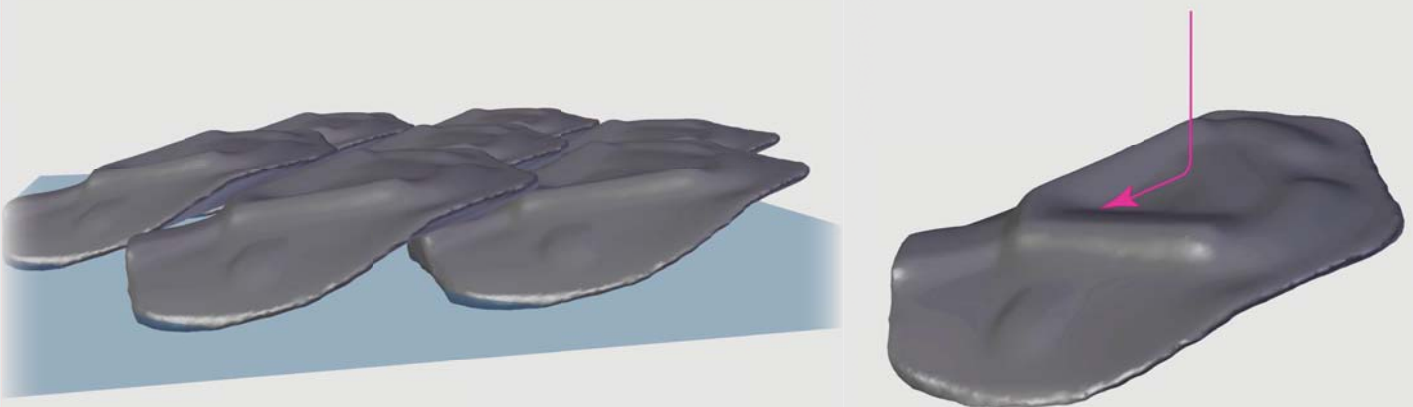
Tile edge regions of 2- and 3-tile overlaps are thicker to compensate for edge weakening.

This gives all locations of the imbrication pattern more equal ballistic performance.



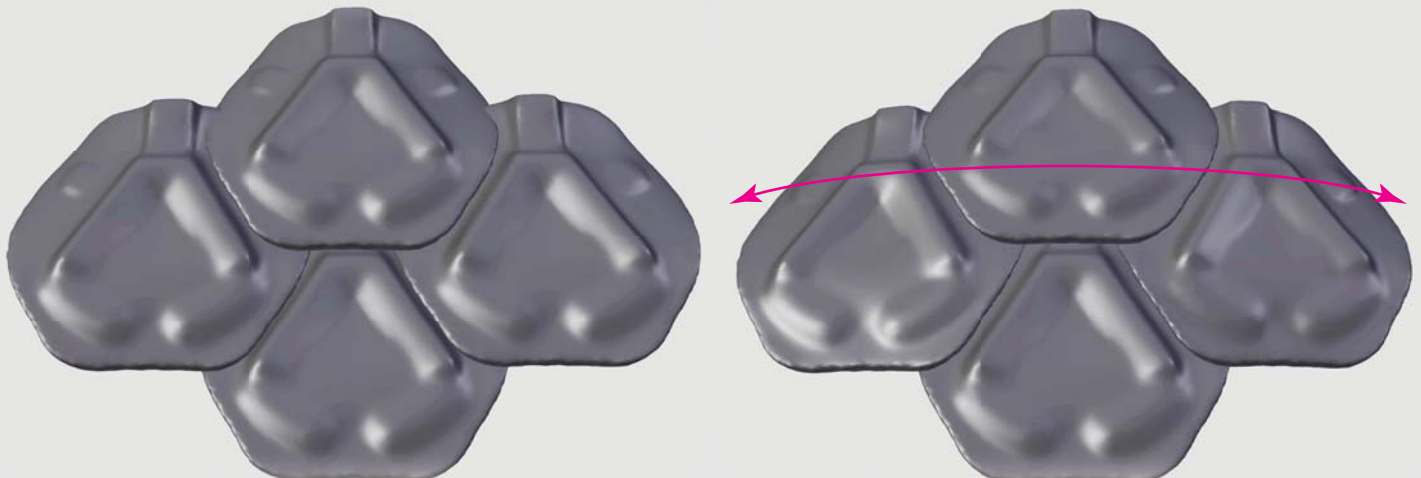
Tiles rest at an angle to the body.

That, and surface undulations encourage projectiles to turn on impact, facilitating defeat.



Tiles rock, showing limited flex without opening oblique gaps.

Over an entire panel, this imbues conformability and pliancy.



Containment*

The tiles are wrapped in carbon fiber weave epoxy prepreg.

Carbon has the highest stiffness (per gram) of any fiber.



The epoxy is set at elevated temperature and pressure to entomb the $\text{VercoB}_4\text{C}^{\text{TM}}$ tile in tight containment.

This confinement enhances tile durability against damage from rough handling.

Constrained rubblized boron carbide impedes projectile perforation, extending dwell.

The immobile ceramic continues to pulverize, absorbing the projectile's energy in forming new surfaces.



Ceramic Rubble

With Containment

Without Containment

Single tiles center-shot with M855
Oregon Ballistic Laboratories

*Method for Wrapping of Ceramic Tiles..." **United States Patent** US 9,677,858 B1, June 13, 2017, Assignee: Verco Materials, LLC.

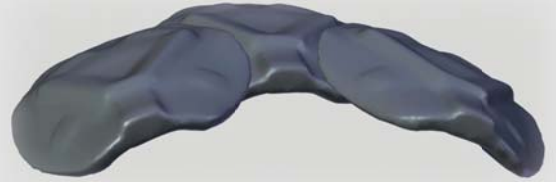
Curved Tiles



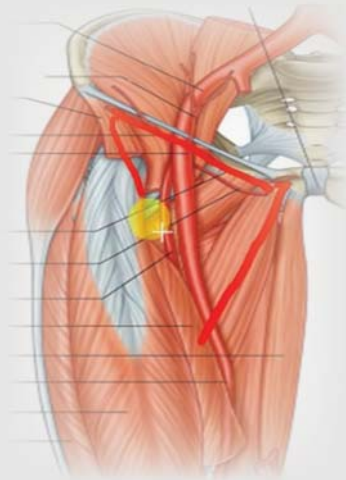
Standard Tile



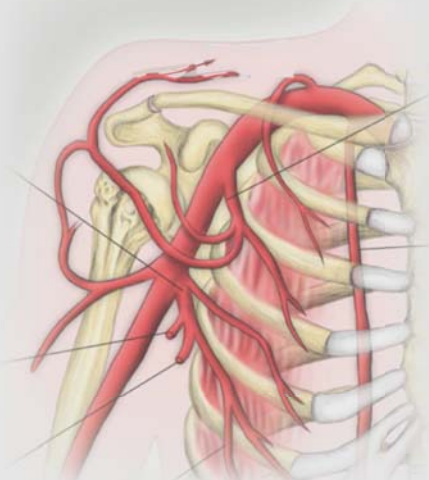
Curved Tile



Assembly of Three
Curved Tiles



Femoral Artery

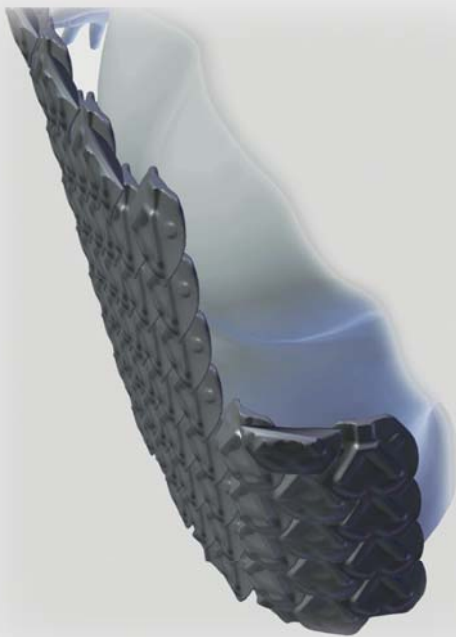


Brachial Artery

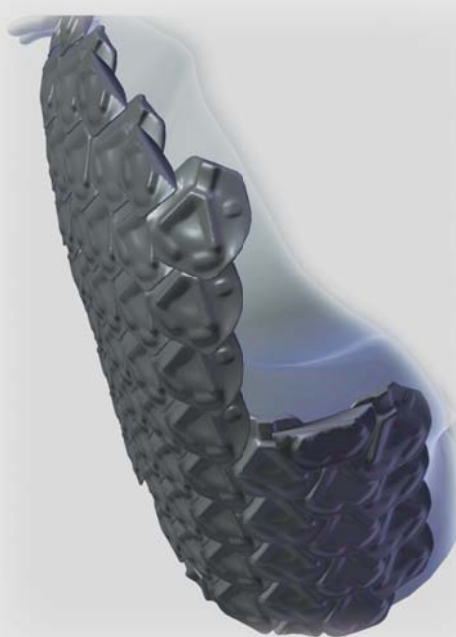
Locations outside those protected by torso plates can have equally low survivability.



Assemblies of curved tiles* can be utilized for protection of such high radii of curvature areas.



Neutral Imbrication



Conforming to the Body

Curved tiles as part of a torso panel adopt neutral assembly positions which need to rotate only slightly to follow body contours.

*"Ballistic Tile," **United States Patent Application** 16/421,958, August 2019.