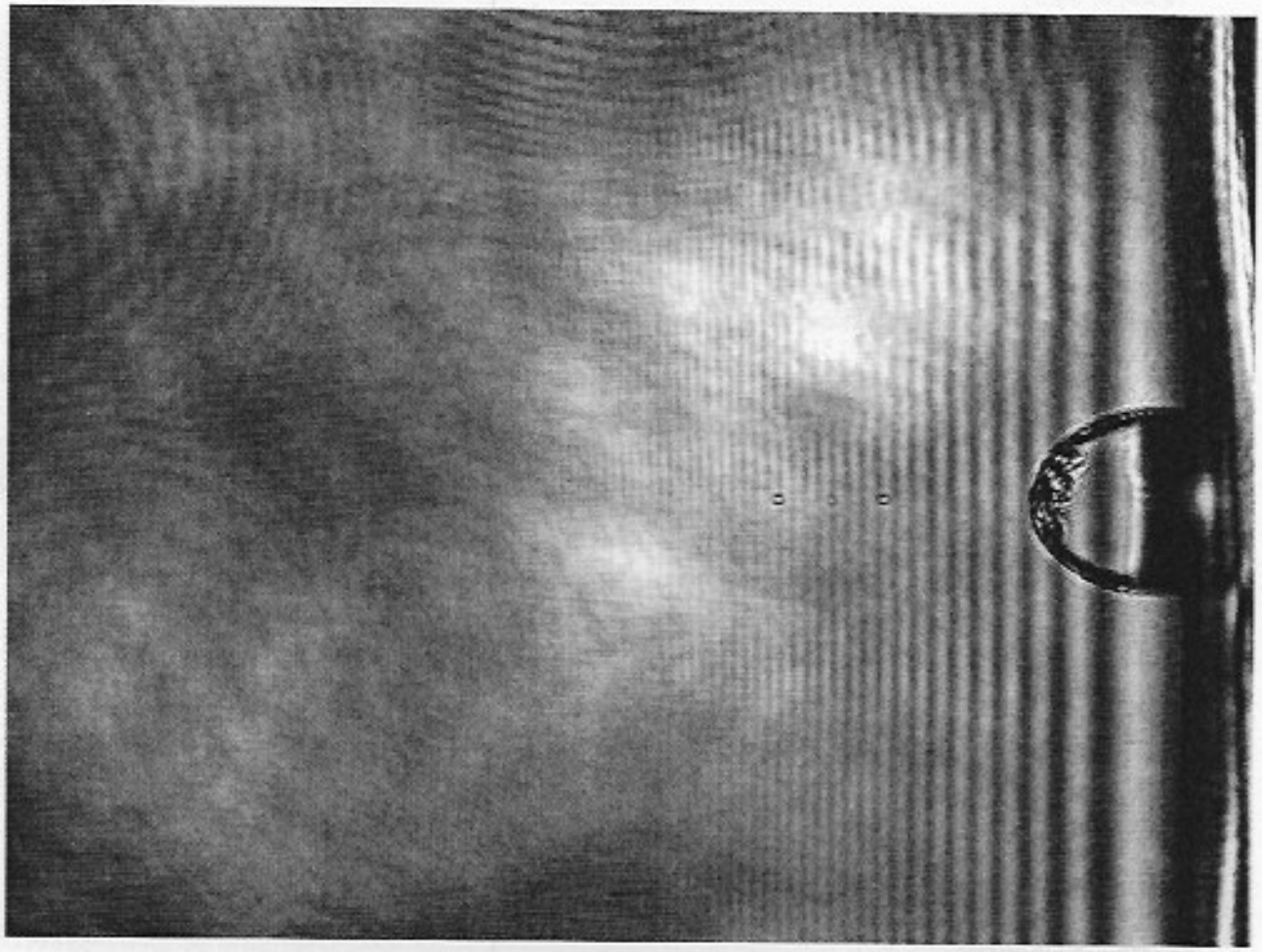
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Developments in Bullet Proof Materials using Nanotechnology

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By Stuart MilneDec 8 2014



A microbullet traveling at supersonic speed is captured in this composite of three timed images as it makes its way toward a suspended sheet of multilayer graphene. Experiments carried out at Rice University show graphene is 10 times better than steel at absorbing the energy of a penetrating projectile. The bubble at left is a polymer film expanding away from the gold substrate that transfers energy from a laser to the microbullet. Click image for a larger version. Courtesy of the Thomas Research Group

It's hard to imagine the number of lives that have been saved thanks to bulletproof materials. Soldiers, police and others who put themselves in harm's way can depend on Kevlar and other fabrics to spread the impact of projectiles and allow them to perform their jobs in relative safety. Now, scientists from Rice University have used microbullets to analyse graphene's strength in these applications.

Bullet-Proof Nano

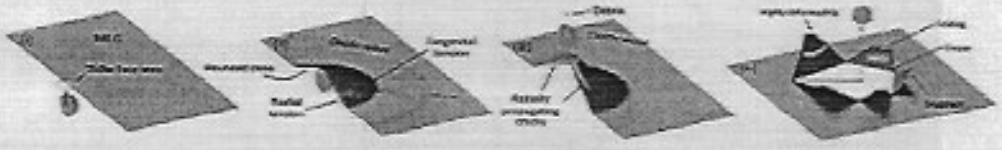
Until recently, most anti-ballistic materials that were used in such products as bullet-proof jackets, explosion-proof blankets, and others, were made of Kevlar, Twaron or Dyneema fibers, which stop bullets from penetrating the surface by spreading and absorbing the impact of the bullet's force.

These products were a significant step forward in protecting the wearer, but often still resulted in the target suffering from blunt force trauma, severe bruising, or worse, damage to vital organs. This is because even though the bullet was stopped, the force still eventually reached the wearer and could result in injury.

Video Courtesy of Rice University YouTube Channel

Lead researcher Edwin Thomas from Rice University, has demonstrated that firing microscopic projectiles at multilayer graphene sheets allowed his team to measure how difficult it is to penetrate the graphene on the nano scale.

Research has often focused on graphene's electronic properties and tensile strength, but these new finding show graphene's ability to be stiff, strong and elastic all at once. These characteristics could offer applications in body armour and aerospace shielding.



The research team built a tailor made stage to line up multilayer graphene sheets. Using a high speed cameras, the team were able to capture detailed images of the projectiles penetrating the sheets. Edwin and his team were able to determine that graphene acts like a stretchy membrane, distributing the bullets energy over a large area.

The game in protection is getting the stress to distribute over a large area. It's a race. If the cone can move out at an appreciable velocity compared with the velocity of the projectile, the stress isn't localized beneath the projectile.

Edwin Thomas, George R. Brown School of Engineering at Rice University

Carbon Nanotubes

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A team of researchers from the University of Wollogong, have recently developed a new graphene composite material which is stronger than spider silk and Kevlar.

Finding the right ratio of graphene to carbon nanotubes is a key factor in the development of the bullet proof composites. The new graphene composite can easily be made using a wet-spinning method, producing fibres which have potential applications in bullet proof armour and reinforcement materials.

Beehive

Carbon nanotubes have also been used extensively in the pursuit for nano bullet proof materials. With a beehive shaped structure and cylindrical nature, these nanotubes have demonstrated incredible strength.

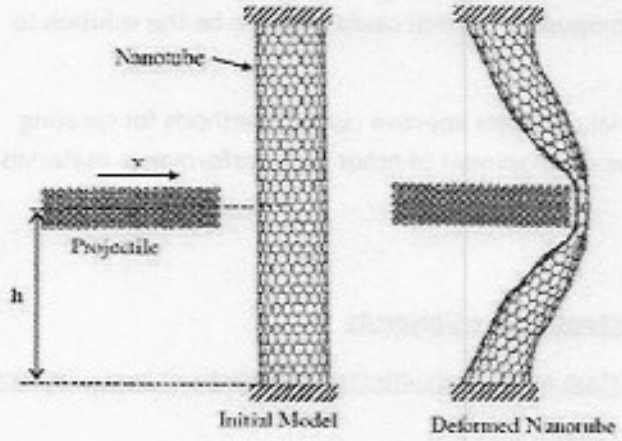


Image Caption: The molecular dynamics model of a carbon nanotube subjected to ballistic impact. (a) Initial model, (b) A deformed (18, 0) nanotube at its maximum energy absorptionImage Reference: Dickinson College

These tubes are capped at each end and formed together with covalent bonds to produce nanofibers that are hundreds of times stronger than steel. Even the bonds themselves are stronger than those found in diamonds, the hardest substance known to man.

The resulting carbon nanotubes are light, flexible, strong and thermally stable. In a bullet proof vest, millions of these nanotubes come together to form carbon nanofibres, which are woven together to create and light weight material. The resulting carbon nanofibers are very good at absorbing energy making them ideal for bullet proof armour.

A team from the Centre for Advanced Materials Technology at the University of Sydney have already created a material which can rebound the force of a bullet using these materials.

Another example of this can be found in the Garrison Bespoke bulletproof suit. The suit uses a thin patented carbon nanotube material which sits between the linings of the suit. The suit protects the owner from stabbings, bullets and any other projectiles which may cause harm.

Conclusion

There are lots of potential applications for bullet proof nano materials, but they still face many challenges.

The primary problem with graphene nanotechnology thus far has been creating adequate tests of the materials that are useful prior to field testing. Current tests provide little reliable evidence of the material's real strength in the uses against high-speed projectiles.

In the most recent tests, Jae-Hwang Lee and his collegues at the University of Massachusetts--Amherst have devised a ballistics test that pits the graphene nanotubes against laser pulses that have been superheated until they vaporize, which acts like gunpowder to fire a micrometer-size glass bullet into 10 to 100 sheets of graphene at 3 kilometers per second, about three times the speed of a bullet fired from an M16 rifle.

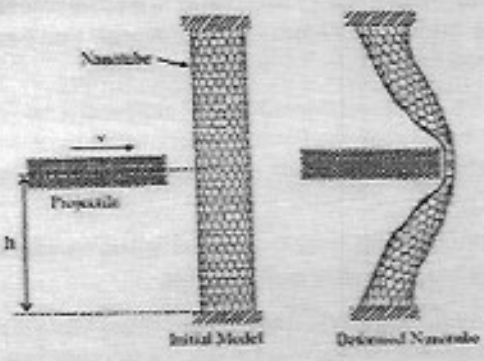
The result of these tests have shown that the graphene nanotubes absorb the impact by stretching into a cone shape at the point of the bullet's strike, then cracking outward. The cracks that are formed are the one weakness that the materials have showed thus far. However, it is important to note that despite this weakness, the material still performed better than Kevlar and absorbs 10 times the kinetic energy that steel can. It is also important to note that by assembling multiple layers of the graphene material or combining them into a composite material could prove to be the solution to this problem.

It's clear that nanotechnology is helping material scientists improve current methods for creating bullet proof materials and this could lead to the development of other high-performance materials in the future.

References

- Microbullet hits confirm graphene's strength - Rice University
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- UOW RESEARCHERS DEVELOP 'BULLET PROOF' GRAPHENE - UOW

Bulletproof Vests



Picture

Bulletproof vests are designed to absorb the energy of the bullet, and disperse the force of the bullet throughout the vest (Lecours, et al.). This reduces the force of the bullet on one area, and prevents the bullet from penetrating the human body. However, in a regular bulletproof vest the force of the bullet can still cause damage to the wearer by knocking them off their feet, bruising the skin, or causing severe injuries to internal organs. This is known as blunt force trauma. A bulletproof vest superior a regular one would be able to deflect most of the energy, as well as the bullet, upon impact (Lecours, et al.). This is where the phenomenon known as carbon nanotubes comes in.

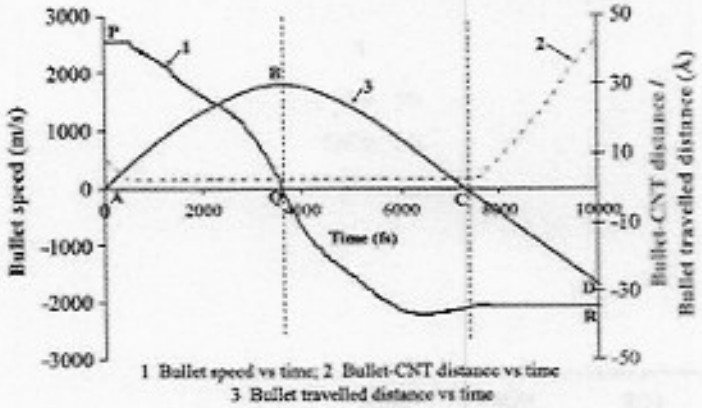
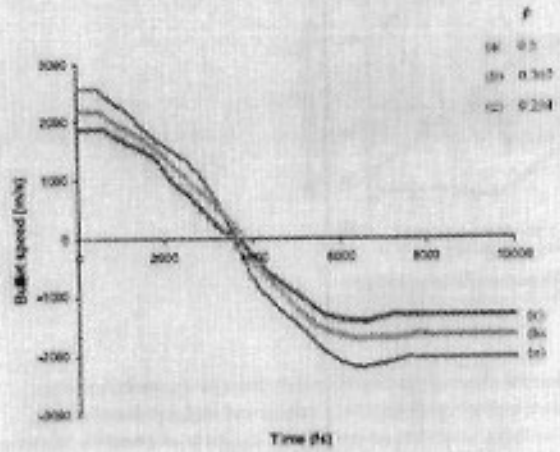


Figure 5. Variation of different properties of a bullet with time during its impact and bouncing-back processes when impacting the middle of a (18, 0) nanotube.

Carbon nanotubes are light, flexible, thermally stabile, chemically inert, and extremely strong- making them ideal for bulletproof technology (Adams). In a bulletproof vest, millions of carbon nanotubes make up carbon nanofibres, which are woven together to create an extremely lightweight material (Paneer, et al). The carbon nanofibres are extremely good at absorbing energy. Their capacity to absorb this energy and not permanently deform or fail is the reason that carbon nanotubes are ideal for the purpose of a bulletproof vest (Paneer, et al). The high elasticity module of carbon nanotubes is also a major reason why researchers are focusing on using it as bulletproof material. A team from the Centre for Advanced Materials Technology at the University of Sydney have recently developed a new material that is actually capable of rebounding the force of a bullet (Mylvaganam, et al).

Single-walled nanotubes (SWNTs) are preferred over the multi-walled nanotubes for the purpose of manufacturing bullet proof vests. SWNTs are composed of a single rolled graphene sheet. Kausala Mylvaganam and L C Zhang from the Centre for Advanced Materials Technology at the University of Sydney conducted a study on the ballistic resistance capacity of different carbon nanotubes. Their studies showed that nanotubes with larger radii could withstand higher bullet speeds, and nanotubes with larger lengths could absorb more energy. They also found that the energy absorption and rebound is highest when the bullet hits the middle of the nanotubes (Mylvaganam, et al).



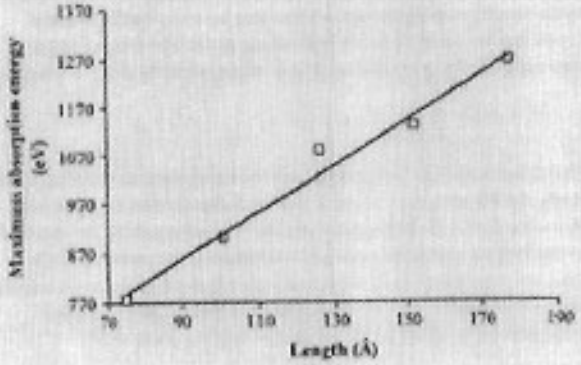


Figure 3. Variation of the maximum energy absorbed with nanotube length.

Carbon nanotubes hold a very promising future for technology being developed in the study of Ballistics. There is no doubt that future generations involved in law enforcement and the military will benefit from nanotechnology.

Amendment II Ballistic Armor is a company that has already commercialized their own carbon nanotube bulletproof vest.