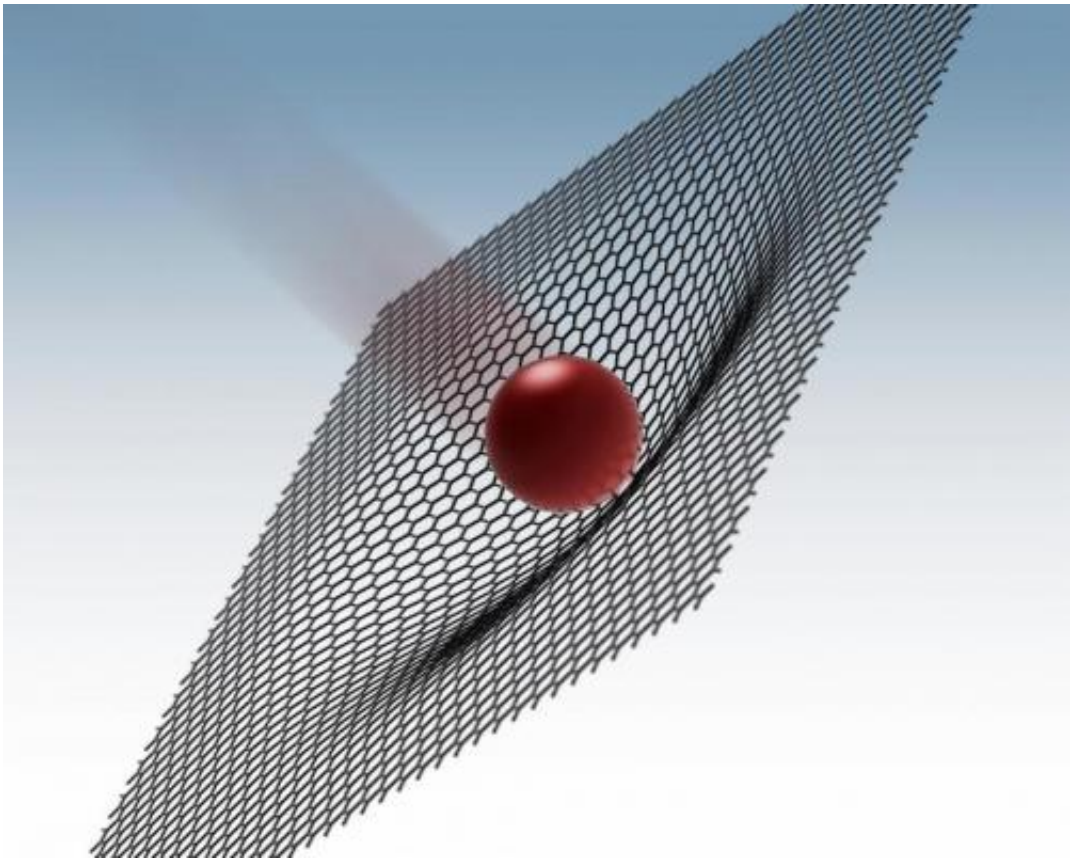
Study shows graphene able to withstand a speeding bullet

November 28 2014, by Bob Yirka



Rice University scientists fired microbullets at supersonic speeds in experiments that show graphene is 10 times better than steel at absorbing the energy of a penetrating projectile. Credit: Jae-Hwang Lee

(Phys.org)—A team of researchers working at Rice University in the U.S. has demonstrated that graphene is better able to withstand the

impact of a bullet than either steel or Kevlar. In their paper published in the journal *Science*, the team describes how they set up a miniature firing range in their laboratory and used it to test the strength of graphene sheets.

Scientists know that graphene sheets are tough, due to their dense one atom think structure. Until now, however, no one has tested the material for use as armor—to protect against being struck by a speeding bullet. In this new effort, the researchers did just that, albeit at a much smaller scale.

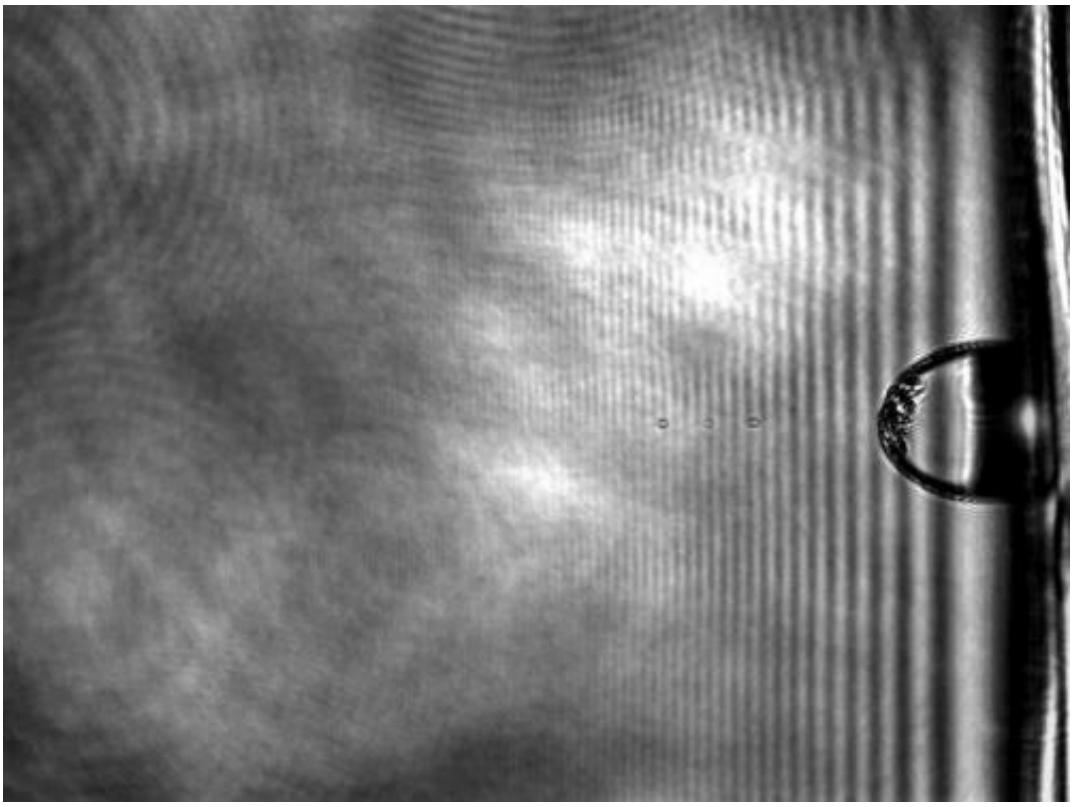
Scientists have yet to figure out a way to mass produce sheets of graphene in large sizes, thus, for this experiment, the researchers confined their efforts to a very small scale. Their firing range consisted of using a laser to vaporize gold filaments to serve as the gunpowder. The explosion pushed micron-sized glass bullets at graphene targets—10 to 100 sheets placed together to form a mat—at speeds up to 6,700 mph (approximately a third of the speed of a real bullet fired from an M16 machine gun). Electron microscopy was used to measure how well the graphene sheets absorbed the impact.

The researchers found that the sheets were able to dissipate the energy of the bullet by stretching backwards—sort of like when someone jumps on a trampoline. Tiny cracks also formed radially, using up more of the energy. In analyzing the results, the researchers found that the graphene was able to perform twice as well as Kevlar, the material currently used in bullet-proof vests, and up to ten times as well as steel. Put another way, the graphene was able to absorb aproximately 0.92MJ/kg of projectile energy, while steel can typically absorb 0.08MJ/kg when both are being tested at similar speeds.

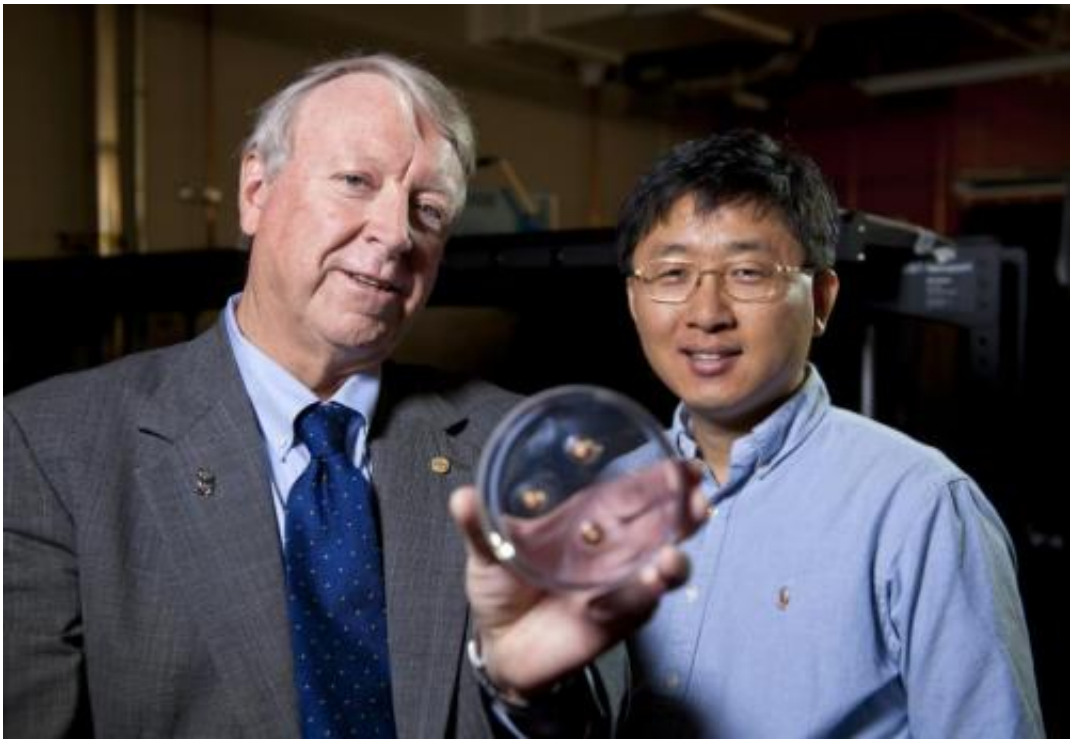
The ability of graphene to dissipate energy, the team explains, is due to a high degree of stiffness combined with low density, which means that

energy can move through it very quickly, allowing for the dissipation of energy from something traveling as fast as a bullet.

The researchers efforts show that graphene could very well mean a better bullet-proof vest, if a way could be found to produce it in enough quantity and at a low enough price.



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. Credit: Thomas Research Group/Rice University



Materials scientist Edwin "Ned" Thomas, left, dean of the George R. Brown School of Engineering at Rice University, and Jae-Hwang Lee, a former postdoctoral researcher in his lab and now an assistant professor at the University of Massachusetts, Amherst, found graphene is stronger than steel in tests with microbullets. The researchers hold a polymer encasing bullets, the focus of a previous experiment. Credit: Tommy LaVergne/Rice University

More information: Dynamic mechanical behavior of multilayer graphene via supersonic projectile penetration, *Science* 28 November 2014: Vol. 346 no. 6213 pp. 1092-1096. DOI: 10.1126/science.1258544

ABSTRACT
Multilayer graphene is an exceptional anisotropic material due to its layered structure composed of two-dimensional carbon lattices. Although the intrinsic mechanical properties of graphene have been

investigated at quasi-static conditions, its behavior under extreme dynamic conditions has not yet been studied. We report the high–strain-rate behavior of multilayer graphene over a range of thicknesses from 10 to 100 nanometers by using miniaturized ballistic tests. Tensile stretching of the membrane into a cone shape is followed by initiation of radial cracks that approximately follow crystallographic directions and extend outward well beyond the impact area. The specific penetration energy for multilayer graphene is ~10 times more than literature values for macroscopic steel sheets at 600 meters per second.

Press release