HIGH RATE DEFORMATION BEHAVIOR AND EXTRAORDINARY ENERGY ABSORPTION OF CARBON NANOTUBE MATS AND GLASSY POLYMER THIN FILMS

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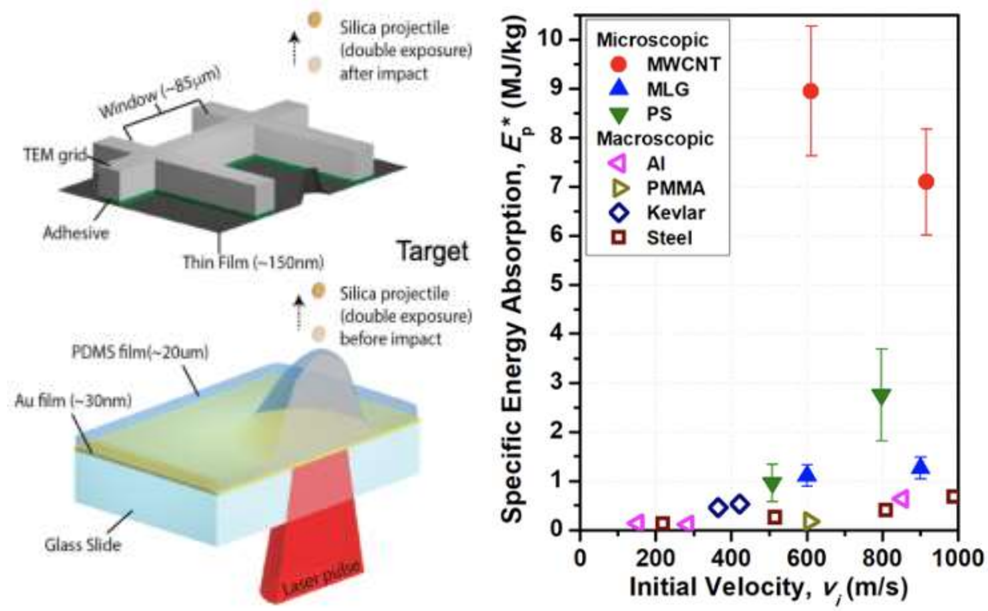
We investigate the energy absorption characteristics and associated deformation behavior of free standing thin films using a micro-projectile impact test for two different materials: (1) multiwall carbon nanotubes (MWCNTs) and (2) glassy polystyrene. Films from 50-250nm thickness are impacted with silica microprojectiles at velocities from 300-900 m/s. The interconnected network of multiwall carbon nanotubes (MWCNT) sample while having quite modest quasi-static mechanical properties shows strong energy absorption at the extreme strain rates resulting from ballistic impact. As the spherical projectile engages the film, the bundles of MWCNT tubes straighten and translate into the impact region, dissipating the kinetic energy of the projectile via frictional interactions between tubes and stretching of the network, ultimately leading to fracture of principal tubes. The specific energy absorption depends on velocity and film thickness and can range up to 9 MJ/kg. For glassy, well entangled high molecular weight polystyrene, the impact of a supersonic micro-projectile initiates extensive crazing, yielding, and adiabatic heating leading to plastic flow of the load-bearing viscoelastic melt prior to film rupture and perforation. The less entangled, more mobile near-surface regions of these freestanding films favorably modify the deformation processes, increasing the specific energy absorption with decreased film thickness and increased impact velocity to impressive values of 2-3 MJ/kg for what is normally considered a brittle material.



(left) Laser Induced Projectile Impact Test (LIPIT). (right) Specific energy absorption of macro membranes and 50-1250 nanometer thick films.

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