Fracture patterns of graphene sheets under ballistic penetration

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Abstract

Graphene is a remarkable material with unique electronic, thermal and mechanical properties. Recent miniaturized ballistic tests showed that under high strain rate conditions graphene displays exceptional energy absorption properties: the specific penetration energies of a multi-layered (30~300) graphene sheets are ten times larger than the ones for macroscopic steel sheets [1]. These results associated with the fact that graphene is a low-density material suggests that it is a promising candidate for use in light and strong bulletproof vests. In spite of many theoretical and experimental studies on the graphene mechanical properties, some fundamental questions are still not fully understood, such as, the fracture mechanisms at atomic level. In this work we combined analytical modeling based on a recent work [2] and fully atomistic molecular dynamics (MD) simulations to study the impact of a nickel sphere shot against multi-layered (1,2) graphene sheets. The MD simulations were carried out using the Reactive Force Field [3] as implemented in the LAMMPS package [4]. From MD trajectories we obtained more accurate (in relation to estimated values from macroscale experiments [1]) values for dynamic quantities, such as, the velocity of the elastic deformation that propagates after impact. Our model shows that the specific penetration energy decreases with the number of layers of the graphene sheet as a power law that fits exceptionally well both experimental [1] and recent numerical results [5].

References

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