Fracture patterns of graphene sheets under ballistic penetration

Rafael A. Bizao¹,², L. D. Machado¹,³, J. M. de Sousa¹, Nicola M. Pugno²,⁴,⁵, Douglas S. Galvao¹,∗

¹Applied Physics Department, State University of Campinas, Campinas-SP 13083-970, Brazil.
²Department of Civil, Environmental and Mechanical Engineering, Laboratory of Bio-Inspired and
Graphene Nanomechanics, University of Trento, via Mesiano, 77, 38123 Trento, Italy.
³Department of Theoretical and Experimental Physics, Federal University of Rio Grande do Norte,
Natal-RN 59072-970, Brazil.
⁴Center for Materials and Microsystems, Fondazione Bruno Kessler, Via Sommarive 18, 38123 Trento,
Italy.
⁵School of Engineering and Materials Science, Queen Mary University of London, Mile End Road,
London E1 4NS, United Kingdom.

galvao@ifi.unicamp.br

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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