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Dissipation of Mechanical Energy in Carbon Nanotube-based Mechanical Devices

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The creation of functional mechanical devices at the nanoscale is a major goal of nanoscience, and multiwalled carbon nanotubes (MWCNT) are promising materials for constructing such devices. The large disparity between the strengths of intralayer and interlayer interactions in MWCNTS allows for smooth relative motion of concentric tubes. Some simple mechanical elements such as linear and rotational bearings have already been constructed from MWCNTs by exploiting this feature[1]. However, little is known about the dominant mechanisms for dissipation of mechanical energy at the nano scale, and devices based on MWCNTs are both technologically important and useful as test systems for theoretical investigations. In this talk, atomistic simulations of some simple MWCNT-based mechanical systems will be presented. It is shown that reducing the dimensions of a device can have a strong impact on phononic friction. The small masses of nanotubes relative to the forces between them means that relative velocities can be comparable to and larger than atomic thermal velocities. In this regime, theories based on a quasi-adiabatic response of atoms to the relative motion of nanotubes fail and simulations reveal a strong and complex velocity dependence of friction[2]. Large edge to surface ratios mean that edges can play an important role in energy dissipation and for concentric nanotubes of length 10s of nm, the ends of the nanotubes have been shown to dominate sliding friction[2]. These and other important features of friction in nanotube-based devices will be discussed and illustrated with the results of molecular dynamics simulations. This work was supported by the NSF Grant No. DMR04-39768 and U.S. DOE Contract No. DE-AC03-76SF00098. [1] J. Cumings and A. Zettl, Science 289, 602 (2000); A. M. Fennimore et al., Nature 424, 408 (2003). [2] P. Tangney, S. G. Louie, and M. L. Cohen, Phys. Rev. Lett. 93,065503 (2004) ; P. Tangney, M. L. Cohen, and S. G. Louie, to be published.