



CNAM Condensed Matter Colloquium

2 p.m., Thursday, February 18:
Room PHYS1201

Nanomechanics of nano-carbon

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This talk will describe our work toward fundamental understanding of the mechanical and electromechanical properties of carbon nanotubes and graphene, and their application in nano-electromechanical devices (NEMS). Using a combination of optical characterization and electromagnetic displacement, we have measured the mechanical stiffness of individual nanotubes of known chiral index¹, and the strain-induced changes in electronic bandstructure². We have used nanoindentation to measure the elastic stiffness and ultimate strength of single graphene sheets³. These measurements show that graphene is the strongest material ever measured, with an ultimate strength of 130 GPa at strain rates of over 25%. As such, it is the first material whose mechanical properties can be probed deep into the nonlinear elastic regime. As an example, we are able to probe the vibrational modes by Raman spectroscopy under large strain, to observe shifts and splitting in the G, 2D, and 2D' modes. We have also measured the frictional behavior of graphene and related 2-dimensional materials, which shows a strong dependence on the number of atomic layers in all cases. Finally, we have demonstrated electronic readout of graphene nanomechanical resonators, and tested their response to changes in mass and temperature.

Time permitting, I will also provide a short summary of ongoing work on the properties of other 2-dimensional materials, and their use with graphene in hybrid devices.

¹Yang Wu, Mingyuan Huang, Feng Wang, Henry X. M. Huang, Sami Rosenblatt, Limin Huang, Hugen Yan, Stephen P. O'Brien, J. Hone, and Tony F. Heinz, "Determination of the Young's Modulus of Structurally Defined Single-Walled Carbon Nanotubes," *Nano Letters* **8**, 4158 (2008)

² Mingyuan Huang, Yang Wu, Bhupesh Chandra, Hugen Yan, Yuyao Shan, Tony F. Heinz, J. Hone, "Direct Measurement of Strain-induced Changes in the Band Structure of Carbon Nanotubes," *Phys. Rev. Lett.* **100**, 136803 (2008).

³ Changgu Lee, Xiaoding Wei, Jeffrey Kysar, J. Hone, "Measured elastic properties and ultimate strength of monolayer graphene," *Science* **321**, 385 (2008)