Electromechanical Resonators from Graphene Sheets

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We fabricate nanoelectromechanical systems (NEMS) from graphene sheets by mechanically exfoliating thin sheets[12] over trenches in silicon dioxide substrates with adjacent gold electrodes. The thinnest resonator consists of a single suspended layer of atoms and represents the ultimate limit of a two dimensional NEMS. Vibrations with fundamental resonant frequencies in the MHz range are actuated either optically via thermal expansion and contraction,[3,4] or electrically by applying a radio frequency voltage relative to a doped silicon back-gate.[5] Motion is detected optically by laser interferometry. We detect the thermal motion of the resonators, and use the equipartition theorem to calibrate the amplitude of motion with the optical signal. Static mechanical properties are measured using calibrated atomic force microscopy (AFM) probes. We make a detailed study of the mechanical properties of these resonators including resonance frequency, spring constant, built in tension, and quality factor. The resonance frequency is tuned by varying an additional DC gate voltage. AFM and spatially resolved Raman spectroscopy are used to determine the thickness of the suspended sheets. The unusually small mass, electrically active material and reasonable dynamic range indicate that graphite resonators would make excellent mass and charge sensors.

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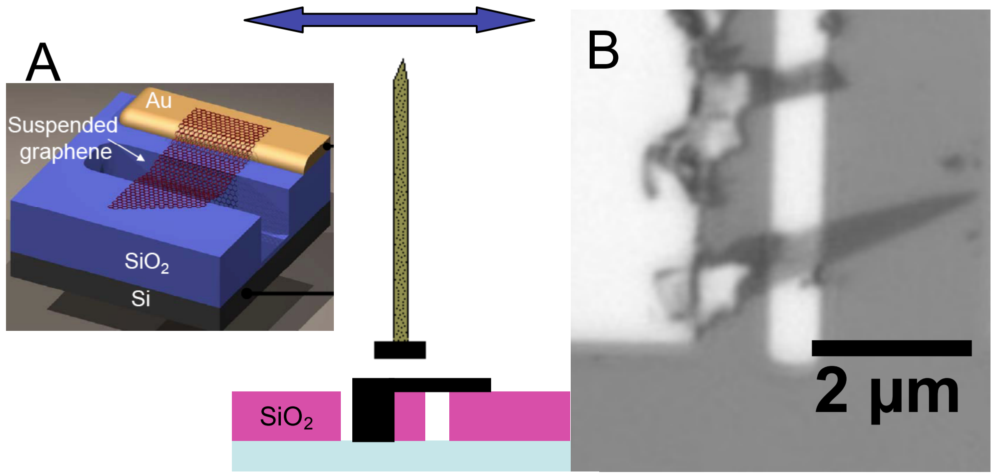
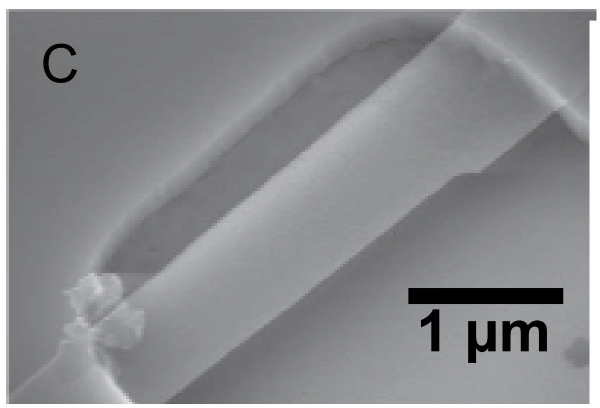
[3] M. Zalalutdinov *et al*., Appl. Phys. Lett., 78, 3142 (2001).
[4] B. Ilic *et al*., Appl. Phys. Lett., 86, 193114 (2005).
[5] V. Sazonova *et al*., Nature, 431, 284 (2004).





Figures: Schematics of the device and fabrication process (A) with optical (B) and SEM (C) images of suspended graphene sheets. Resonance curves (D) and a plot of the amplitude of the calibrated resonance peak amplitude and Quality factor versus drive voltage (E) detected from a single capacitively driven device.