A local optical probe for measuring motion and stress in a nanoelectromechanical system

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Nanoelectromechanical systems can be operated as ultrasensitive mass sensors and ultrahigh frequency resonators, and can also be used to explore fundamental physical phenomena such as nonlinear damping and quantum effects in macroscopic objects. Various dissipation mechanisms are known to limit the mechanical quality factors of nanoelectromechanical systems and to induce aging due to material degradation, so there is a need for methods that can probe the motion of these systems, and the stresses within them, at the nanoscale. Here, we report a non-invasive local optical probe for the quantitative measurement of motion and stress within a nanoelectromechanical system based on Fizeau interferometry and Raman spectroscopy. The system consists of a multilayer graphene resonator that is clamped to a gold film on an oxidized silicon surface. The resonator and the surface both act as mirrors and therefore define an optical cavity. Fizeau interferometry provides a calibrated measurement of the motion of the resonator, while Raman spectroscopy can probe the strain within the system and allows a purely spectral detection of mechanical resonance at the nanoscale.

References

[1] Bunch, S.J. et al, Science, **315** (2007) 490.
[2] Otakar, F. et al, Nature Communications, **2** (2011) 255.
[3] Reserbat-Plantey, A. Marty, L. Arcizet, O. Bendiab, N. and Bouchiat, V. Nature Nanotechnology, *accepted* 15/12/11

Figures

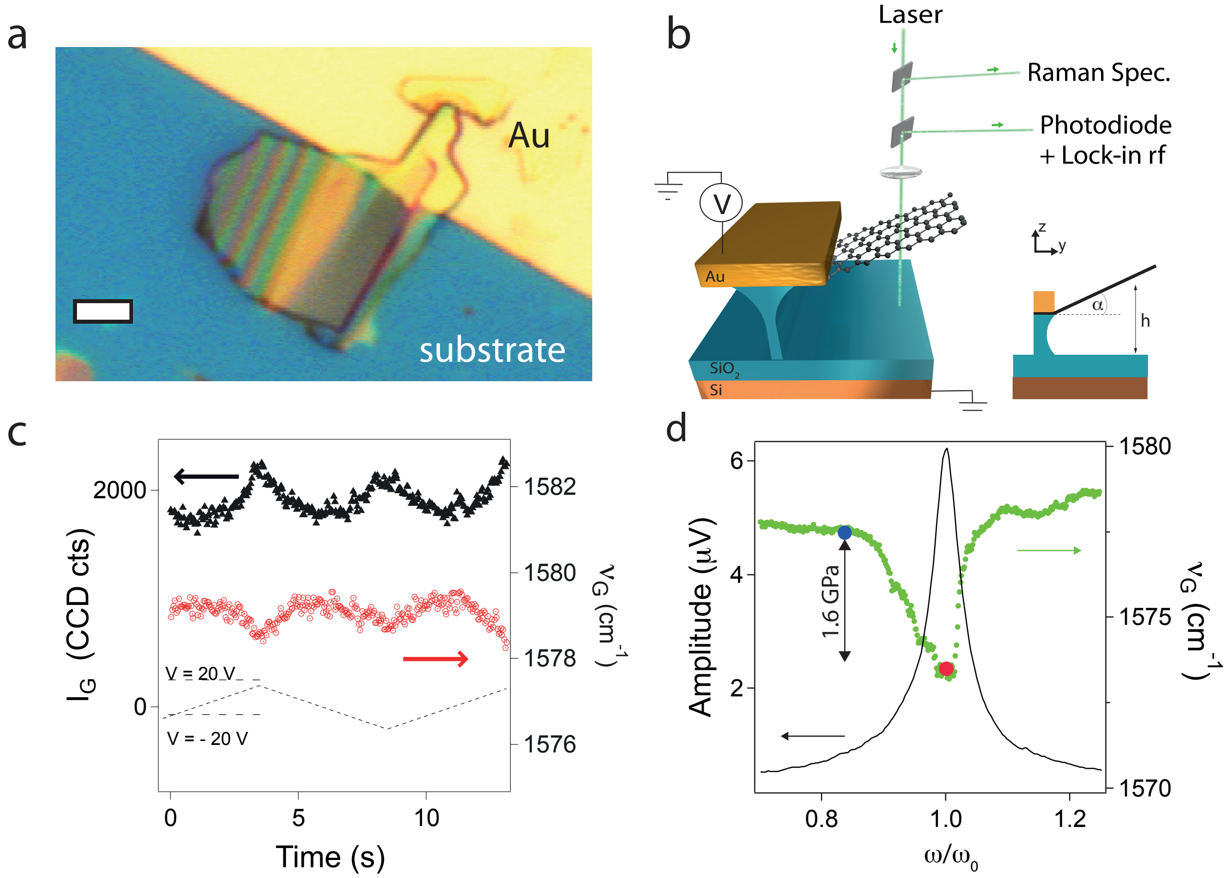

Figure I*. a:** *White light optical image of a wedged MLG cantilever showing iridescence. Scale bar represents 5 μm.* ***b: *Schematic view of the device : electrical excitation and optical detection, either with a photodiode (intensity) or a Raman spectrometer (intensity and spectral data).* ***c:*** *Variations in G peak intensity (▲) and position (⊙) under MLG electrostatic actuation, revealing peak softening at maximum cantilever deviation. The lower dashed line represents the drive voltage.* ***d:*** *Lock-in amplitude (dark line) as a function of the drive frequency showing a resonant peak at ω_0 = 1.3 MHz. The position of the Raman G peak (•) shows a softening, which coincides with the mechanical resonance of the MLG cantilever.*