Self Oscillations and Cooling of Carbon Based NEMS Devices

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ABSTRACT

We investigate the electromechanical properties of a number of system geometries featuring a doubly clamped Carbon Nanotube or Graphene sheet with a deflection sensitive resistance and an electronic feedback in the form of a Lorentz force or an electrostatic attraction. The nanotube is subjected to a constant current- or voltage bias and it is shown that when the electromechanical coupling exceeds a certain critical value the system becomes unstable to self-excitations of the mechanical vibrations accompanied by oscillations in the voltage drop and current through the nanotube. The critical value typically depends on the quality factor and some function of the mechanical and electronic relaxation times. We discuss applications of the devices as active tunable radiofrequency oscillators and for cooling.

Keywords: Nanoelectromechanical systems, NEMS, carbon nanotubes, suspended carbon nanotubes, self oscillations, negative differential resistance, oscillator, transmission line, cooling.