When micromechanics and quantum electrodynamics meet: MEMS based on Casimir-Lifschitz forces

Federico Capasso
Lucent Bell Laboratories

We present a new class of micro-electro-mechanical systems (MEMS) in which the Casimir force between metallic surfaces at submicron distances has been exploited for the quantum mechanical actuation and for the realization of a new class of nonlinear bistable oscillators.

The Casimir force is the attraction between uncharged metallic surfaces due to quantum mechanical vacuum fluctuations of the electromagnetic field. We demonstrate the Casimir effect in microelectromechanical systems (MEMS) using a micromachined torsional device. Attraction between a polysilicon plate and a spherical metallic surface results in a torque that rotates the plate about two thin torsional rods. The dependence of the rotation angle on the separation between the surfaces is in agreement with calculations of the Casimir force. These results show that quantum electrodynamical effects play a significant role in MEMS when the separation between components is in the nanometer range.

We have also demonstrated that the Casimir effect has a profound influence on the oscillatory behavior of MEMS when surfaces are in close proximity (<100 nm). Frequency shifts, hysteretic behavior and bistability are observed in the frequency response of a periodically driven micromachined torsional oscillator due to the nonlinear dependence of the Casimir force on distance. Our measurements also show that this device can be utilized as a high sensitivity position sensor.

The topological nature of the Casimir force and of the more general Lifschitz force between macroscopic bodies opens the door to the design of the latter forces by suitable control of the boundary conditions of the electromagnetic fields in MEMS and to many applications.