An Epitaxial Device for Dynamic Interaction with the Vacuum State

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Abstract

More than 60 years ago, H. B. G. Casimir [1], and Casimir and D. Polder [2] explained the retarded van der Waals force in terms of the zero-point energy of a quantized field. Both the static and dynamic Casimir effects are discussed in several large reviews [3-7]. This work is concerned with the dynamic Casimir effect, which involves the interaction between moving mirrors and the ground state ("vacuum state') of the electromagnetic field. In particular, following Maclay and Forward, [8], we are motivated by its potential to provide a propulsive mechanism. When estimating the magnitude of the force that could be generated, Maclay and Forward assumed that the amplitude of high frequency motion of an actual mirror need be in the nanometer range due to the finite strength of materials. This restriction limits the possible propulsive force to very small values. However, this author observes that motion of a single reflective surface is not essential: that the Casimir effect is due to the motion of the boundary conditions constraining the free field in its ground state. The advent of amorphous oxide, transparent semiconductors used for thin film applications suggests the possibility of achieving large motions of reflective surfaces without mechanically moving parts. We propose the use of an epitaxial assembly of semiconductor laminae. Without the application of voltage, each lamina is a partially transparent dielectric; but when supplied by voltage it becomes a reflecting conductor serving as a mirror. Voltage inputs can be switched among the laminae at high speed, effectively moving the mirror at high velocities and accelerations without the use of moving parts. Thus motions of the reflective surface that have both high frequencies and large amplitudes can be produced. In a thorough treatment of the pressure on moving mirrors due to the Casimir effect, Neto and his colleagues, [7], took a perturbative approach consistent with the assumption that the mirror motion be constrained to very small amplitudes. The objectives of this paper are to extend the analysis to large motions and the epitaxial approach described above; to obtain explicit expressions for the forces produced by particular trajectories of motion; and to estimate the numerical values of these forces. We also discuss the design of a laboratory-scale experiment with a fabricated prototype.

Keywords: Dynamic Casimir effect, Epitaxial Devices, Transparent Semiconductors

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