All-dielectric nanomechanical metamaterials for sub-GHz optical modulation

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We report on the experimental demonstration of all-dielectric nano-mechanical metamaterials, fabricated in free-standing silicon and silicon/ITO bilayer membranes, with resonant reflection and transmission characteristics that can be manipulated via the spatial reconfiguration of the constituent elements under the action of electrostatic and optical forces. They provide, in the former case, reflectivity changes of up to 20% at applied biases of only a few volts, and in the latter a large optomechanical nonlinearity at intensities of only a few µW per unit cell and a modulation frequency of 152 MHz.

Non-metallic metamaterial nanostructures have attracted considerable attention of late as a means of circumventing the losses and costs associated with the use of noble metals in plasmonic architectures. High-Q resonant metamaterials has been realized in a variety of oxide and nitride, graphene, topological insulator, and high-index dielectric platforms. In parallel, it has been seen in plasmonic systems that nanomechanical reconfiguration offers a range of approaches (harnessing the changing balance among Coulomb, Lorentz, Ampère, optical and elastic forces at the nanoscale) for high-contrast reversible switching and tuning of metasurface optical properties.

Here, we demonstrate subwavelength-thickness all-dielectric nano-grating and nano-cantilever array metamaterials with resonant reflection and transmission characteristics that can be dynamically controlled via the spatial reconfiguration of the constituent elements under the action, respectively, of electrostatic and optical forces.