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Small Footprint Nano-Mechanical Plasmonic Phase Modulators

BRIAN DENNIS, Rutgers University, MICHAEL HAFTEL, University of Colorado, Colorado Springs, DAVID CZAPLEWSKI, DANIEL LOPEZ, Argonne National Labs, GIRSH BLUMBERG, Rutgers University, VLADIMIR AKSYUK, NIST - Natl Inst of Stds & Tech — Miniaturization of photonic devices is fundamentally limited by the refractive index of the constituent dielectric materials. By coupling light to metal's free electrons, plasmonic devices achieve deeper localization, which scales down with the device geometric size. However, when the localization approaches the skin depth, energy shifts from the dielectric into the metal, and modulation via the electro-optic effect in the dielectric becomes less efficient. Here we propose a nano-electromechanical phase modulation principle exploiting the extraordinarily strong dependence of the phase velocity of metal-insulator-metal (MIM) gap plasmons on dynamically variable gap size. We demonstrate a 23 μm long non-resonant modulator having a 1.5 π rad range with 1.7 dB excess loss at 780 nm. Analysis shows that an ultracompact 1 μm^2 footprint π rad phase modulator can be realized, more than an order of magnitude smaller than any previously shown. This size reduction can be realized without incurring extra loss, since the nanobeam-plasmon coupling strength increases at a similar rate as the loss. Such small, high density electrically controllable components may find applications in optical switch fabrics and reconfigurable flat plasmonic optics.

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