Randomly Addressable Reconfigurable Photonic Metamaterials

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Abstract: We report on randomly addressable reconfigurable metamaterials that can be driven by thermal, Lorentz or Coulomb forces. Simultaneous spatial and temporal modulation of optical material properties enables various metadevices on demand.

Recently, we have demonstrated that nanomechanically reconfigurable photonic metamaterials provide a flexible platform for modulation of metamaterial properties in time, providing contrast on the order of 50% and megahertz-scale modulation rates [1].

Here we demonstrate the first solutions that allow modulation of optical properties in time and space, taking reconfigurable metamaterials to the next level of functionality. Fig. 1(a) shows an implementation of an electrically addressable metadevice manufactured by focused ion beam milling from a 50 nm gold layer supported by a 50 nm thick silicon nitride membrane. The one-dimensionally addressable metamaterial consists of free-standing gold-on-silicon nitride bridges, which can be individually electrically addressed and deform out of the device plane due to differential thermal expansion in response to resistive heating by the applied electrical current. Panel (b) shows the simulated transmission of the device for regular displacement of every second bridge. Local deformation of the nanostructure modulates the amplitude and phase of transmission and reflection of the semi-transparent nanostructure locally by modifying the near-field coupling between different meta-molecules and their plasmonic components. Two-dimensional addressing as well as electrostatically and magnetically driven solutions will also be discussed at the conference.

The ability to apply the same or different control signals to all parts of such metadevices, allows operation as homogeneous or massively parallel phase and intensity modulators, gratings of switchable period, tuneable cylindrical lenses, high resolution spatial light modulators and – in principle – even tuneable transformation optics devices.

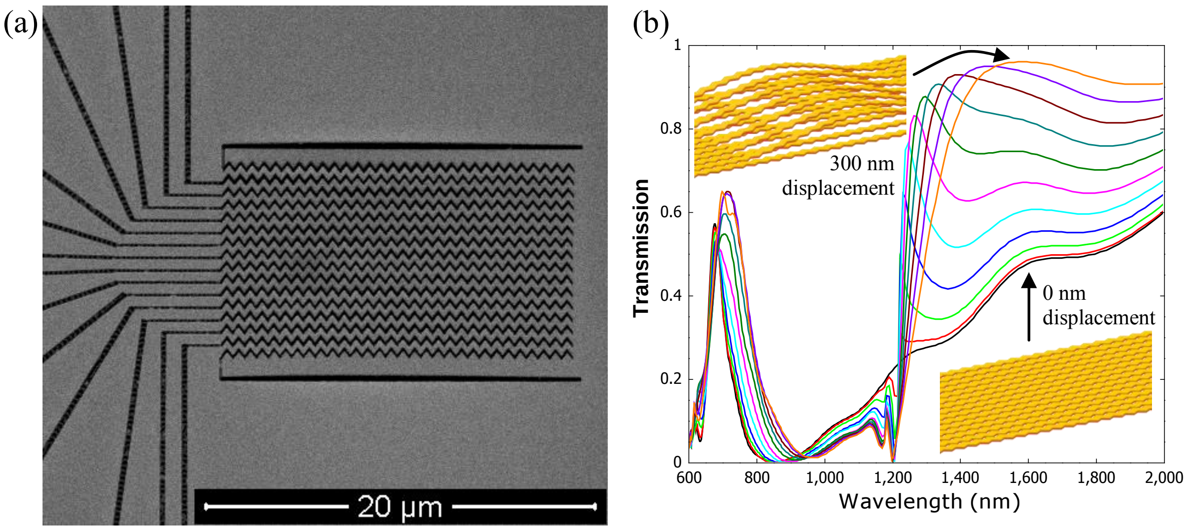

Fig. 1: (a) Photonic metamaterial with randomly addressable reconfigurable rows of meta-molecules. (b) Simulated dependence of transmission on displacement of every second bridge for waves polarized perpendicular to the bridges.

[1] J. Y. Ou, E. Plum, J. Zhang, and N. I. Zheludev, "An electromechanically reconfigurable plasmonic metamaterial operating in the near-infrared," Nature Nanotech. 8, 252-255 (2013).