100 THz optical switching with plasmonic metamaterial

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Using femtosecond laser with variable pulse duration we probe the limits of switching that exploits coherent absorption in nanostructured gold films. Switching contrast ratios of 7:1 with a modulation bandwidth exceeding 100 THz has been observed.

All-optical signal processing is one of the rising fields to eliminate the disadvantages of optical –electrical – optical conversion and continuing advances in terabits per second communications for high-performance computing. All-optical modulation is control of the phase or intensity of one light beam by another.[1] Although modulation can be achieved using nonlinear optical materials, it can be also obtained using constructive or destructive interference of a coherent beam. In coherent perfect absorption, the interference of two counter-propagating coherent beams on a highly absorbing material of sub- wavelength thickness can either lead to nearly total transmission or to nearly total absorption of the incident light, depending on their mutual intensity and phase.[1] A device based on coherent absorption has the advantage of being compact, fast, and intrinsically low power while demonstrating large modulations of light. It has been demonstrated to work even with single photons and both with continuous and pulsed lasers.

In this paper we evaluate the effect of plasmonic finite response time on the coherent perfect absorption process for a plasmonic metamaterial absorber, based on asymmetric split ring resonators. We study the coherent modulation of the total energy as a function of the pulse duration, down to 6 fs. Our measurements allow to assess the maximal bandwidth for all-optical control of femtosecond pulses, which is about 100 THz. Finally we evaluate the effect of non linearities, showing that the best coherent modulation is obtained in a very low power regime. We also evaluate the wavelength dependent coherent modulation; maximum modulation is at plasmonic peak.

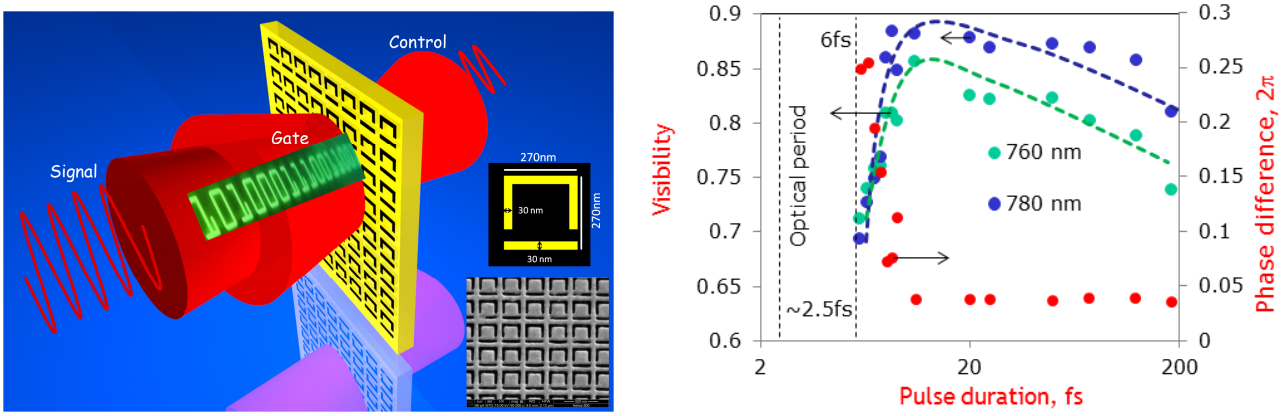

Fig.1: (Left) Artistic impression of metamaterial all optical switch, (Right) Input pulse duration dependent visibility at two different wavelength excitations (760 nm – green dots, 780 nm – blue dots) and phase difference (Δϕ) between both the output beams (red dots), interacting on two sides of the metamaterial film.

Reference

[1] J. Zhang, K. F. MacDonald, and N. I. Zheludev, Light Sci. Appl. **1,** e18 (2012).

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