100 THz bandwidth all-optical switching using coherent absorption in plasmonic metamaterials

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Abstract: 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/second communications for high-performance computing. All-optical modulation is control of the phase or intensity of one light beam by another.[1] The interference of two counter-propagating coherent beams on a photonic metamaterial of sub- wavelength thickness can either entirely eliminate Joule losses in the metallic nanostructure or lead to the total absorption of all incident light, depending on their mutual intensity and phase and on their polarization.[1] This device has the advantage of being compact, fast, and intrinsically low power while demonstrating large modulations. The band width and other performance of these devices depend on metamaterial made of metals. The electron dynamics in metals are governed by the interaction and scattering of electrons with other charge carriers, phonons, defects, and impurities.[2] Electronic dephasing is one of the fastest processes, generally in few-femtoseconds governing the initial interaction of an optical field with the metal. Dephasing time is one of the limitations for the metadevices, relates to the local field enhancement of metal nanostructure, thus affecting the degrees of freedom for coherent control on the nanoscale devices.[3]

Here, we illustrate the effect of dephasing time on coherent control (Sagnac interferometry), by which demonstrating an ultrafast, all-optical coherent "meta-device" modulator, and achieving light-by-light control of femtosecond pulses exceeding 100 THz bandwidth.

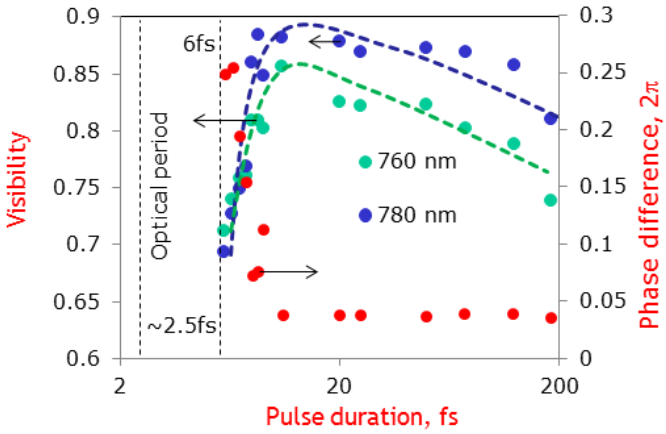

Figure: Input pulse duration dependent visibility at two different wavelength excitations (760 nm – green dots, 780 nm – blue dots) and phase difference ($\Delta\phi$) between both the output beams (red dots), interacting on two sides of the metamaterial film.

References:

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