Nonlinear properties of epsilon near zero metamaterials

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Large Kerr nonlinear optical effects are extremely desirable for applications, which are based on the modulation of phase, amplitude or frequency of light, especially those which require low-power operations, such as all-optical switching and memory elements. Despite this widespread interest, harnessing a large nonlinear response of available materials is extremely challenging. Here we demonstrate a mechanism to enhance the nonlinearity in artificially nano-fabricated metamaterials with permittivity close to zero.

Our sample [1-2] is composed of alternating layers of dielectric (silica) and metal (silver) and the parameters of the system are chosen so that at a certain wavelength (in the red end of the visible bandwidth) the homogenized dielectric permittivity vanishes. Nonlinear properties of samples are measured by the z-scan technique using a pulsed Ti:sapphire laser. We observed that the real part of the nonlinear Kerr index is of the same order of magnitude as that of a single silver layer. At the same time, the transmission of our samples is remarkably higher than that of a single silver layer of the same thickness. These characteristics have a great impact on the amount of optical energy which can be pumped into the structure, thus allowing its nonlinear properties to be accumulated over a long propagation distance along the sample.

References

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