Extraordinary optical properties of visible and terahertz metamaterials

Choon-Gi Choi*, Yoonsik Yi, Chi-Young Hwang

Creative Research Center for Graphene Electronics,
Electronics and Telecommunications Research Institute (ETRI), Daejeon, Korea
*cgchoi@etri.re.kr

Abstract

Metamaterials and metasurfaces are artificially fabricated materials and surfaces with periodic wavelength structures that exhibit exotic properties such as negative refraction, superlens imaging, invisibility cloaking, extraordinary transmission and near-perfect absorption.

In this work, we report a flexible and freestanding fishnet structured negative refractive index media working at visible wavelength. The metamaterial has basically a multilayer fishnet structure with circular hole instead of the rectangular one to reduce the pitch size of the metamaterial. The metamaterial shows negative refractive index in optical regime between 570nm and 615nm.

In addition, we introduce a flexible multi-layered THz metamaterial designed by using the Babinet's principle with functionality of narrow band-pass filter. The metamaterial give us systematic ways to design frequency selective surfaces (FSSs) working on the intended frequency and band (width). It shows an extraordinary transmission at the THz working frequency due to the strong coupling of the two layers of metamaterial complementary to each other

Finally, we propose a design of metamaterial absorber structures and its numerical analysis for the use of reflection type spatial light modulation in the visible regime. Since the size of each metamaterial element is subwavelength scale, neighboring metamaterial elements of the same type can be grouped into a single pixel of a hologram or a spatial light modulator. The modification of the structure allows the control of each pixel's reflectivity from near-zero to a pre-designed level. Each metamaterial hologram pixel consists of 20×20 absorbers of the same structure (pixel size of 4×4μm^2, 500×500 pixels).

Figures

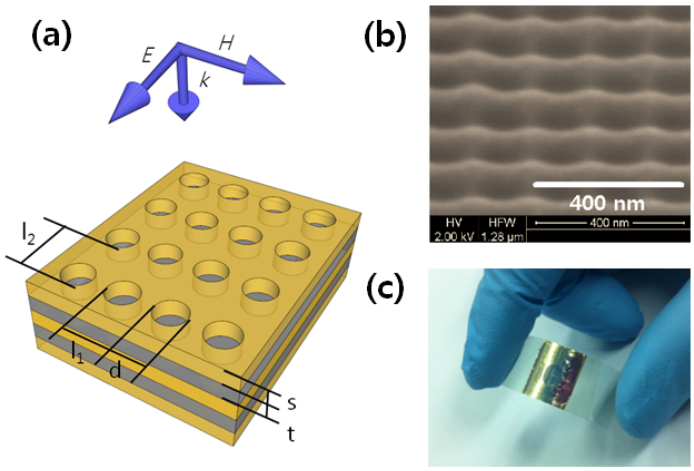

Figure 1. (a) Negative index media flexible metamaterial. The lengths of a unit cell along the incident electric field (l_1) and magnetic field (l_1) are set to 160nm and 224 respectively, the thicknesses of both metal (t) and polyimide layer (s) are 50 nm, and the hole diameter (d) is 100nm. (b) Top-view of the SEM image of the fabricated metamaterial. (c) The image the metamaterial on the flexible substrate.

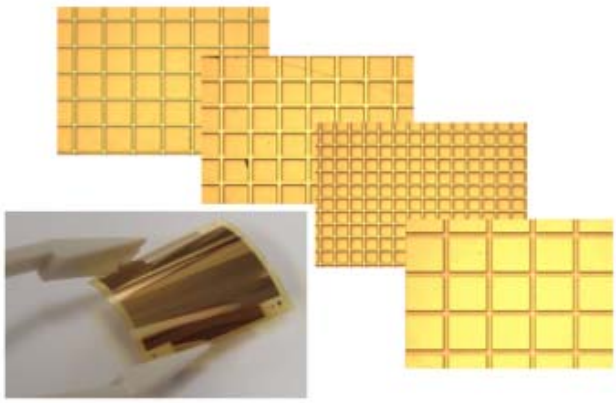

Figure 2. Thin square-fishnet-square flexible terahertz metamaterial. Unit cell period is 40 um and gap is 5 um.

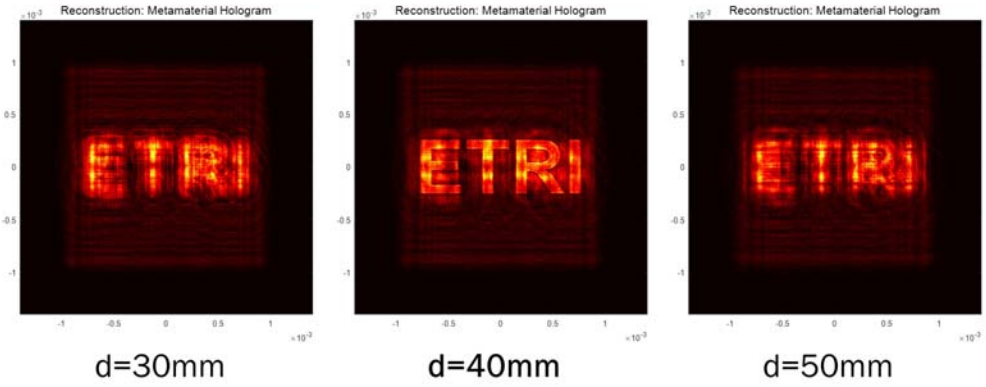

Figure 3. Simulations for metamaterial hologram generation and reconstruction. Accommodation effect can be observed from the reconstruction results (d: reconstruction distance)