A Broadband THz Cutline Metamaterial Absorber

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Introduction: Metamaterials (MM) are artificially engineered to exhibit properties not inherently seen in nature. Here, we demonstrate a broadband MM absorber in the THz regime of electromagnetic spectrum. The MM was characterized in the spectral region of 0.3 – 3 THz with Time domain spectroscopy (TDS) technique using 1 mm ZnTe crystal for electro-optic detection. The cutline MM (CLMM) is a periodically repeating structure of cutlines in 2 dimensions along the plane of the substrate, each cutline being 67.5 µm and 2 µm wide. The periodicity of each cutline was optimized to be 50 µm and 100 nm gold was sputtered on the patterned cutlines.

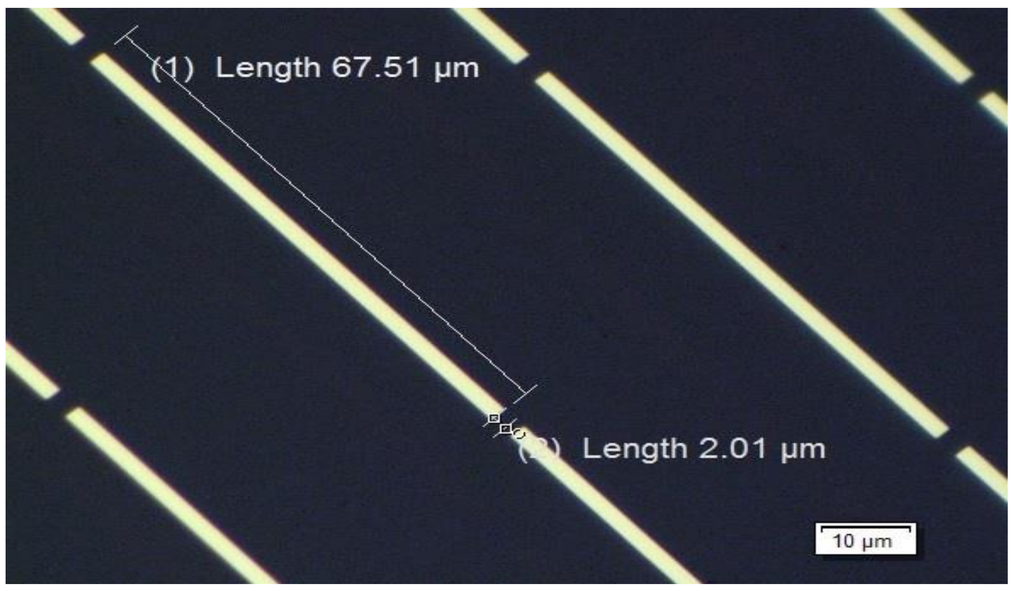

Figure 1. Microscopic image of CLMM fabricated by E-beam lithography

Computational Methods: We used the RF module of COMSOL Multiphysics which is based upon Finite element analysis. Periodic boundary conditions were used to simulate the unit cell of CLMM in 2D along the plane of the substrate. The wave excitation was perpendicular to this plane and the E-field components are given below corresponding to wave vector *K* :

$$E_x = \cos(\theta)e^{-iK_{az}z}$$
$$E_y = \sin(\theta)e^{-iK_{az}z}$$

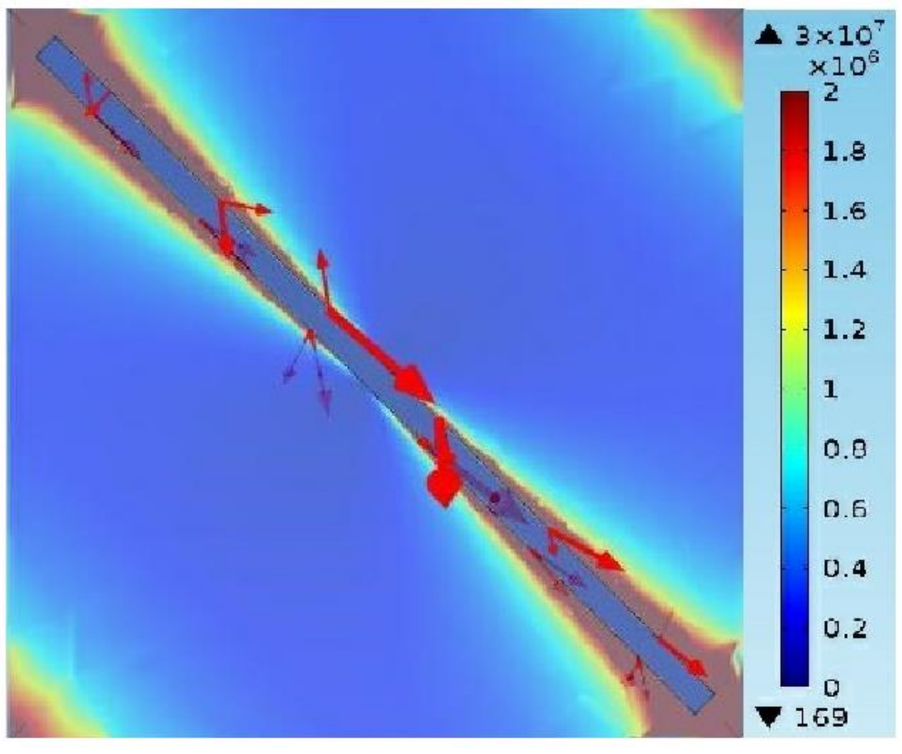

Figure 2. Electric current density at resonance

Simulation and Results: A strong resonance is observed around 1.8 THz when the cutlines are aligned along the polarization of the incoming THz Electric field as seen in Fig. 3 (0 degree). The resonance is observed due to interaction of cutlines with incident THz field. Tuning of the central resonant frequency is possible by changing the length of the cutlines which effectively changes its inductance and capacitance if the MM is studied by LC circuit theory. The full width at half maximum (FWHM) of the resonance is ~1THz. No such resonance is observed when the cutlines are aligned perpendicular h the THz Electric field (90 degree).

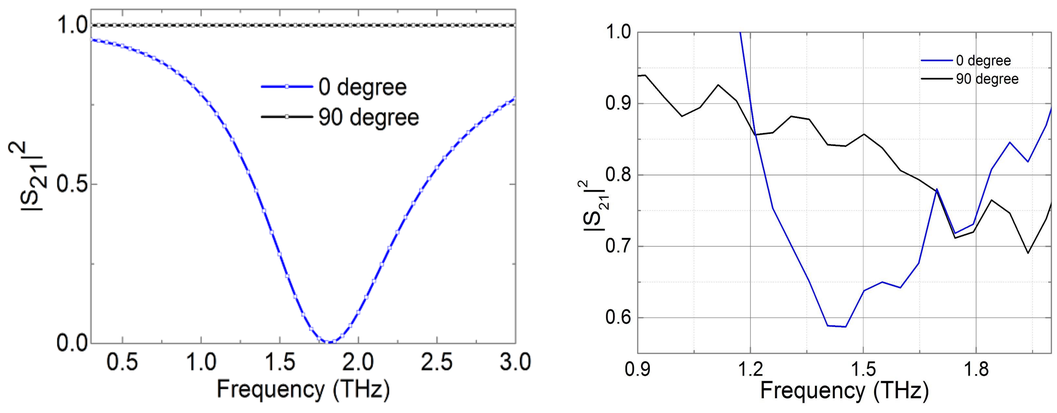

Figure 3. Simulated and Experimental results of CLMM with THz TDS

It was observed that the resonance has shifted and is narrower as compared to simulated results which could be attributed to artifacts during fabrication. The extinction ratio can be defined in terms of power transmission as:

$$ER\ (dB) = 10\log[\frac{T_0}{T_{90}}]$$

The experimentally obtained ER was ~ 3.1 dB.

Conclusions: A Cultine metamaterial was simulated using the RF module of COMSOL Multiphysics which strongly resonated at 1.8 THz with the FWHM being ~1 THz. The MM was then fabricated using E-beam Lithography and then characterized using THz – TDS. The experimentally observed value of extinction ratio was ~3.1 dB.

References:

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