

# PLASMONIC METAMATERIALS AND THEIR FABRICATION TECHNIQUES

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A plasmonic metamaterial is an object that gains its electromagnetic properties from its intrinsic structure rather than directly from the materials it is composed of. This enables us to design artificial materials with unprecedented electromagnetic properties and to observe photonic phenomena never seen in natural substances. We have theoretically investigated the controllability of the electromagnetic properties, in particular magnetic permeability, of the materials in the visible light region[1, 2]. Figure 1 shows the split-ring-resonator (SRR) model used in our calculations. Figure 2 shows the result of the frequency dependence of the minimum value of  $\mu_{Re}$  for SRRs made of silver, gold, and copper. Silver SRRs exhibit negative  $\mu_{Re}$  in the visible range, while the response of gold and copper SRRs do not cover the entire visible light region. In the experimental study, we have proposed new fabrication techniques for three-dimensional metallic structures in order to realize 3D metamaterials. One technique consists of direct laser drawing of 3D metal structure by using two-photon induced metal-ion reduction [3-5]. Figure 3 shows a three-dimensional self-standing silver gate structure on a glass substrate. The resistivity of this structure is  $5.30 \times 10^{-8} \Omega\text{m}$ . This value is only 3.3 times larger than that of bulk silver ( $1.62 \times 10^{-8} \Omega\text{m}$ ), which demonstrates that the proposed technique is effective for fabricating well conductive metallic structures. In the presentation, we will also talk about another fabrication technique that combines two-photon photo-polymerization and electroless metal deposition [6-8].

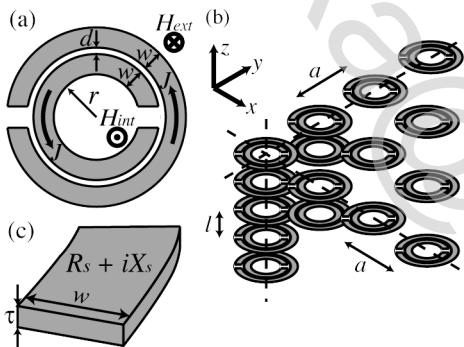


Fig. 1 Calculation model

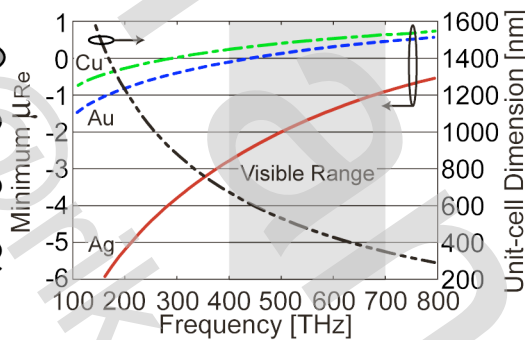


Fig. 2. Magnetic response of SRR

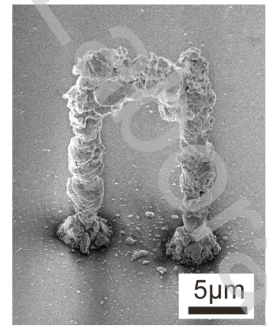


Fig. 3. 3D silver structure

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