# Plasmonic metamaterials and its application to novel optical devices in the visible light frequency region

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Negative permeability of plasmonic metamaterials is theoretically investigated in the visible light frequency region [1, 2]. To estimate magnetic responses of metallic elements precisely, we determined internal impedance by considering the delay of the current inside the metal structure. In our calculation, the surface resistivity saturates at the inherent frequency of each metal as the frequency increases. For the silver case, the saturation value is 0.4 ohms/$m^2$ and this value is remarkably smaller than that of gold and copper. On the other hand, the internal reactance is increasing as the frequency increases independently of metal. We concluded that the internal reactance is dominant factor to realize the negative magnetic permeability in the optical frequency region. We also show the frequency dependence of the magnetic permeability of Split-ring resonators (SRRs). In the case of SRRs made of gold, only on the filling factor was 11%, the minimum value of the magnetic permeability takes negative value in the entire visible range. On the other hand, the silver SRR exhibits negative magnetic permeability in the visible range even under the low filling factor condition of 3%. Therefore, we concluded that reducing the geometrical capacitance and using silver for SRR are necessary to realize the negative magnetic permeability in the visible light range. In addition, we talk about an application of the plasmonic metamaterials to the novel optical device that can eliminate the unwanted light reflection at the interface between two materials with different indices of refraction [3]. The fabrication techniques of the plasmonic metamaterials are also presented [4, 5, 6].

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