Metamaterials

Jeremy Baumberg, Univ. of Southampton, UK

QMD

10:15 am-12:00 pm

Room: 201

Microwave Transmission through Metamaterials in Free Space

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Recently, the composite metamaterials, which was first theoretically proposed by Veselago in 1968,1 have inspired great attentions due to interesting physical properties and novel applications.2-4 The electric and magnetic behaviors of materials are determined by two important material parameters, ε (dielectric permittivity) and μ (magnetic permeability). Together the permeability and the permittivity determine the response of the material to the electromagnetic radiation. Generally, ε and μ are both positive in ordinary materials. Negative dielectric medium at microwave domain can be obtained by arranging thin metallic wires periodically.5 Below plasma frequency, dielectric permittivity will take negative values. Pendry et al. proposed negative magnetic permeability by using special configurations of metals, named as split ring resonator and swiss roll capacitor.6

In order to investigate properties of metamaterials, we constructed a composite structures which consists of periodical arrangement of thin copper wires and SRRs on a circuit board (see Fig. 1). We first measured the transmission spectra of the thin wire and SRR mediums individually. The measurements are performed in free space by using a HP 8510C network analyzer and microwave horn antennas. Figure 2 exhibits the measured transmission spectra of SRRs (dotted line), thin wires (dot-dashed line), and the composite metamaterials (solid line). The SRR medium exhibits a stop band extending from 8.7 to 10.3 GHz. The thin wire structure has a plasma frequency around 11.3 GHz. As shown in Fig. 2, there appears a transmission band for the composite metamaterial within the stop bands of SRR and thin wire structures.

In summary, we investigated the transmission properties of composite metamaterials at microwave frequencies. We observed that a passband is formed within the forbidden transmission bands of thin wire and SRR structures.

References


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QMD1 Fig. 1. (Top panel) Schematic drawing of a single SRR with parameters l = 3 mm and d = w = 0.33 mm. (Bottom panel) The schematics of composite metamaterial consisting of thin wires and SRRs. The structure is consisted of \( N_x = 25 \), \( N_y = 25 \), and \( N_z = 20 \) unit cells, and each unit cell has dimensions \( a_x = 5 \) mm, \( a_y = 3.63 \) mm, and \( a_z = 5 \) mm. The thickness of thin wire is 0.5 mm.

QMD1 Fig. 2. Measured transmission spectra corresponding to thin wires, SRRs, and metamaterials.