CONTROLLABLE PLANE-WAVE REFLECTION AND TRANSMISSION FROM A GYROTROPIC METAFILM

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In previous work (E. F. Kuester *et al.*, *IEEE Trans. Ant. Prop.*, **51**, 2641-2651, 2003) we introduced the idea of a *metafilm*: a distribution of polarizable scatterers on a surface whose response to an incident wave modifies the behavior of the overall field in some desired way. A metafilm is the surface analog of a metamaterial. The main result was an averaged boundary condition for the jumps of the tangential **E** and **H** fields across the metafilm. The coefficients of the boundary conditions involve the densities of the polarizabilities of the scatterers. In subsequent work (C. L. Holloway *et al.*, submitted to *IEEE Trans. Electromag. Compat.*, 2004), we proposed the use of resonant scatterers as a way of modifying the plane wave reflection and transmission properties of the surface. In particular, spherical magnetodielectric scatterers such as the ones proposed as an alternative to the split-ring scatterers widely used for obtaining negative-index metamaterials (C. L. Holloway *et al.*, *IEEE Trans. Ant. Prop.*, **51**, 2596-2603, 2003) were proposed as a means of obtaining substantial reflection from the metafilm.

In this paper, we suggest that this type of metafilm can be controlled via an externally applied DC magnetic bias field. If the spheres are made from a ferrite material, the material becomes magnetically gyrotropic, and the previously obtained boundary conditions no longer apply, since they assumed diagonal polarizability dyadics for the scatterers. Thus, we extend the theory to cover a gyrotropic metafilm by way of the following steps. First, the polarizabilities of magnetically gyrotropic spheres are derived in a Lorenz-Mie form, displaying various kinds of resonant behavior. Second, the previously obtained boundary conditions are generalized to be valid for gyrotropic scatterers. Third, the new boundary conditions are used to derive formulas for the plane wave reflection and transmission coefficients from a gyrotropic metafilm.

Numerical calculations of the reflection and transmission coefficients will be presented. The new theory will also be compared to experimental measurements in waveguide, simulating oblique incidence of plane waves. The measured results show promising correlation to the theory. The results of this study point to the possibility of controlled or "smart" surfaces made with metafilm techniques, enhancing the capabilities of communication systems through the use of nontraditional design methods.

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