Antireflective coatings for high impedance jumps

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It is well known that electromagnetic waves are strongly reflected at the interface between two media with very different wave impedance. For instance, at microwave frequencies, an air-water interface has a strong jump of the relative permittivity from 1 to approximately 80 which causes a low transmittance of 0.36 through the interface. In optics, some metasurfaces formed by plasmonic and silicon nanoparticles have been proposed to avoid the strong reflection (K. V. Baryshnikova et al., Scientific Reports, 6, 22136, 2016). Recently, in the microwave range, an antireflective Huygens' metasurfaces presenting magnetoelectric coupling was located at the interface between two dielectric media (A. H. Dorrah et al., IEEE Transactions on Antennas and Propagation, 9, 66, 2018) to increase the transmission. However, this structure requires a complicated design for each specific jump of the wave impedance.

In this work, we demonstrate the scattering by some simple shapes of the unit cell which also reduces the microwave reflection at the air-water interface. It was demonstrated that subwavelength spheres and cubes made of perfect electric conductor are good candidates. We have developed an effective surface impedance model which can reproduce the result from a full wave simulation. The simulated transmittance is shown in Fig. 1, for cubic and spherical building blocks. The frequency of total transmission as well as the bandwidth of improved transmission can be easily tuned by changing the geometrical parameters. Although the coating was designed for the air-water interface, the same ideas could be used to improve indoor communications through high impedance walls or medical heating treatments.

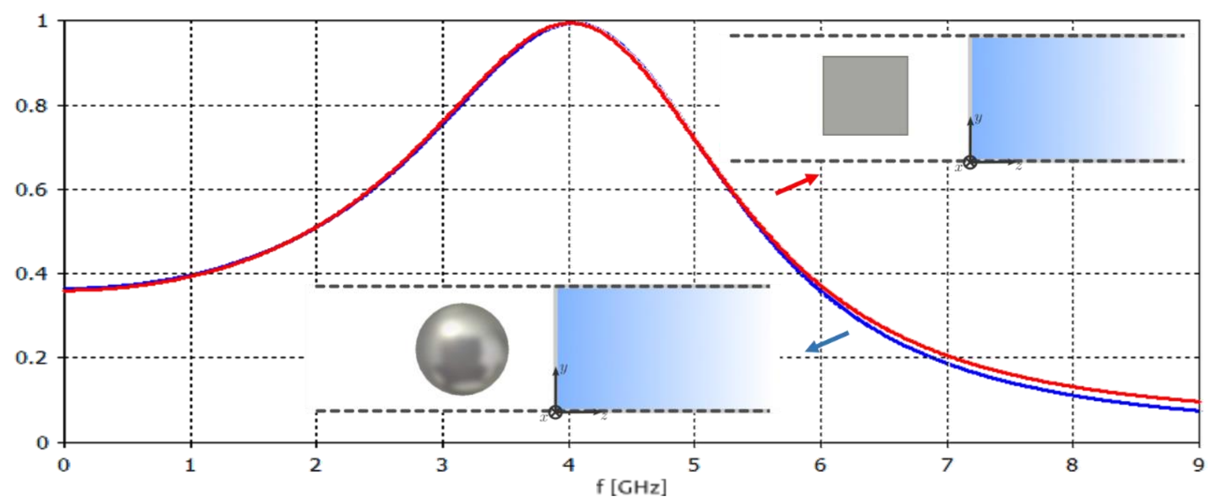

Figure 1. Transmittance vs frequency through an air-water interface coated with an array of cubes of size 7.8 mm (red line) and spheres of radius 4.7 mm (blue line). The coatings were simulated with perfect conductor.