Enhanced Transmission through Metamaterial-Lined Subwavelength Apertures

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In the optical regime, the phenomenon of extraordinary transmission (EOT) through subwavelength apertures has been attributed to the interaction of surface plasmons formed at the interface between two media. This enhanced transmission is also evident in periodic structures in the microwave regime, and has been found to be related to the formation of leaky waves on a corrugated metallic surface (D. R. Jackson, J. Chen, R. Qiang, F. Capolino and A. A. Oliner, vol. 16, no. 26, *Opt. Express* 21271, Dec. 2008). Recently, it was shown that transmission through miniaturized circular waveguides (CWGs) can be vastly improved through the introduction of thin metamaterial (MTM) liners. An HE_{11} mode passband is introduced well below the natural cutoff frequency, in the regime in which the MTM liner exhibits epsilon-negative and near-zero (ENNZ) permittivity (J. G. Pollock, and A. K. Iyer, *IEEE Trans. Microwave Theory Tech*. vol. 61, no. 9, Sep. 2013). The present work offers a novel approach for EOT in the microwave regime by establishing the analogy between transmission through miniaturized MTM-lined CWGs and subwavelength apertures loaded using MTM liners.

This work studies the transmission and reflection properties of square arrays of MTM-lined subwavelength circular holes in a metallic screen. A printed-circuit implementation for the ENNZ MTM liner demonstrates several-fold enhancements in transmission over empty apertures for diameters of fractions of a wavelength at the frequency of interest. The transmission responses also exhibit an antiresonance, observed at a slightly higher frequency compared to the transmission peak, which enables the usage of such MTM-infused screens for narrowband shielding applications. Parametric studies are also performed to evaluate the dependence of transmission and reflection on the angle of incidence and periodicity of the apertures.