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Free-Space Superlensing With Transmission-Line and Related Metamaterial Structures

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Summary

Superlensing is the ability to create an image with fine features beyond the diffraction limit. This can be achieved with a a? Veselago-Pendrya?T lens made out of a metamaterial. A superlens for imaging in free space must be stringently designed to restore both propagating and evanescent waves; meeting these design conditions has proven difficult and has made its realization elusive. We demonstrate free-space imaging with a resolution over three times better than the diffraction limit at microwave frequencies using a quarter-wavelength thick Veselago-Pendry metamaterial superlens. This superlens is made based on the negative-refractive-index transmission-line (NRI-TL) approach, which affords precise control over its electromagnetic properties and is less susceptible to losses than other approaches [1]. Such microwave superlenses can be particularly useful for illuminating and discriminating closely spaced buried objects over practical distances.

We also present a second approach for creating sub-wavelength spots in free space using a a?ometascreena??. This is a metallic screen that is designed drawing on concepts from holography applied in the near field [2]. The screen achieves sub-wavelength focusing by controlling E-field transmission with a closely spaced array of rectangular slits. An experiment using such a simple a?ometascreen has shown an E-field sub-wavelength focusing with a full-width-half-maximum of 0.17I> at an image plane 0.15I> away from the screen an effect which is quite insensitive to material losses. This represents a significant improvement over the diffraction limit.

1. A.K. Iyer and G.V. Eleftheriades, a?oA multilayer negative-refractive-index transmission-line (NRI-TL) metamaterial free-space lens at X-band,a?? IEEE Trans. on Antennas and Propagation, pp. 2746-2753, Oct. 2007.

2. A.M.H. Wong, C.D. Sarris and G.V. Eleftheriades, a?oMetallic transmission screen for sub-wavelength focusing,a?? IET Electronics Letters, pp. 1402-1404, Dec. 2007.