High-Resolution Sub-Surface Imaging in Layered Lossy Media

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Novel electromagnetic (EM) techniques for sub-surface high resolution imaging in layered lossy media are presented in this talk.

First, a general method based on negative refraction imaging in layered lossy media is discussed in detail. This imaging technique involves an antenna array or an active lens with profiled amplitude and phase distribution across its aperture that compensates for dielectric contrast and EM loss inside the imaged medium.

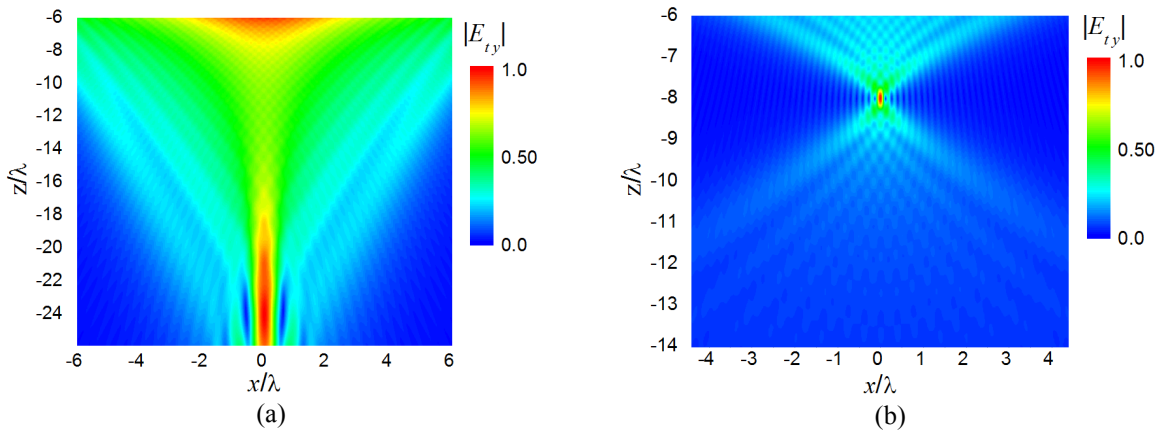

Fig.1. EM dipole source image inside the dielectric half-space with relative permittivity 16. The focal position is at z = -8λ, λ is a wavelength of radiation. Image without (a) and with (b) phase compensation

In general, dielectric contrast at the interface(s) of layered medium leads to significant defocusing and displacement of the source image inside the lossy medium, Fig.1(a). Compensation of the material parameters contrast by means of gradient amplitude and/or phase distribution across the antenna array lens leads to high-resolution image formation in the desired position, Fig.1(b). Analytical closed form expressions of the phase and amplitude gradient functions are derived using Huygens-Kirchhoff principle and approximate near field expressions. These results are applicable to media with arbitrary stratification and material parameters, including lossy materials. The image resolution properties, aberrations due to the dielectric contrast at the interface, particularly EM loss, mechanisms for aberration compensation and the design of the antenna array lens are discussed in detail. The results of the study are of importance in a wide range of imaging problems in layered media for medical, civil, and military applications.

Next, high-resolution near field imaging in lossy media using resonance microwave antennas based on loaded apertures will be discussed. The application of this method is limited to shallow sources/objects however due to simplicity of the measurement hardware, possibility of real-time low-power operation and high resolution contrast the proposed technique may be promising in the areas like non-destructive testing and biomedical imaging. Experimental results demonstrating the application of the proposed technique in a range of realistic imaging scenarios will be presented.