Optimization of Stepped-Waveguide Applicators for the Characterization of Conductor-Backed Absorbing Materials

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It is important to know accurately the electromagnetic properties of radar absorbers for the purposes of design and quality control. These properties often have high manufacturing variability and can change after exposure to severe environmental conditions. Since the materials are strongly bonded to metal surfaces it may not be possible to remove them to perform typical laboratory measurements. The most common technique for homogeneous, isotropic materials is to place a sample into a waveguide and measure the reflection and transmission properties of the material, thereby obtaining sufficient information to determine ε and μ. Unfortunately, the samples are thin, and if adhered to a conductor backing, cannot be placed into the guide in the standard configuration.

The authors recently proposed a technique ("A Stepped Waveguide Technique for the Characterization of Conductor-Backed Absorbing Materials," North American Radio Science Meeting, Vancouver, July 2016) whereby the sample is placed against the broad wall of the guide with the conductor backing in contact with the conducting wall. By adding one or more metallic steps beneath the conductor backing, the sample is raised up so that the material completely fills the remaining space. Analysis of the structure, including the sample, is easily done using mode matching. The authors demonstrated the viability of the technique by designing the steps so that when a representative material is present there is a balance between the transmission and reflection properties of the stepped guide.

A better approach to designing the stepped waveguide structure is to minimize the sensitivity of the extracted material parameters to uncertainties in important measurement variables, such as sample thickness, step height, or S-parameters. In this paper, the stepped waveguide structure is designed to minimize the propagated error due to uncertainties in the S-parameters for a typical commercial radar absorber. A genetic algorithm is combined with a mode-matching technique to find structures that produce low error in the extracted values of both ε and μ. Measurements will be undertaken using 3D printed structures plated with copper.