Evaluation of Anisotropic Overlay Materials for Use in the Free-Space, TEM, or Waveguide Characterization of Conductor-Backed Absorbers

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Absorbing materials are often applied to conducting surfaces to reduce radar cross section. The material properties must be measured regularly to evaluate the effectiveness and possible degradation of the coatings. This may be done in situ using a contact probe or an offset free-space system. In certain circumstances a sample may be removed and placed into a TEM waveguiding system such as a coaxial cable or stripline, or into a TE_{10} mode rectangular waveguide system, with the conductor still attached. If the material has both electric and magnetic properties, two sufficiently different reflection measurements are required to determine both permittivity and permeability.

For probe systems, one simple method for obtaining two reflection measurements is to first measure with the probe directly against the conductor-backed sample, and then to repeat the measurement with a known overlay material placed between the probe and the sample (G. Dester, et al., Progress in Electromagnetic Research B, Vol. 26, pp. 1-21, 2010.) However, this method does not work in the case of free-space, TEM, or rectangular waveguide systems using planar, isotropic samples. It has been shown analytically that even if the material is inhomogeneous in the direction normal to the sample plane (i.e., the guiding direction), then the second measurement provides no additional information about the material properties (R. Fenner, et al., Radio Science, 47, pp. 1004-1016, January 2012.)

In this paper we examine the possibility of using anisotropic materials as overlays for characterizing conductor-backed materials using free-space, TEM, or rectangular waveguide systems. In particular, we show that uniaxial or biaxial overlay materials are ineffective in the same manner as isotropic materials, but that gyromagnetic materials, such as ferrites, do provide the required additional information. We evaluate the potential usefulness of such overlays by comparing the propagation of measurement uncertainty in comparison to standard reflection-only techniques such as the two-thickness method.