A method for the electromagnetic characterization of an unknown sample layered on a known substrate

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Classification of the electromagnetic properties of new materials at microwave frequencies is an important step in the development of devices and systems using such materials. A well known technique, the Nicolson-Weir-Ross (NWR) method, is commonly employed to characterize the complex permittivity and permeability of bulk materials. This technique is founded on an analytic model for reflection and transmission through a transmission line section filled with the material under test. In this paper, the same methodology used in the NWR method is used to develop a characterization technique to identify the complex permittivity and permeability of an unknown sample which is fixed to a known substrate.

An analytic model for the reflection and transmission coefficients for a general section of transmission line filled with the layered sample and known substrate is developed. Expressions for these coefficients are then derived for various practical transmission line configurations. Validation of these expressions is done via comparison of calculated and simulated scattering parameters with various samples. The procedure for extracting the electromagnetic properties of the unknown layer is done discretely at a single frequency, allowing for the possibility of smoothing results for error reduction if broadband characteristics are desired.

Results for a number of materials, including bulk vertically-aligned carbon nanotubes (VACNT) which are grown on a substrate, will be presented. This technique for layered media characterization will be an important tool in the use of new materials in RF applications. The expanded method could also find use in the microwave characterization of deposited thin films or other materials which are inseparable from their substrate.

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