Technique for Fast, Accurate Measurement of Dielectric Properties of EM Materials with Samples of Arbitrary Shape

Isabella Langdon, Martin P Robinson
School of Physics, Engineering and Technology, University of York, UK
issy.langdon@york.ac.uk, martin.robinson@york.ac.uk

Abstract

This paper presents a novel technique for the rapid and accurate measurement of the complex permittivity of electromagnetic (EM) materials using samples of arbitrary shape. Traditional methods for dielectric measurement often require specific sample geometries or large, flat surfaces, which can be limiting for modern materials and applications. Our approach, based on a modified resonant cavity perturbation (RCP) method, allows for the measurement of small, irregularly shaped samples by combining perturbations from three orthogonal modes in a cuboidal cavity named 4M 2.0 (see Figure, right). The technique is validated through measurements on samples of five different shapes, made of various materials, including polymers and woods. Results are presented in the accompanying graph (see Figure, left), which shows the measured dielectric properties of plywood, acetal, balsa wood, and polycarbonate, illustrating good repeatability despite the differing sample geometries. The results demonstrate the effectiveness of the technique in providing reliable dielectric properties at microwave frequencies. This method is particularly useful for characterizing new materials produced by additive manufacturing and for applications in electromagnetic compatibility (EMC) testing. Additionally, the technique has potential applications in archaeological research, where the dielectric properties of materials can help identify and analyse artifacts.

Keywords

dielectrics, cavity resonators, electromagnetic materials, material characterization, Plywood, Acetal, Balsawood, Polycarbonate, microwave frequencies, resonant cavity perturbation (RCP), arbitrary shape samples, EMC testing, archaeological research.