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EFFECTIVE BROADBAND PERMITTIVITY MEASUREMENTS OF GEOLOGICAL MATERIALS

Abstract

It is a commonly held belief that broadband permittivity measurement techniques have great uncertainties in dielectric loss for low-loss materials, which is unfavorable for applications in planetary and asteroid radar mapping. While true, much of the literature has neglected to address in detail how accurate and effective broadband permittivity measurements truly are. Developing an accurate body of knowledge about the permittivity of good analogs aids in placing regolith samples in the appropriate context and thus broadens our understanding of variations in the radar properties of other objects. This is especially of utmost importance for future missions such as OSIRIS-REx, which will be visiting asteroid Bennu in 2018.

In the present study, a procedure was developed to perform accurate and repeatable permittivity measurements for granular materials using a coaxial airline. The dielectric response of materials was determined over a range of frequencies spanning 0.1 – 8 GHz. A 2-port VNA was used to sweep through different source frequencies and tuned to measure the transmitted and reflected signals of a sample-filled 7mm and 14mm coaxial sample holder. The measured reflected and transmitted waves were used to derive the complex permittivity of the sample-filled medium using the NIST Non-Iterative technique. A custom fixture retro-fitted to a sieve shaker was designed and machined as a novel approach for packing granular material into the airline as well as to insure ideal placement of the line's centre conductor. Materials with well-known dielectric properties such as Air, Alumina, Silica, and Rexolite were measured in order to validate the reliability of the laboratory setup, refined sample handling, and measurement procedure. All granular materials were baked in an industrial oven so as to eliminate absorbed moisture. Alumina samples with average grain sizes of 76, 102, 165, 305, 483, 686, and 940 m were individually measured to discover the influence of porosity on permittivity and compared to past studies. It was found that the uncertainty in dielectric constant and loss varied from 0.1 to 0.3 at very low frequencies where the wavelength greatly exceeded the airline length (MHz), and 0.01 to 0.03 at high frequencies (GHz). In rare instances, or when measuring an empty airline, the uncertainties would dip down to 0.002 although this is uncommon. Although the results suggest this as a reliable technique for dielectric constant measurements and are in agreement with past studies, they reaffirm the conclusion of poor accuracy in dielectric loss measurements.