

**Bi-directional Reflectance Distribution Function of Statistically Known
Samples Over 220-500 GHz using a Frequency Domain Based Scatterometer:
Measurements and Phenomenology**

Joshua A. Gordon^{*(1)}, David R. Novotny⁽¹⁾, Edwin J. Heilweil⁽²⁾
Shu Zee A. Lo⁽²⁾, Nina P. Basta⁽¹⁾, Erich N. Grossman⁽¹⁾

(1) National Institute of Standards and Technology, Boulder, CO 80305

(2) National Institute of Standards and Technology, Gaithersburg, MD, 20899

*josh.gordon@nist.gov

We present a frequency-domain system used for characterizing the scatter from arbitrary samples in the frequency range of 220-500 GHz. This system uses a vector network analyzer along with quasi-optical beam shaping components and frequency converters to illuminate and capture scatter radiation providing nominal dynamic range of 90 dB over the 220-325 GHz and 70 dB over the 325-500 GHz band. High-precision motion control of source and receiver, as well as, precision optical alignment techniques allow detailed characterization of scattered electric field and phase from samples. Precision motion control and carefully designed sample mounting allow for a large part of the four-dimensional bi-directional reflectance distribution function (BRDF) of a sample to be accessed. Measurements over a bi-static angle ranging from 205° to 24° with an angular resolution of 0.002° can be made, including mono-static scattering. Out-of-plane angle can be adjusted over the range of $\pm 5^\circ$ at 0.5° increments to increase sample BRDF coverage.

Data collected from this system is used to generate a zoology of scattering phenomenology from real world and canonical samples. Samples with designed deterministic as well as non-deterministic surface topology statistics were used to both validate this system and to further develop scattering models at millimeter and THz frequencies. The results of an inter-comparison with an analogous time-domain (TD) system developed by NIST in Gaithersburg will be presented.

System design and performance details as well as sample data which are compared to both scattering models and the TD system in Gaithersburg will be presented. Examples of different applications for such a system are also presented.