Abstracts

Thin-sample measurements and error analysis of high-temperature coaxial dielectric probes

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A metallized-ceramic probe has been designed for high-temperature broad-band dielectric properties measurements. The probe has been used to make complex dielectric properties measurements over the complete frequency band from 500 MHz to 3 GHz, and up to temperatures as high as 1000/spl deg/C. In this paper, we investigate new aspects of the development and utilization of this high-temperature dielectric probe. The first aspect is related to the results of an uncertainty analysis which was performed to quantify the errors due to the differential thermal expansion between the inner and outer conductors of metal coaxial probes. In this case, a two-dimensional (2-D) cylindrical finite-difference time-domain (FDTD) code was developed and used for this analysis. The obtained results were compared and shown to be in good agreement with error-analysis data based on analytical solutions for the special case when an air gap exists between the probe and the material under test. Additional new error-analysis results show that differential thermal expansions and rough surfaces cause considerable errors in these measurements, and the use of probes of small differential thermal expansions, such as the developed metallized-ceramic probe, is essential for obtaining accurate results. We also used FDTD numerical simulations to help investigate the use of this probe for the nondestructive complex-permittivity measurements of electrically "thin" samples. It is shown that by backing the material under test with a standard material of known dielectric constant, such as air or metal, the complex permittivity of thin samples can be accurately measured. The other new development is related to the use of the developed metallized-ceramic probe to measure the dielectric properties of thin samples at high temperature and over a broad frequency band. With the developed knowledge from the error analysis, and the new FDTD code for thin-sample measurements, the metallized-ceramic probe was used to measure dielectric properties of thin Al/sub 2/O/sub 3/ and sapphire samples for temperatures up to 1000/spl deg/C. This measurement method has important applications in the on-line characterization of semiconductor wafers. Results from the high-temperature thin-sample measurements and the uncertainty analysis are presented.

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