FREE SPACE MICROWAVE CHARACTERIZATION OF Si WAFERS FOR MICROELECTRONIC APPLICATIONS

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ABSTRACT

A contactless and non-destructive microwave method has been developed to characterize silicon semiconductor wafers from reflection and transmission measurements made at normal incidence. Microwave non-destructive testing (MNDT) using free-space microwave measurement (FSMM) system involve measurement of reflection and transmission coefficients in free-space. The measurement system consists of a pair of spot-focusing horn lens antenna, mode transitions, coaxial cables and a vector network analyzer (VNA). The inaccuracies in free-space measurements are due to two main sources of errors. 1) Diffraction effects at the edges of the material specimen. 2) Multiple reflections between horn lens antennas and the sample. The spot-focusing antennas are used for minimizing diffraction effects and we have implemented free-space TRL calibration technique by establishing three standards, namely, a through connection, a short circuit connected to each port and a transmission line connected between the test ports. The TRL calibration is unable to fully correct for multiple reflections between the antennas and sample. Therefore, time domain gating feature of the VNA is used to eliminate multiple reflections.

In this method, the free-space reflection and transmission coefficients, S_{11} and S_{21} are measured for silicon wafer sandwiched between two Teflon plates of 5mm thickness which act as a quarter-wave transformer at mid-band. The actual reflection and transmission coefficient, S_{11} and S_{21} of the silicon wafers are then calculated from the measured S_{11} and S_{21} by using ABCD matrix transformation in which the complex permittivity and thickness of the Teflon plates are known. From the complex permittivity, the resistivity and conductivity can be obtained. Results for p-type and n-

type doped silicon wafers are reported in the frequency range of 11 – 12.5 GHz. The dielectric constant of silicon wafer obtained by this method agrees well with that measured in the same frequency range by other conventional method.