

Electrical Measurements for Electronic Interconnections at NIST

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The National Institute of Standards and Technology (NIST) operates a number of research projects to advance measurement science and technology for the microelectronic industry. Here we will summarize [1], reporting on one component of the NIST program, the fundamental electrical characterization of electronic interconnections through accurate measurement.

Time-Domain Network Analysis

We have cooperated with an industrial partner to apply complete vector-network-analyzer correction algorithms to Fourier-transformed TDR/T waveforms [2]. The result is a fully calibrated time-domain network analyzer (TDNA). It provides frequency-dependent data that agree with commercial frequency-domain network analyzers within 2 % to 3 % from dc to 12.5 GHz. This research not only produced new methodology, but resulted in publicly available software known as *TDNACal* [3].

Transmission Line Measurements for CMOS

NIST has a long-standing effort to develop, evaluate, and compare methods for measuring the characteristic impedance and propagation constant of planar transmission lines at microwave frequencies. Recent work has focused on extending our methods to transmission lines on silicon substrates, which has resulted in improved methods for characterizing these essential and difficult to model interconnection components [4], and has provided the means to test proposed models for transmission lines in commercial CMOS processes.

Lossy Multiconductor Transmission Lines

NIST has developed measurement methods to characterize lossy multiconductor transmission lines; these do not rely on the usual lossless assumptions employed in many characterizations, which assume that the voltages and currents impressed on the conductor by any given mode are frequency independent. The NIST approach measures the frequency-dependent quantities and correctly constructs the total voltages and current on the conductors even in the presence of high loss [5]. Recent work has focused on evaluating measurement errors of the method.

Multiport Network Analysis

NIST has developed multiport measurement systems and calibration algorithms for the frequency-domain characterization of complex multiport electronic interconnections. Our approach is unique in that it allows

multiport probe stations to be corrected with standard two-port calibrations [6], including the most accurate procedure known at this time, the multiline TRL calibration [7].

Dielectric Properties of Thin-Film Materials

The NIST program has produced accurate methods for extracting the frequency-dependent permittivity of thin films from measurements of transmission lines that incorporate them. It is difficult to separate metal and dielectric loss from measurements of the propagation constant alone, since wave propagation is strongly affected by both. The NIST methods circumvent this problem by directly measuring the characteristic impedance of transmission lines as described above [4]. This additional information is used to calculate the line's equivalent circuit parameters, allowing dielectric and metal material parameters to be extracted with little modeling effort [8].

References

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