Current Limitations and Novel Approaches to THz On-wafer Electronic Characterization

Jerome Cheron
National Institute of Standards and Technology, USA
jerome.cheron@nist.gov

ABSTRACT

The recent demonstration of semiconductor-based transistors with improved RF performance in the upper-end band of millimeter-wave frequency band has motivated the RF industry to develop novel instrumentation up to 1.1 THz. However, substantial obstacles emerge as we perform on-wafer characterization in the sub-THz bands. For instance, higher order modes of propagation, radiation, crosstalk, and the influence of the RF probes can degrade calibrations and prevent accurate estimates of measured RF performance of active devices and circuits.

We evaluate the current approaches to on-wafer calibration and device characterization and expose their limitations as we traverse through the millimeter-wave frequency bands. Through comparative studies and measurement verifications, we discuss and validate alternative approaches that considerably reduce measurement errors and significantly improve accuracy in the measured RF performance of active devices and circuits. We demonstrate a novel and robust design method of on-wafer multiline thru-reflect-line (mTRL) calibration standards with measurement verification from 0.1 GHz to 1.1 THz. In addition, we review alternative techniques that are currently being explored at NIST to enable small- and large-signal device characterization with absolute power and phase calibration to sub-THz frequencies. We report our progress and future plans for on-wafer power meters, new design of on-chip phase references and comb generators to 220 GHz, and explore extended electro-optic sampling methods that will enable ultra-wideband signal characterization.