Non-contact Characterization of Terahertz Circuits Using E-plane Probes

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In many terahertz applications, such as astronomical observations, solid-state integrated circuits are mounted into micro-machined split-block waveguides. Although this configuration allows for low RF loss and modular integration, it is not compatible with traditional device testing methods. Typically, integrated circuits are designed and fabricated with contact pads to allow for on-wafer device characterization. However, contact pads cannot couple the RF signal properly from the device microstrip line (or CPW) environment into the rectangular waveguide. For this purpose, an E-plane probe is *either* monolithically integrated with the device *or* wire-bonded onto the contact pads, thus forming a smooth transition between the rectangular waveguide and the integrated circuit. In both scenarios, assessing the device performance with current technology is complicated and/or unreliable. In our proposed approach, we use the waveguide E-plane probes to achieve an efficient transition from the microstrip line (or CPW) to quasi-optics, thus coupling the signal from the DUT to the network analyzer without using contact probes.

Recently, a non-contact testbed has been implemented for millimeter and sub-millimeter wave devices testing (C. Caglayan et al. "IEEE Trans. Microw. Theory Techn., vol.62, no.11, pp.2791-2801, Nov. 2014"). In this approach, the signal from the network analyzer is coupled quasi-optically onto the DUT through a series of focusing elements (mirrors, lenses). Here, we propose to establish an efficient quasi-optical link using the device's integrated E-plane probes. When the chip under test is placed behind a high resistivity silicon lens, the E-plane probes operate as antennas and radiate most of the signal into the dielectric lens. As a result, a microstrip to quasi-optics transition is formed using the same chip layout that will later be mounted into the rectangular waveguide. Multiple calibration standards (e.g. quick offset shorts) are fabricated on the same substrate for on-wafer calibration. Thus, errors stemming from the E-plane probe transition and quasi-optical path propagation can be reliably deembedded.

In our numerical study, we have shown that the integrated E-plane probes can provide excellent microstrip line (or CPW) to quasi-optics transition for at least one waveguide band. In general, the proposed method allows for economical and reliable high frequency characterization (0.1 – 2 THz) of rectangular waveguide circuits. The performance of various E-plane probe configurations will be presented at the time of the conference.