On-Wafer, Non-contact Characterization of Differential-mode mmW and THz Devices and Integrated Circuits

Cosan Caglayan and Kubilay Sertel
ElectroScience Laboratory, Department of ECE
The Ohio State University, Columbus OH 43212

Differential circuit topologies offer key advantages such as improved noise performance, gain, stability and bandwidth. Although commonly used in analog RF and millimeter-wave (mmW) applications, differential terahertz monolithically integrated circuits (TMICs) are emerging to harness the aforementioned advantages for high performance applications (Öjefors et. al, *IEEE Transactions on Microwave Theory and Techniques*, vol. 60, no. 5, pp. 1397-1404, 2012). Nevertheless, on-wafer testing of differential devices and circuits for mmW and sub-mmW applications has long been a challenge due to the fragility of contact-based probes and the requirement for on-chip baluns. Although there are efforts for balun-integrated contact probe tips (Zhang et. al, 2014 *IEEE International Microwave Symposium*), scaling of current prototypes at W-band to sub-mmW range is extremely challenging.

As an alternative to conventional contact-probe testing, we recently proposed a non-contact on-wafer device characterization approach that is both low-cost and wear/tear free (Caglayan et. al, *IEEE Transactions on Microwave Theory and Techniques*, vol. 62, no. 11, pp. 2791-2801, 2014). This non-contact method is based on radiative coupling of standard network analyzer test ports onto the wafer environment of typical monolithic THz devices enabled by planar on-chip antennas integrated with the device. Here, we present –for the first time- new on-chip antenna designs allowing straightforward characterization of differential mmW and THz electronics without the need of an integrated or on-wafer balun structure. With the new differential antenna designs, non-contact GSGSG probing is possible while concurrently suppressing the common mode, thanks to the unique radiation properties of the on-wafer antennas. The common-mode pattern of the new antenna exhibits a null in the broadside direction, thus, any common-more return signal is radiated away from the test-port leading to excellent isolation of the common and differential modes. Experimental performance of the new differential-mode non-contact probes will be presented at the conference.