Monolithic UWB Phased Arrays for mmW and THz Applications

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Increasing demand for ubiquitous mobile connectivity is driving the industry toward the higher RF and mmW bands. To sustain the explosive growth of connected devices, high performance front-ends capable of wideband tuning and multi-beam steering for energy-efficiency are necessary, along with high throughput communication protocols for sustained, high-quality service. As an immediate goal, 5G systems are focusing on utilizing the mmW bands for high capacity fixed and mobile channels for next-generation wireless networks.

In addition to the much increased data bandwidth, the mmW band also offers unique advantages for the antenna front-ends. Thanks to much smaller wavelengths, tiny antennas and even small scale arrays can be readily incorporated into even the smallest of mobile devices and on-chip implementation of such radiators offers substantial cost reduction. Nevertheless, the proximity of a high-power radiator to high-sensitivity receiver circuitry creates obvious challenges. Moreover, strong coupling of on-chip antenna radiation into the substrate results in poor antenna efficiencies, typically no more than 10%. As an alternative, traditional packaging methods, such as wire-bonding, flip-chip and C4 bumps, can achieve higher antenna efficiencies, however, they are quite costly to implement in large scale (Cheema, H.M., and A. Shamim. "The Last Barrier: On-Chip Antennas," *Microwave Magazine, IEEE* 14.1 (2013): 79-91).

We will present an on-chip UWB phased array topology that can be lithographically fabricated on the electronic wafers directly above the transceiver electronics. The array is based on late Prof. Munk's current sheet concept and can be scaled for mmW and THz band applications. The key advantage of the current sheet array is that UWB operation is achieved when the array plane is a fraction of a wavelength above a conducting ground plane that isolates the electronic substrate and minimizes the associated losses. As such, radiation efficiencies over 70% can be achieved over a very large bandwidth, while concurrently allowing for beam-steering. The proposed topology is commensurate with standard (CMOS, BiCMOS, etc.) as well as emerging technologies, such as GaN. More importantly, the proposed structure is simple enough to be realized through standard lithography using SU-8 as the substrate material. Nevertheless, large internal stress in the thick SU-8 films and poor adhesion between metals and SU-8 have been a major fabrication challenges that we recently overcome. We will present the fabrication details and measured performance of the proposed array at the conference.