Next-generation mobile technology (5G) aims to provide an improved experience through higher data-rates, lower latency, and improved link robustness. Millimeter-wave phased arrays offer a path to support multiple users at high data-rates using high-bandwidth directional links between the base station and mobile devices. To realize this vision, a phased-array-based pico-cell must support a large number of precisely controlled beams, yet be compact and power efficient. This paper focuses on concurrent dual-polarized beams and 1.4° beam steering using a scalable SiGe BiCMOS phased-array IC, including scalability of the RFIC+antenna-array solution, increase in the number of concurrent beams by supporting dual-polarization, precise beam steering, and high output power without sacrificing TX power efficiency. The 32TRX monolithic IC is implemented in a 0.13μm SiGe BiCMOS process. The authors would like to thank Christian Baks and Duixian Liu for technical support and Mikaël Wahlen, Ali Ladjemmi, and Adam Malmcrona for management support.

References:
Figure 7.2.1: IC architecture and block level schematic (left) showing the front-end block-level schematic in the inset (top right).

Figure 7.2.2: Conceptual schematic of traditional TX/RX switch (top left) and proposed TX/RX switch (top right) with detailed schematic of the implemented TX/RX switch (bottom).

Figure 7.2.3: Simulations and measurements showing performance ($P_{sat}$, $O_{1dB}$ of TX FE and NF of LNA+switch+PA) with the proposed TX/RX switch compared to simulations of the same with a traditional TX/RX switch across frequency.

Figure 7.2.4: Different measured operating modes of the IC-package module showing simultaneous 16-element RX H/V beams (top left) and simultaneous 16-element TX H/V beams (top right) using 1 IC; and 8 simultaneous 16-element RX beams (bottom left) and 2 simultaneous 64-element TX beams (bottom right) using a 4-IC module.

Figure 7.2.5: Uncalibrated 16-element beam steering precision between $\pm 30^\circ$ with 8dB VGA control (top left); 1 beam steering example at a fixed VGA setting (top right) and one gain-control example at a fixed phase setting (bottom left). Uncalibrated steering angle vs calculated steering angle (bottom right).

Figure 7.2.6: Summary table showing the performance of the IC and sub-blocks (measured on wafer) and antenna module with 4 ICs (measured over the air).
Figure 7.2.7: Annotated die photograph of the IC implemented in 0.13µm SiGe BiCMOS.