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Photonic-Electronic Ultra-Broadband Signal Processing: Concepts, Devices, and Applications

High-speed digital signal processing (DSP) has experienced tremendous performance increases over the last years, primarily driven by massive parallelization of logic operations in large-scale CMOS circuits. This has led to digital processors that would allow for real-time processing of ultra-broadband signals with analogue bandwidths of hundreds of GHz. Generation and acquisition of such signals, however, is still impossible due to limited bandwidth scalability of conventional digital-to-analogue and analogue-to-digital converters (DAC/ADC). This talk will give an overview on our recent progress in the field of photonic-electronic signal processing, aiming at overcoming the bandwidth limitations of conventional microelectronics. Our schemes exploit optical frequency combs for ultra-broadband optical arbitrary waveform generation and measurement (OAWG/OAWM) and leverage ultra-fast electro-optic modulators and photodetectors to transform these waveforms between the optical and the electronic domain. The presentation will cover the underlying concepts, the associated devices, as well as proof-of-concept experiments and application demonstrations. We demonstrated OAWG at bandwidths of more than 300 GHz, OAWM at bandwidths of more than 600 GHz, as well as ultra-broad photonic-electronic ADC with acquisition bandwidths of 320 GHz. We believe that these concepts have the potential to disrupt a variety of highly relevant applications, comprising as high-speed communications, advanced radar systems, or acquisition of ultra-short events in scientific experiments.