Integrated photonics for RF filters

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Photonics is now part of the heart of modern radar systems, with already hundreds of optical links implemented in latest generation of radars. Beside signal transportation, a decisive objective for radar and communication systems is to exploit photonics properties to perform more complex signal processing functions [1].

Photonics has proved for years its remarkable potential for manipulations of optically carried microwave signals, such as delaying, weighting, routing or sampling, which are enabling building blocks for signal processing implementations such as finite impulse response (FIR) filters. A classical multi-tap FIR filter implementation requires to weight time-delayed replicas of an incident signal by both positive and negative weighting coefficients [2]. The incoherent addition of the replicas reconstructs the impulse response of the filter [3,4]. Negative weighting coefficients are however extremely difficult to obtain in an integrated platform and usually requires single-sideband format and optical carrier phase tuning [5]. When the whole system is integrated on a single device, the tap-to-tap optical phase distribution within the chip can be easily stabilized. It is then possible to add the signal replicas coherently in the optical domain and to use the optical phase distribution to program the filter weighting coefficients. These coefficients result from phase interference products and can be arbitrarily positive or negative. In the frame of the ongoing Symphonie project, funded by the French research agency (ANR), we implement this concept on a Silicon On Insulator platform, using a photonic crystal directional coupler network to generate the multiple taps. Each tap then includes a fixed delay section (spiral waveguide) and a tunable delay section (photonic crystal thermally tunable waveguide). In this structure, the tunable delay line is used for the dual purpose of delaying the optically carried RF modulation envelope (the RF signal), and to adjust the carrier optical phase.

References

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