Integrated Microwave Photonics: The evolution from ASICs to Universal Processors

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Integrated microwave photonics (IMWP) deals with the application of integrated photonics technologies to microwave photonics (MWP) systems [1,2]. During the last 5 years, IMWP has become probably the most active area of current research and development in the discipline of MWP [3], capitalizing upon the outstanding progress of integrated photonics in various material platforms such as indium phosphide (InP), Silicon on Insulator (SOI) and silicon nitride (Si_3N_4). In this paper, we will first introduce this topic with special emphasis on its relevant application fields to the community briefly outlining the salient characteristics of available material platforms that can be employed for the implementation of IMWP chips. We will compare the features of more mature material platforms such as InP [4], SOI [5] and Si3N4 [6].

The core part of the paper will be devoted to describe the two salient approaches that are available for the implementation of IMWP chips from a functional point of view. On one hand, we will review the recent progress in Application-Specific Photonic Integrated Circuits (ASPICs), where a particular circuit and chip configuration is designed to optimally perform a particular MWP functionality [2]. Examples on different functionalities recently reported will be presented, including tunable filtering, optoelectronic oscillation, instantaneous frequency measurement, frequency up and down conversion, etc. On another hand, recent progress will be reported on a radically different approach, the universal MWP signal processor architecture that can be integrated on a chip and is capable of performing all the main functionalities by suitable software programming of its control signals [7-9]. This last approach is inspired by the flexibility of digital signal processors, where a common hardware is shared by multiple functionalities through a software-defined approach (or programmability), leading to significant cost reduction in the hardware fabrication. Figure 1 shows a picture of such concept, where the central element is a reconfigurable optical core included after external modulation (represented as an E/O device) and prior to detection (represented as an O/E device). The role of the optical core is to provide the required routing/switching functionalities and also the implementation of reconfigurable processing elements such as FIR/IIR filtering, delay lines and phase shifting operations either in standalone or in cascade configuration.

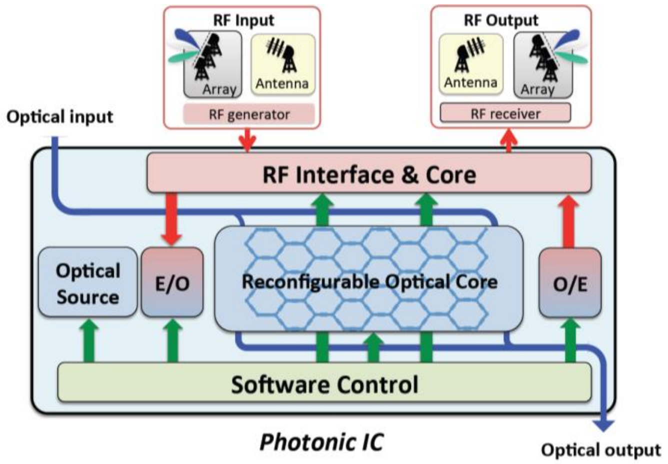

Fig. 1. Reconfigurable Universal MWP signal processor architecture.

The flexible implementation of the optical core requires a design approach based on interconnected waveguide meshes. In particular, we shall address the recent theoretical and experimental progress achieved in our group in Silicon based reconfigurable hexagonal [10] lattices.

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