On the control of reconfigurable photonics integrated circuits

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A collection of control, calibration, tuning and locking recipes for photonic integrated circuits are presented and discussed with focus on tunable, hitless, polarisation independent, optical add drop multiplexing devices and programmable meshes for automatic beam processing.
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1. Introduction

Photonic integrated circuits made of tuneable elements enable the implementation of functions programmable on demand and are being envisioned as the optical counterpart of electronic field programmable gate arrays. Several examples of photonic processors capable of performing arbitrary linear operations have been recently proposed, and are expected to find applications in different areas, from the on-chip processing of telecom signals to microwave photonics, and from quantum optics to neural networks.

In this work, we present the key elements to enable a programmable photonic platform and show their exploitation in two applications. In the first one we use a reconfigurable mesh of silicon photonic Mach-Zehnder Interferometers (MZIs) to manipulate free-space optical beams. We demonstrate beam steering, beam coupling from a free-space optical source to a single mode waveguide and automatic identification of the direction of arrival of a beam from a free-space source. The second one focuses on a novel polarization independent hitless tuning scheme for coupled-resonator WDM filters operating across the extended C-band.

2. Optical Meshes

Fig. 1 shows a triangular mesh of Mach-Zehnder Interferometers, employed to manipulate optical beams. This mesh has a plurality of applications: we used the mesh to demonstrate the steering of a free-space optical beam (using the mesh as a beam forming network) and achieve beam coupling and source identification (using the mesh as receiver). When a beam from free-space or a multimode fiber impinges on the input array, the mesh automatically self-configures by following a progressive tuning scheme [1] to maximize the transmission to port WG1. This feature implies that the mesh can automatically identify the direction from which a beam is arriving and separate overlapped beams or modes.

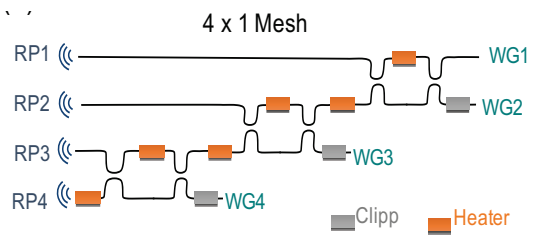

Figure 1 - Schematic representation of a 4 x 1 triangular mesh

3. Polarization independent tunable hitless filter

Fig. 2 shows the top-view photograph of a 4th order ring-based polarization diversity filter implemented on a silicon photonic platform. All the ports of the filter own a Polarization Splitter and Rotator that splits the incoming signal polarizations in two separate waveguides and rotates the TM polarization to have all the waveguides of the circuit operating in TE mode only. The spectral behavior of the filter is almost the same in terms of bandwidth (40GHz), FSR (50nm) and band rejection (16 dB) for both polarizations. A novel disconnection mechanism, to effectively perform hitless tuning and exploiting two p-i-n junctions in the rings has been proposed and demonstrated.

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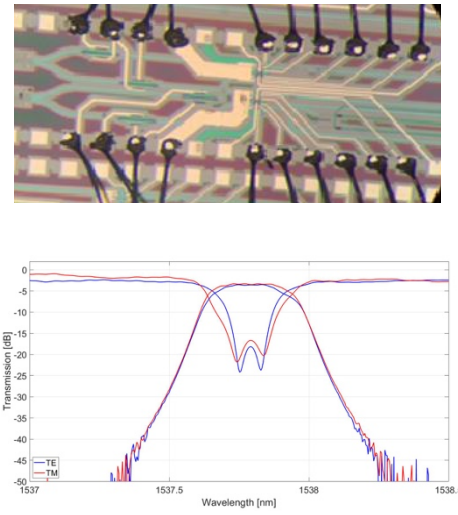

Figure 2 – Photo of a silicon photonics polarization independent hitless filter and its spectral response for the TE and TM polarization