Integrated polarization controller with 40 dB polarization extinction ratio range in the C-Band

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In this work we present a technology-independent highly tolerant tunable polarization controller. The device is implemented in the silicon-on-insulator platform, experimentally achieving 40 dB of polarization extinction ratio (PER) range in the complete C-band, with a Poincaré sphere coverage of 98%. The key benefit of this approach is that a broad PER range is achieved, even when the individual polarization rotators have limited polarization conversion efficiency (PCE) in the range 25-75%. This results in substantially relaxed fabrication tolerances. To the best of our knowledge, this is the highest PER range yet demonstrated in an integrated polarization controller.

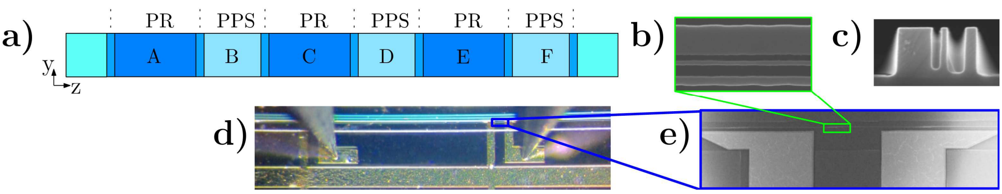

Fig. 1. a) Schematic of the fabricated polarization controller. b) Top-view of the polarization rotator waveguide. c) Polarization rotator waveguide cross-section. d) Gold heaters placed alongside the waveguides. e) Detail of the heaters placement.

Polarization controllers are important for many applications, including telecommunications, polarization diversity circuits and sensing, to name a few. These devices typically comprise two elements: a polarization rotator (PR) and a tunable polarization phase shifter (TPPS). While the latter can be implemented using waveguide heaters, the former require either specialized fabrication processes or a tight control of the fabrication tolerances on the order of a few nanometers [1]. These stringent tolerances hinder the integration prospects of these devices. To overcome this limitation we propose a polarization controller device based on three TPPSs and three PRs, shown in figure 1a.

The device operates as follows: Elements A to E (see figure 1.a), act as a tunable polarization rotator [2], establishing the desired polarization extinction ratio, which is defined as the ratio of power in the vertical and horizontal component, i.e. PER = $(|E_x|/|E_y|)^2$. The last element (F) introduces the polarization-dependent phase shift. Note that practically full coverage of the Poincaré sphere is achieved for polarization rotators with PCE in the range 25-75% (polarization rotator PER in the range ±4.7 dB). This largely relaxes the fabrication tolerances.

Our approach has been experimentally demonstrated in the silicon-on-insulator (SOI)_platform [3]. Figure 1.b,c shows the polarization rotator element. For the implementation of the TPPS we take advantage of the opposite thermo-optics coefficients of the SU-8 (used as cladding material) and the SiO_2. As waveguide heaters we used metal pads (gold), as shown in figure 1.d,e.

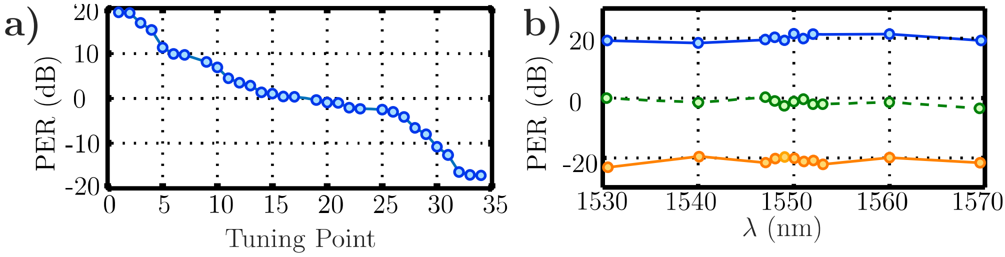

Fig. 2. a) Measured PER at a constant wavelength, a full 40 dB PER range is achieved. b) Solid lines: Maximum and minimum measured PER over the C-band. Dashed line: raw PER of the polarization rotator elements.

Several experiments have been carried out to demonstrate the device operation. First, we have demonstrated that a single TPPS can induce polarization phase shifts in the range 0 - 2π. This has been done by increasing the temperature of the last TPPS and measuring the polarization phase. In the second experiment, we evaluated the PER range, by tuning the first two TPPS. Figure 2.a shows the measured PER for this experiment. A range of 40 dB was achieved (PER = 20dB represents virtually pure TE polarization state, while PER=-20dB corresponds to TM state). Once the performance of the device has been demonstrated at a single wavelength, we have tuned the device for different wavelengths, within the C-band. Figure 2.b shows the maximum and minimum measured PERs over the C-band (solid lines) and the raw PER of the rotator elements (dashed line). Our device thus overcomes the current limitations of a trade-off between integration and device performance in polarization management circuits, paving the way towards the monolithic integration of highly efficienct polarization controllers.

References

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