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Design of integrated, tuneable filters for telecom application

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To increase throughput of mobile data traffic the Comander project [1] proposed a network that merges fibre and wireless solutions. The key component is a Remote Access Unit (RAU) realized as a Photonic Integrated Chip on the Indium Phosphide platforms of Heinrich Hertz Institute (HHI) and Oclaro. RAU chips have been manufactured via the FP7 project PARADIGM. Each RAU combines several tuneable transmitters and receivers. Here we report on the design of the tuneable filter of the receiver circuit for the HHI chip.

According to the chip specifications, the filter should be tuneable in a few nanometre range, offer a 3-dB bandwidth (BW) of 1 nm and an extinction ratio (ER) of 20 dB. Various design configurations have been investigated in a circuit simulator (Aspic [2]) to meet specifications with a small footprint. Figure 1a shows a schematic diagram and a photograph of a 3-stage MZI based filter [3], of which the mask layout was made using OptoDesigner. The same concept was demonstrated in [4], where cascaded MZIs form the intracavity filter of a laser.

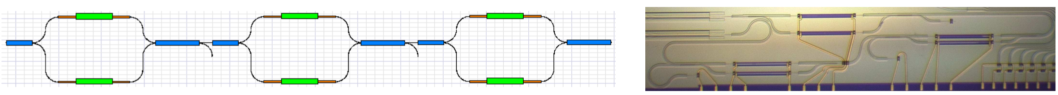


Fig. 67. Schematic diagram and a photograph of a 3 stage MZI based tunable filter.

The filter measures a quarter of the chip size. Each MZI in the cascade is composed of a 1x2 multi-mode interferometer (MMI), a 2x2 MMI and thermo-optic phase modulators. The MMIs have a 50/50 spitting ratio and the FSRs of consecutive stages are 3, 16 and 8 nm. The central wavelength of the filter is 1535 nm. Figure 2a shows the spectral response for the TE polarization of the filter. The extinction ratio between the main peak and side lobes is 7.5 dB and the 3-dB transmission bandwidth is 1.4 nm. The central wavelength can be tuned with appropriate currents of the phase shifters. In order to improve the extinction ratio and the 3 dB BW it is possible to add one more

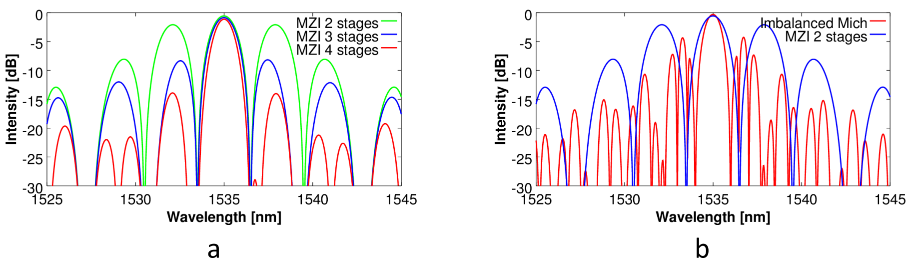
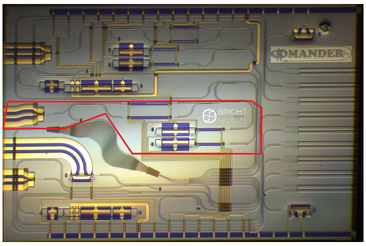


Fig. 2. (a) Spectral response of 2, 3 and 4 stage MZI filters. (b) Response of Michelson filter

MZI stage with an FSR equal to 4 nm. However, this solution increases the size of the filter and adds complexity to its later utilization, as it requires precise tuning of eight phase shifters.

The next approach is based on an asymmetric Michelson interferometer with Bragg gratings in its arms [5]. The filter consists of a 2x2 MMI and two identical 400 µm long Bragg gratings. The imbalance allows to shape the filter response and decreases the 3 dB BW from 2.6 to 1.0 nm as presented in figure 2b. While a combination like this has been tested in SOI [6], an implementation in InP has not been reported.



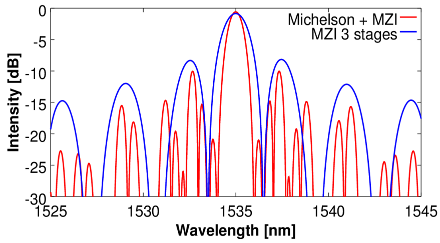


Fig. 68. (a) Photograph of a chip. Tunable filter (cascade of Michelson and MZI) was encircled. (b) Spectral response of the filter.

Figure 2b shows that the Bragg-grating-supported Michelson interferometer offers better performance than a cascade of 2 MZIs. Therefore, in order to reach the required performance, the Michelson interferometer is cascaded with one MZI, as presented in Fig. 3. The device occupies only 10% of the chip. The extinction ratio of the filter is 10 dB and the 3 dB BW is 0.85 nm. Tests in ASPIC have shown that the circuit is sensitive to the waveguide width, which influences the phase and leads to detuning of the MZI and Michelson responses. However, this effect can be compensated by the phase shifters in the arms of cascaded stages, as shown in Figure 4.

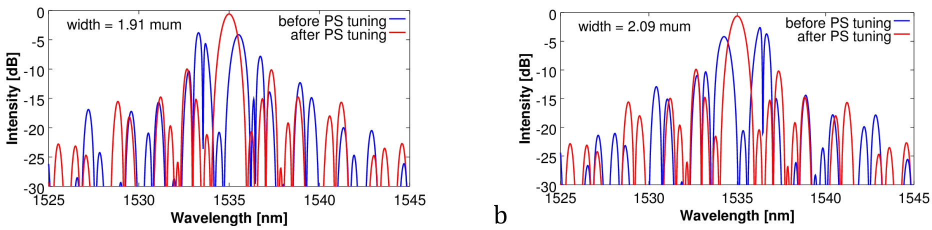


Fig. 69. Tuning the filter response with phase shifters (PS) for different waveguide widths.

Even though the filter does not exactly meet the ER requirement, the concept itself and the small footprint of the circuit was encouraging enough to use the latter filter for the final chip design. A detailed filter characterization will be reported in an upcoming publication.

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