INTEGRATED MICRORINGS FOR ON-CHIP FILTERING AND EFFICIENT FWM GENERATION

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Abstract — **A silicon micro-ring device with tunable four-wave mixing efficiency is presented. The micro-ring is monolithically integrated with a dual polarisation filter based on a cascaded three ring resonator geometry. Four-wave mixing is demonstrated with signal and idler transmitted through the filter with only 1.8 dB of insertion loss. The pump light is rejected with over 62 dB extinction for both TE and TM guided modes.**

Keywords — FWM; High extinction; Ring resonator; PIC

Optical parametric processes such as four-wave mixing (FWM) are the foundation of all-optical switching, multi-wavelength broadcasting, and correlated/entangled photon pair generation for quantum optical systems [1],[2]. Resonant enhancement of these nonlinear effects, particularly in guided wave systems such as silicon micro-ring resonators, can be attained with low optical pump powers and can therefore be included in multicomponent photonic integrated circuits (PICs)[3],[4].

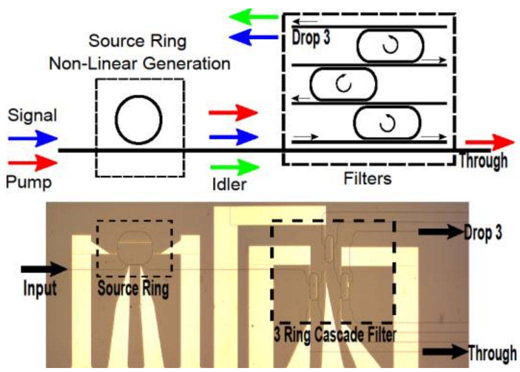

Figure 1: A schematic of the monolithically integrated four-wave mixing source with polarisation insensitive cascade filter.

In order to integrate these non-linear sources with larger PICs it is necessary to optimise the resonant FWM efficiency and the pump light rejection in both TE and TM guided modes. To obtain these goals ring resonators have been used for both FWM efficiency control and pump filtering.

To produce the maximum nonlinear resonant enhancement, the ring resonator should be operated at its critical coupling point. For low-loss waveguide technology the critical coupling value of a ring resonator is of the order of a few percent. The tolerances of nanofabrication techniques can easily change designed coupling values by a few percent. Therefore, to ensure optimal performance a device was designed with a tunable coupler section [5]. By designing the ring to be overcoupled, the device can be trimmed post-fabrication, using tunable evanescent field coupler, to achieve the critical coupling point. A FWM efficiency range of > 20 dB with a peak efficiency of 16.3 dB has been demonstrated.

The filter used to reject the pump light and transmit the signal and idler is a three ring cascade filter designed with tunable resonance wavelengths in order to align the filter with the generated signals. The cascade filter was monolithically integrated with a FWM source ring (as shown in Figure 1). Given the strong polarisation scattering in silicon nanophotonic waveguides, the filter was designed to reject both TE and TM modes at the pump wavelength making use of a polarisation dependent plasmonic filter. Figure 2 shows the results of a dual polarisation filter ring resonator geometry with high rejection over 62 dB monolithically applied to FWM generated light from a separately tunable micro-ring resonator. The device exhibited signal and idler insertion loss of only 1.8 dB, filtering the pump below the limit of the substrate scattering light.

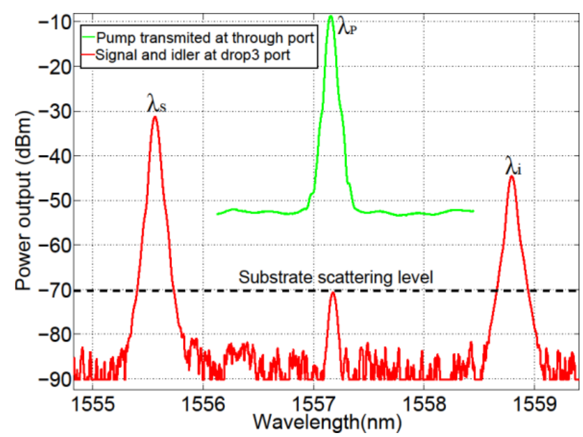

Figure 2: Transmitted pump power at through port (green curve) compared with FWM and pump filtering at drop port respectively (red curve).

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