Impact of waveguide cross section on nonlinear impairments in integrated optical filters for WDM communication systems

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Integrated optical chips enabling the realization of low-cost optical network units (ONU) is of great interest both for data centre solutions and for passive optical networks. In particular, in the frame of passive optical networks an interesting possibility is constituted by the presence, in the ONU of a Wavelength Division Multiplexing (WDM) filter [1] One of the most popular solution is based on a micro-ring resonators. The filter doesn't introduce any relevant impairment in the downstream signal, as the optical power reaching the ONU, at the resonant wavelength, is generally so small that nonlinear effects can be generally neglected. Nevertheless, if the upstream signal, that generally has a much higher power, has to pass through the same resonator can undergo nonlinear effects like two-photon absorption (TPA), free-carriers absorption (FCA), and free-carrier dispersion (FCD) [2]. In this abstract we show the results of an experimental analysis we carried out in order to investigate the impact of optical nonlinear effects in WDM integrated micro-filters exploiting different designs (double- and triple- resonators structures, racetracks, rings, curved coupling regions, etc…) and exhibiting significantly different waveguide cross-sections (from 500 × 220 nm to 825 × 100 nm). The nonlinear behaviour evaluation has been carried out by performing two different sets of experiments. In the first one the amplified spontaneous emission emitted by an Er-doped fiber amplifier was filtered (by using a tunable filter with 5 nm band-width) and then amplified and then input by grating-assisted coupling to the filtering structures. Changes of filter transfer function were observed as a function of the input power. Conversely, in the second setup a narrowband CW-laser was used, and the behaviour of output power as a function of the input power was recorded.

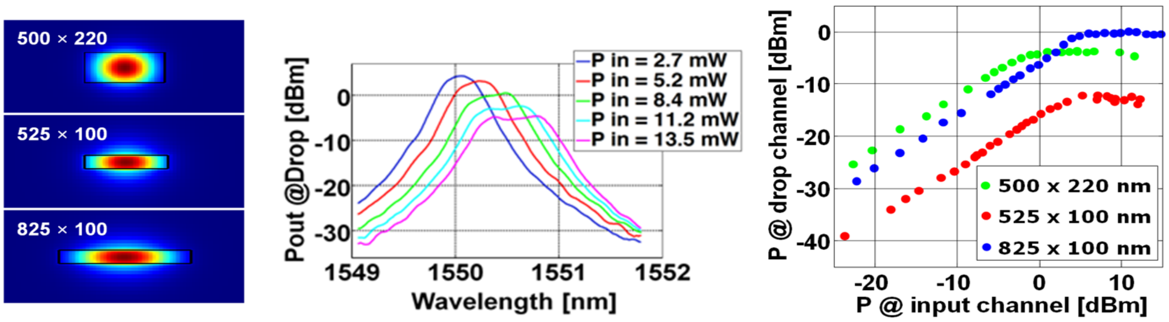

Fig. 1 Left: Optical fundamental-mode intensity distribution in the three waveguides used to realize the integrated filters. Center: example of transfer function deterioration (loss increase and band broadening) caused by optical nonlinear effects. Right: curves of output power as a function of input power for filters exploiting the three different waveguides (500 × 220, 525 × 100 and 825 × 100 nm, in green, red and blue respectively)

The obtained results clearly highlight that even when moderate optical power (e.g. 0 - 3 dBm) is present on the chip, the resonating filter performance can be severely degraded by the two-photon absorption and by the accumulation of free carriers in the waveguide structure. Interestingly, the use of waveguides with a reduced-height, which have been extensively reported in the literature to allow a significant reduction of propagation losses, also show an increased saturation-power with respect to the standard (500 × 220 nm) waveguide cross-section. We believe that this behavior can be related to the reduced height of the waveguide: as recombination centers are mainly located on the waveguide surfaces, the use of a reduced-height structure allows for a faster free-carrier recombination. Indeed free-carriers travel for less than half of the length required in standard waveguides before reaching the surface. Further measurements on additional structures, including both measurements with modulated signals (to evaluate also the impact of self-phase modulation) and measurements of free-carriers recombination time are currently on-going.

References

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