INTEGRATED TE/TM GRATING FILTERS WITH HIGH EXTINCTION RATIO

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***Abstract* — An analysis of sidewall grating filters with sinusoidal perturbation is presented. Measurements indicate that the maximum extinction-ratio of the filters is limited by the polarisation scattering in the waveguide. We show that TM polarisation absorbers and filters offer a simple design solution that can provide extinction ratio values up to 60 dB.**

Keywords — Silicon-on-Insulator, Bragg gratings, Optical filter

Integrated optical filters such as Bragg gratings are widely used in silicon-on-insulator technology for telecommunications [1], signal processing [2] and quantum photonics [3]. Such filters offer high extinction ratios and accurate control over the grating stop-band and central wavelength. Furthermore, this design benefits from simple fabrication processes since the gratings and the waveguides can be defined during the same lithography and etching process (see Fig. 1a). However, a major drawback in highly confined waveguides is the polarization scattering, which limits the maximum achievable filter extinction [4]. Grating geometries that can reject both the TE and TM polarization offer a simple route for the design of gratings with far better performance.

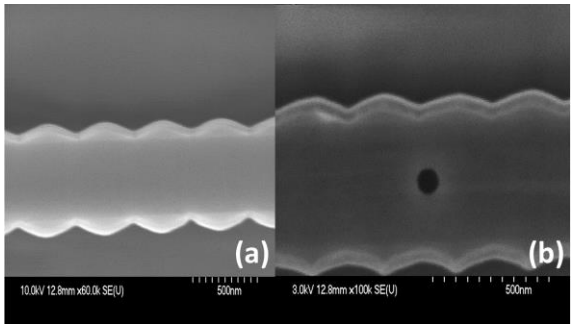

Figure 1*: SEM images of a silicon-on-insulator waveguide with (a) a sidewall grating, and (b) a sidewall/top grating.*

The SOI waveguides investigated in this work consist of a standard silicon core with height of 220 nm and width of 500 nm. The devices were fabricated with standard silicon photonic fabrication processing and the gratings were defined as a sinusoidal perturbation on the waveguide sidewalls. Several sidewall grating devices with varying lengths L and grating strengths k were fabricated and assessed. As expected, experimental results show an increase of the extinction-ratio with the kL product until the extinction-ratio saturates to a value of 30-35 dB (Fig. 2). Further analysis of the output signal indicates that the residual signal inside the stop-band is mostly TM polarised. Because the TM mode profile has a much wider extension in the vertical direction, it can be efficiently absorbed by a metallic layer deposited on top of the waveguide upper cladding [5]. The metallic layer absorbs the TM polarised mode by approximately 20dB, increasing the extinction-ratio to values approaching 60 dB (see Fig. 2).

A further increase of the extinction-ratio can be achieved with gratings designed to filter the TM polarised mode. To this end, top surface relief waveguide gratings provide an interesting solution as they strongly interact with the TM mode with a negligible influence on the TE polarised mode (see Fig. 1b) [6].

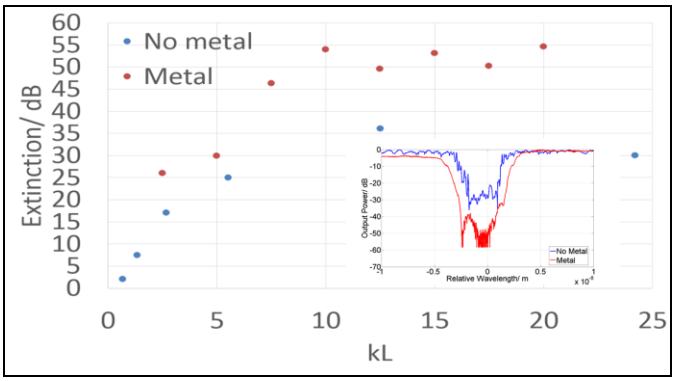

Figure 2: *Transmitted power against the kL product for devices with sidewall gratings only (blue line) and sidewall gratings with a metallic layer deposited on top of the upper cladding (red line).*

In summary, we have investigated the limitations on the extinction ratio of side-wall gratings. These devices show a limited extinction-ratio in the order of 35 dB because of the strong polarisation scattering that occurs in high refractive index waveguides. The addition of a TM absorbing metallic layer on the waveguiding structure provides an increase of the extinction-ratio to nearly 60 dB. Further improvements in the rejection of the scattered TM polarised mode and in the extinction ratio are expected with a combination of sidewall and top waveguide gratings, which are currently being assessed. Because of the very different interaction with TE and TM polarised light, the integration of top and sidewall gratings offers a powerful and flexible design approach to independently manipulate the polarisation state of the propagating light on-chip.

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