

Reducing optical losses in focused-ion-beam etched silicon

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Silicon-on-insulator is rapidly emerging as the material system of interest for future photonic devices for the consumer market. Optical lithography with 248 nm and 193 nm UV lithography on wafer scale is the ideal tool for volume production of photonic components [1]. However, due to the cost of masks and processing it is expensive and often slow to fabricate prototypes of new device concepts with optical lithography.

Therefore one needs prototyping technologies that enable rapid and flexible fabrication of nanophotonic components. The best example nowadays is electron beam lithography. One of the inconveniences however, is the fact that electrons can not directly etch a semiconductor. Therefore one has to work with resist layers and etch with the conventional tools such as plasma etching. This slows down the optimization process and limits the designs to planar structures. An interesting alternative is focused-ion-beam (FIB), where a beam of ions is used instead of an electron beam. In current commercial systems the particle optics enables local sputtering with a spot smaller than 10 nm, enabling fabrication of devices with a smallest feature size < 50 nm [2].

However, it was reported that FIB etching generates high optical losses in silicon [3]. We propose iodine enhanced etching and annealing at high temperatures as techniques to reduce these optical losses after FIB etching. The best results were obtained for 2 hours annealing at 1000°C: optical losses are reduced from several thousands to less than 100 dB/cm; for a typical device length of 10-100 μm the losses will thus be reduced to 0.1-1 dB, which is a tolerable value for most now device concepts.

1. S. Selvaraja, P. Jaenen, S. Beckx, W. Bogaerts, P. Dumon, D. Van Thourhout, R. Baets, LEOS Annual Meeting 2007, United States (2007)
2. W. C. L. Hopman, F. Ay, W. B. Hu, V. J. Gadgil, L. Kuipers, M. Pollnau, and R. M. de Ridder, *Nanotechnology* **18**, 195305 (2007).
3. J. Schrauwen, D. Van Thourhout, and R. Baets, "Focused-ion-beam fabricated vertical fiber couplers on silicon-on-insulator waveguides," *Applied Physics Letters* **89**, 141102 (2006).

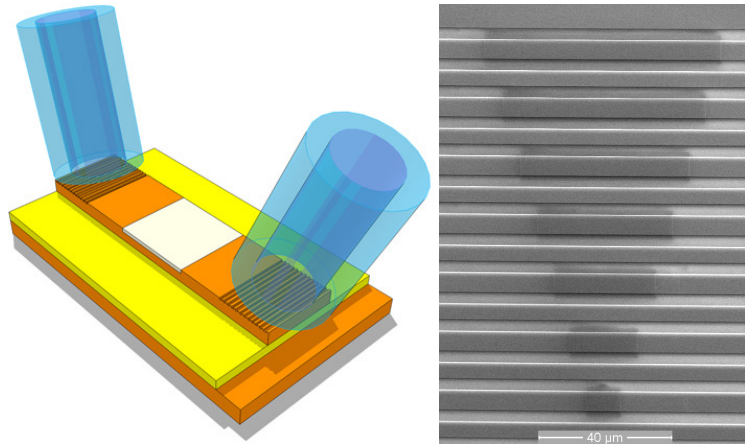


Fig. 1. Left: Principle of the experiment: implantation and etching of prefabricated waveguides; light is coupled from fibers by vertical grating couplers. Right: SEM micrograph of implantations on varying length sections.

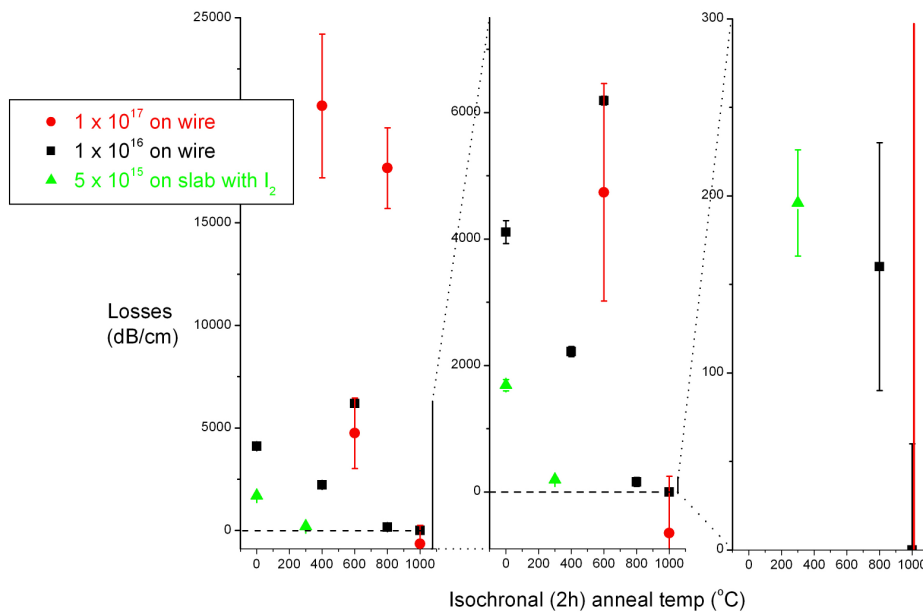


Fig. 2. Optical losses extracted from transmission measurements on wire and slab waveguides. The losses can be reduced to practicable values by both annealing at high temperatures and/or using iodine etch.