Development of Broadband, Polarization Insensitive Light Couplers for a SOI Based Integrated Optics

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The growing demand for quickly transporting big amounts of data within and between Si integrated circuit chips will hit the limits set by data transfer rates achievable with *electrical* inter-connects in the near future. Intra- and inter-chip *optical* data transmission is regarded as one of the most promising future strategies for providing sufficiently fast data channels. Thus, large efforts are spent world-wide to the development of a Silicon On Insulator (SOI) based optoelectronic platform [1]. Besides the challenges faced in the development of efficient Si based light sources, detectors and fast modulators for integration, also reliable interfaces between optical fibers and chips are required.

In our work, we develop interfaces for efficiently coupling light from optical fibers into SOI based integrated optical circuits that are both interesting for research as well as for commercial applications. The emphasis is devoted to couplers with high efficiency over a broad wavelength region (from 1400 nm to 1600 nm) and for all directions of polarization. From thorough simulations, “inverted taper” structures (see Fig. 1 for a schematic) have been identified as most promising structures satisfying these demands while keeping the overall dimensions of the coupling device as small as possible. A detailed discussion of the working principle is presented that shows the matching the modes of the incident beam of light to the input of the coupler and then transforming the modes to fit the single SOI-waveguide mode at the end of the structure. We show that it is crucial to optimize the dimensions at the start and the end of the tapered waveguide according to “mode coupling” calculations for maximum coupling efficiency.

For the fabrication of our structure we use a combination of optical lithography and electron-beam lithography, exploiting the advantages of both techniques for optimal results. While optical lithography is used to quickly define waveguides over a wide working area, electron beam lithography allows to further alter and “fine-tune” the dimensions of the structures with a very high precision. Aside from this “mix and match” technique, which will also be used to define resonators, inter-chip couplers, feedback structures and devices for light amplification and detection with pinpoint accuracy, we also plan to further increase our range of possibilities for the fabrication of our samples by using nano-imprint technology.

References

[1] see for example L. Tsybeskov, D. J. Lockwood, M. Ichikawa, Proc. IEEE **97**, 1161 (2009) and references therein.

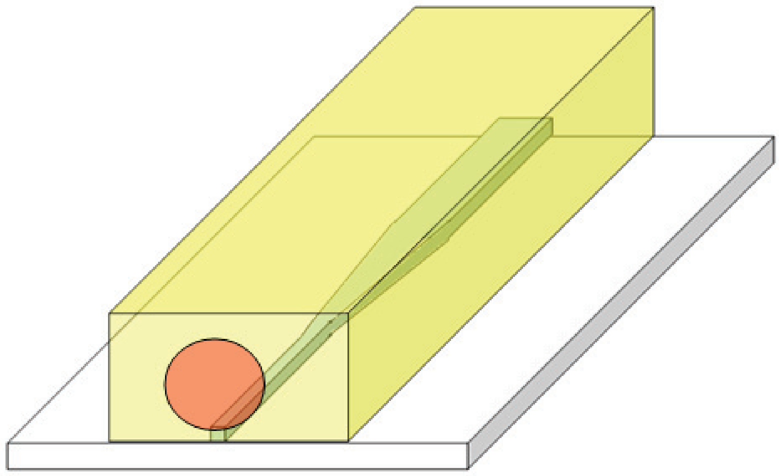

Fig. 1: Schematic of the proposed structure. Light from a lensed fiber is launched at the facet of an injection waveguide sitting on top of the “inverted taper”, which then transforms the light to fit the SOI waveguide mode at the end of the structure.