Photonics and Microwave Engineering

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High Efficiency Grating Couplers for Silicon-on-Insulator Photonic Circuits

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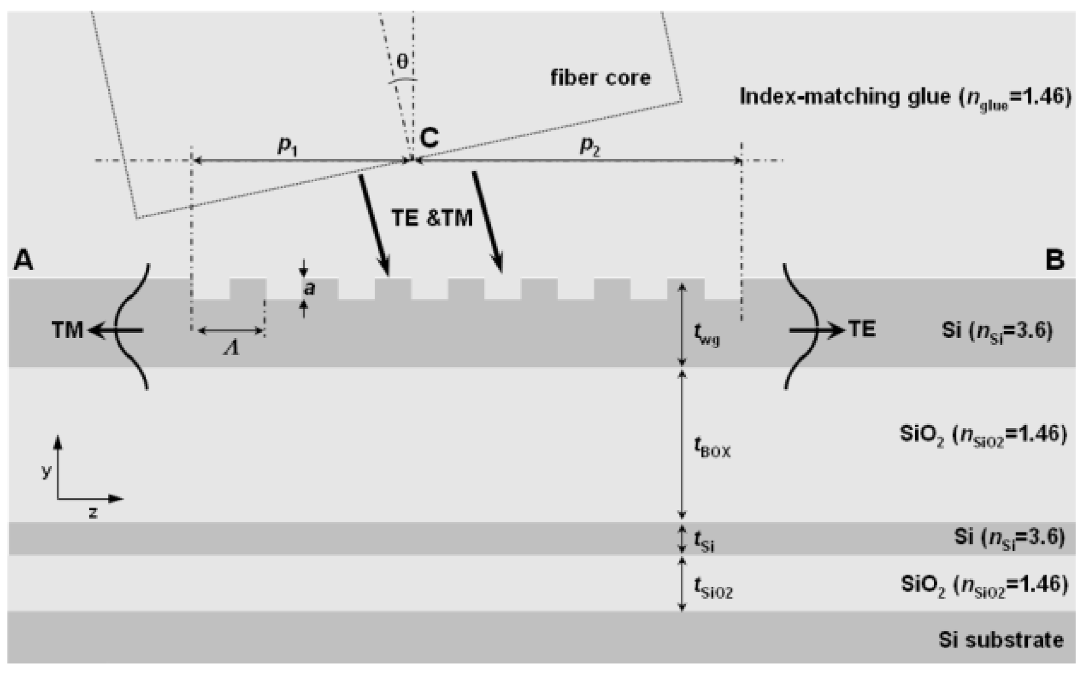
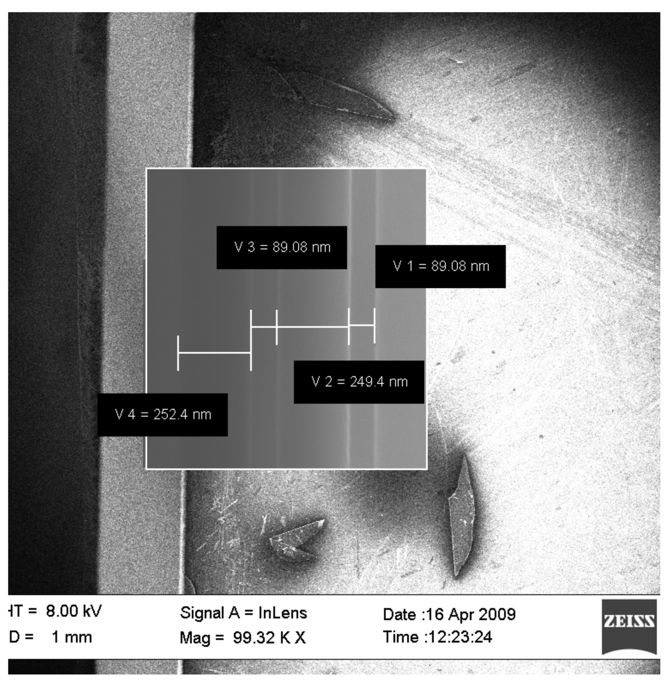
We have experimentally demonstrated two methods for improving the waveguide-to-fiber coupling efficiency of grating couplers. A grating coupler-polarization splitter is measured to have over 50% efficiency for both polarizations. 68% efficiency for single polarization is achieved by a nonuniform grating coupler.

Bragg reflector-assisted grating coupler for polarization splitting

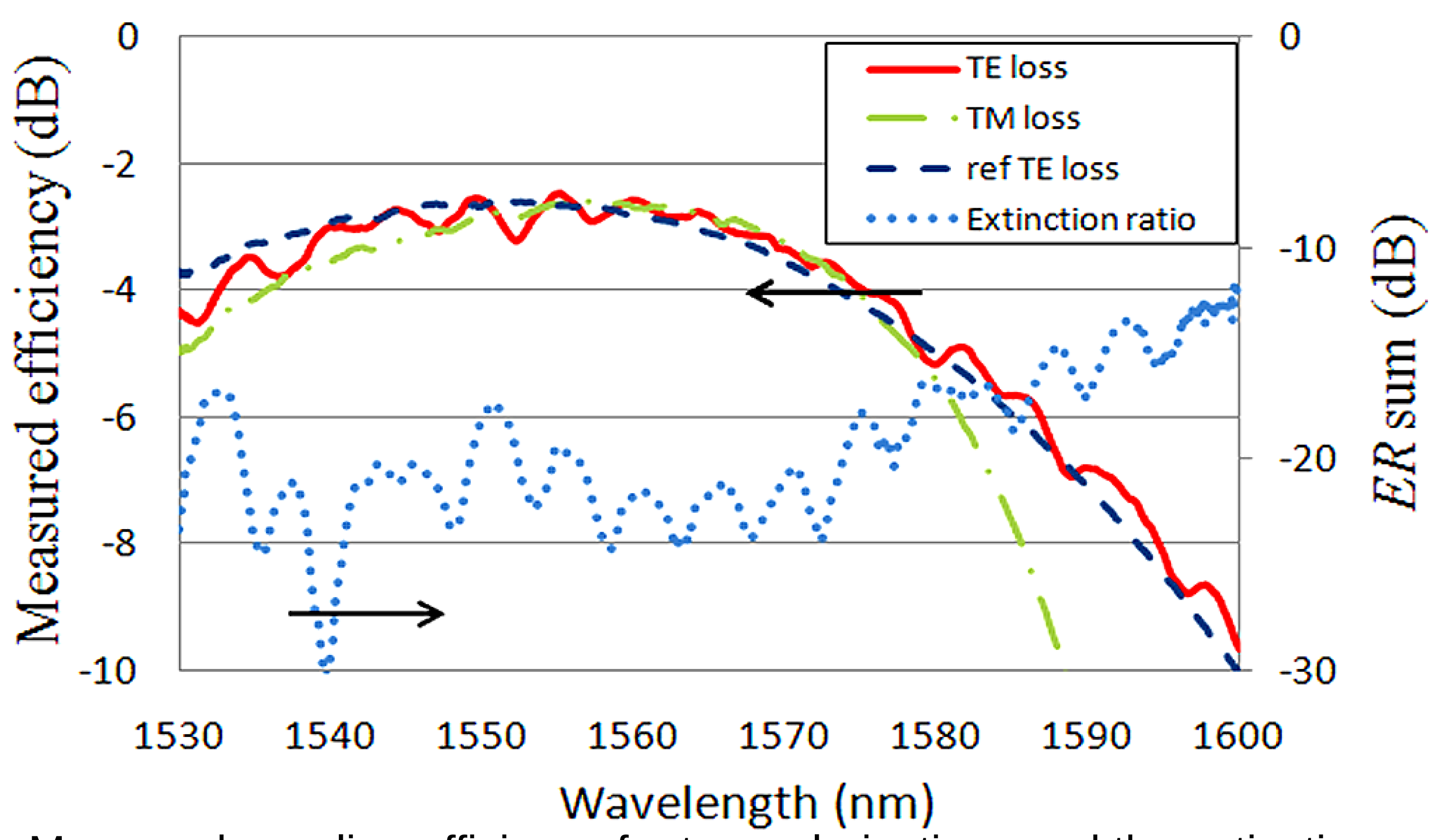
Beside light coupling, grating coupler can also perform as a functional element. We proposed to use a one-dimensional grating coupler as a polarization splitter. By coupling the two input polarization components into two optical modes that propagate in opposite directions, we can realize polarization splitting by a single grating. In order to improve the efficiency further, we propose here a Bragg reflector to reduce the substrate leakage. The Bragg reflector underneath consists of a high index amorphous Si (αSi) layer and a low index SiO_2 layer.



Proposed grating coupler serving as a polarization splitter



SEM photo of the fabricated Bragg reflector



Measured coupling efficiency for two polarizations and the extinction ratio between them.

The fiber was placed at the optimal position for TE polarization coupling. We can find that over -2.8 dB (52%) coupling efficiencies are obtained for both polarizations and the 3 dB bandwidth is about 65 nm. In order to remove the influence of the waveguide loss and the Fabry-Perot cavity, we fabricated a reference structure in which two grating couplers are directly connected by a 12 μm wide waveguide. The measured efficiency spectrum of TE polarization agrees well with the previous experimental results.

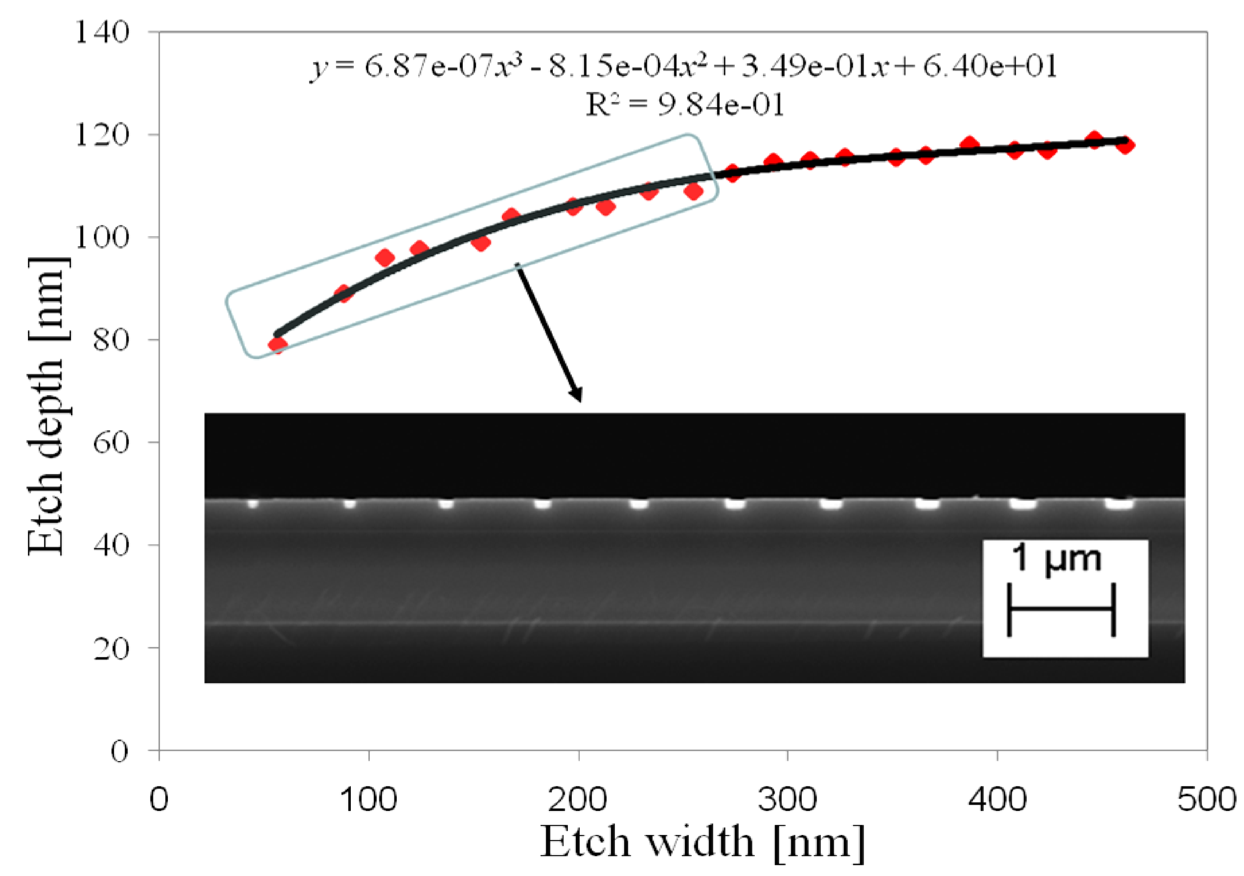
Z. Wang et. al., “Experimental Demonstration of a High Efficiency Polarization Splitter based on a One-Dimensional Grating with a Bragg Reflector underneath”, IEEE Photon. Technol. Lett., 2010 (to be published)

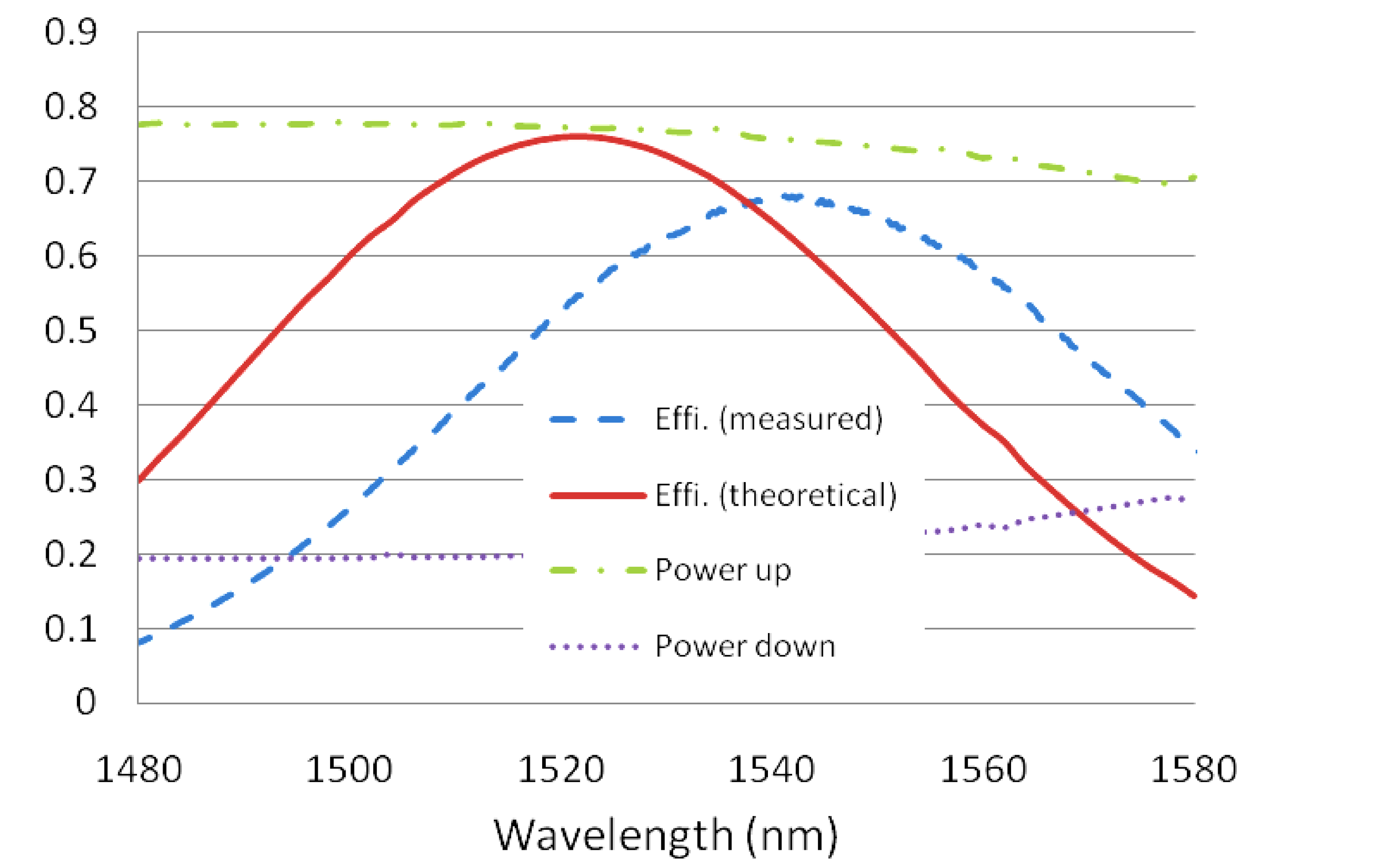
Nonuniform grating couplers

One of the ways to increase the coupling efficiency of a grating coupler is matching the radiated light distribution with the optical fiber mode. We use nonuniform gratings to optimize the leakage factor distribution along the grating, making perfect matching between the radiated light distribution and the fiber mode.

Lag effect of the ICP-RIE dry etching.

Inset: SEM picture of the cross section of the testing sample





Theoretical and measured coupling efficiency for TE polarization, as well as the calculated power radiated upwards and downwards

The nonuniform grating is assembled based on the leakage factor distribution and then slightly tuned by using genetic algorithm to achieve a maximum coupling efficiency. The grating coupler is designed for TE polarization. Due to a shallower etch depth, the measured center wavelength moves to 1540 nm. However, we still get a 68% maximal waveguide-to-fiber coupling efficiency, which approaches the theoretical design. Maximal coupling efficiency is achieved at 1520 nm. Besides, the 3-dB bandwidth is measured to be 70 nm

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