Fabrication of SOI Waveguide Based Photonic Devices

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Abstract:
Electronic-photonic integrated circuits (EPICs) will enable some exciting new applications such as inter-/intra-chip optical interconnects, free-space optical wireless communications, ranging/locating, and imaging. Our research focuses on how to seamlessly integrate photonic devices (lasers, photodetectors, waveguides, modulators, micro-lens, micro-mirrors and others) together with ultrafast electronics. As the first step in our EPIC research, we have fabricated silicon-on-insulator (SOI) waveguides using conventional photolithography.

Summary of Research:
Because the top silicon thickness of our SOI wafer is 500 nm, the rib waveguide structure is chosen to satisfy the single mode condition. The resolution of photolithography limits the minimum width of the waveguides to be around 600 nm using Autostep200. Therefore, the nominal width of our waveguides is designed to be 600 nm. After lithography, top silicon is etched by CF$_4$ using reactive ion etching (RIE). According to our simulation, 150 nm etching depth is chosen for a 600 nm wide single mode rib waveguide. Figure 1 is a scanning electron microscope (SEM) image showing the fabricated silicon rib waveguide. We also tried different widths of the waveguides, changing from 500 nm to 1.2 µm with a step of 100 nm. The dimensions of the fabricated waveguides match with the design values. The sidewalls show some footings at the lower corners of the rib, which are transferred from the photoresist shape in photolithography.

We also fabricated rib waveguides with 90° bends. The bend radius is chosen to be 100 µm for a relatively compact device. The FDTD simulation shows a 90°,
100 µm radius bending loss to be 0.65 dB for a rib cross-section of 600 nm width, 500 nm height and 150 nm etching depth. Figure 2 shows part of a 90° bend. We can see the sidewall of the rib has some undercut and is relatively rough due to CF₄ RIE. This will result in a high propagation loss of the waveguides, but can be reduced by thermal oxidation later. The measurements are still in process at the time of this submission.

References:

