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Development and fabrication of V-grooves on silicon for autoalignment of optical fibers to integrated photonic devices

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Abstract
The objective of this project is to fabricate V-grooves on silicon and use them for the alignment of optical fibers to integrated photonic devices. Anisotropic wet etching will be employed. Subsequent alignment tests will be performed.

Key words:
V-grooves, optical fiber, alignment

Introduction

The recent rise and development of photonic devices have created a need for efficient alignment techniques of optical fibers to integrated devices. The Device Research Laboratory (LPD) – IFGW-UNICAMP currently uses micropositioners for alignment. This project aims to develop and fabricate V-grooves as an alternative method. The grooves will be fabricated on silicon wafers, using anisotropic wet etching. After, fiber-to-fiber coupling tests will be run to test the efficiency of the grooves for aligning.

Results and Discussion

The V-grooves were fabricated on a (100) oriented Si wafer with a thermally grown 500 nm layer of SiO_2 on top of it, using the following steps:

1. Through a spinner, photoresist (AZ3312) is spread uniformly over the wafer. This material is sensitive to UV radiation;
2. A mask with 100 μm wide stripes is placed on the sample. It lets UV light go through the stripes and protects the rest;
3. The sample is exposed to UV light;
4. The mask is taken off and, through a process called revelation, the exposed parts of AZ3312 are removed;
5. The SiO_2 layer suffers an isotropic etching of HF using the photoresist as mask, exposing the silicon;
6. Using SiO_2 as mask, the Si suffers an anisotropic etching of KOH, forming a V-groove due to the selectivity of the etching for the crystalline planes;
7. Finally, the rest of the SiO_2 layer is removed with HF.

The fabrication is illustrated in image 1.

For the fabrication it was necessary to characterize the etching rate of both HF and KOH. For both substances, four samples were etched in different times and then a linear fit was made of those points in a graph of etching depth versus time. The rate obtained for HF was 127 ± 4 nm/min and for KOH was 2.09 ± 0.08 μm/min. Then, using these rates, the V-grooves were successfully fabricated.

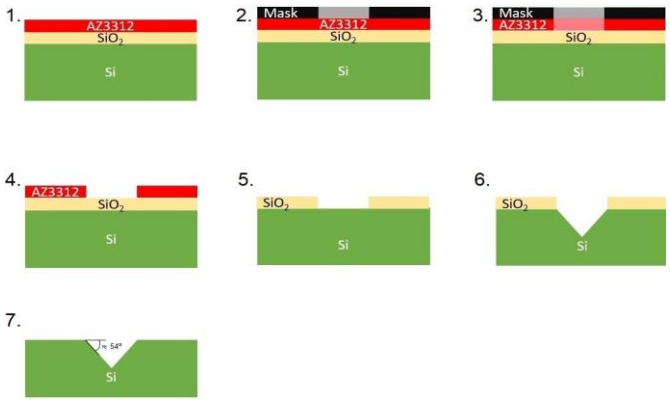

Image 1. Illustration of the process. The pink region on step 3 represents the area exposed to the UV light.

The project is still ongoing, and the fiber-to-fiber coupling tests using V-grooves are yet still to be done. Two optical fibers will be coupled using micropositioners and then the same fibers will be coupled using V-grooves. Both efficiencies will be compared.

Conclusions

The project has been developed to implement V-grooves as an effective technique for autoalignment of optical fibers to photonic circuits. In order to fabricate the V-grooves, KOH and HF etching was employed. Etching rate for KOH and HF were determined as in 2.09 ± 0.08 μm/min and 127 ± 4 nm/min, respectively. The first V-grooves were successfully fabricated and characterized by optical microscopy.

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