Sidewall Channel Fabrication Using Membrane Projection Lithography and Metal Assisted Chemical Etching (Invited)

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Horizontal, enclosed nanochannels have interesting potential applications in nanofluidics, nanobiotechnology, DNA sensing, photonic crystals, and optical waveguides[1,2]. But, despite recent advances in top-down nanofabrication technologies not a lot of research has been focused on Si nanochannel fabrication. In this report, we employ membrane projection lithography (MPL) as used by Burckel et al., to obtain 100 to 400 nm features on the sidewalls of the 2µm deep silicon trenches and then apply metal assisted chemical etching (MacEtch) to obtain Si nanochannels[3].

MPL uses a standard planar lithography technique combined with a sequence of processing steps to create features on vertical sidewalls. Previous reports on sidewall patterning indicate that it is very difficult to obtain sidewall features and that either the substrate has to be tilted or the incident light has to be deflected; the complexity rises if the sidewalls are narrower or the features are smaller[4,5]. MPL gives an effective way to do sidewall patterning and when combined with metal assisted chemical etching, it can be used to obtain 3D Si nanostructures such as horizontal Si nanochannels as reported here.

The basic premise behind MPL is to create a patterned membrane positioned over a cavity, and then use directional metal evaporation through the membrane to deposit instances of the membrane pattern on the sidewall of the cavity[3]. In this report, we are using Deep Reactive ion Etching (DRiE) to create 2µm deep Si trenches, which is then planarized by spin coating and back etching a coating of LOR-20B. E-beam lithography with ZEP-520A resist was used to form the features on the membrane material above the Si trenches. The combination of LOR-20B and ZEP-520A since LOR-20B is compatible with the ZEP-520A developer o-xylene. LOR-20B was then washed away using MF-319 developer and the sample was dried using critical point drying to obtain the free-standing ZEP membrane on top of Si trenches. Directional evaporation of Au at 45° was done using e-beam evaporator to deposit 20nm thick metallic pattern on the Si sidewalls. Finally, lift-off of the membrane yields the desired structure. Metal assisted chemical etching, which is a wet etching process using the catalytic activity of noble metals (Au) to etch silicon beneath it, in a mixed solution of an oxidant (hydrogen peroxide (H_2O_2)) and an acid (hydrogen fluoride (HF)) is used to etch patterns on Si sidewall[6]. Figure 1 illustrates the step by step process flow to obtain horizontal Si nanochannels. Figure 2 shows SEM images at various stages of the process.

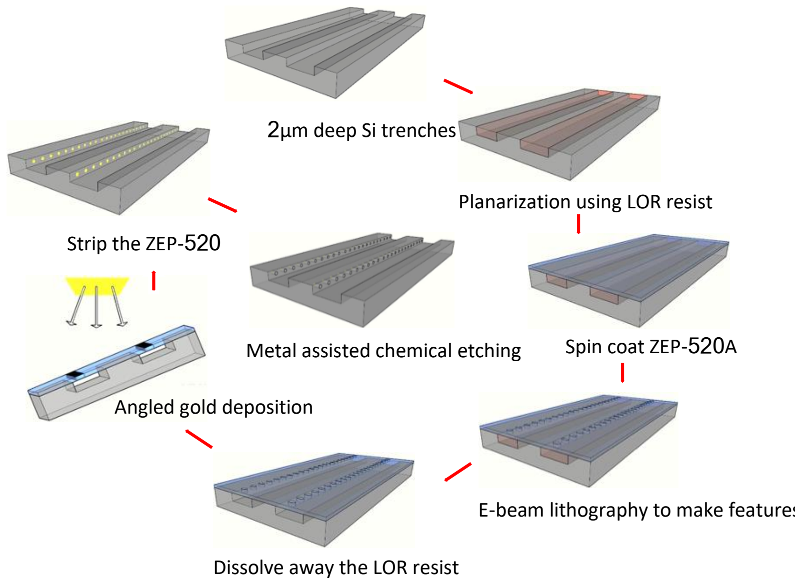

Figure 1. Illustrations of the process.

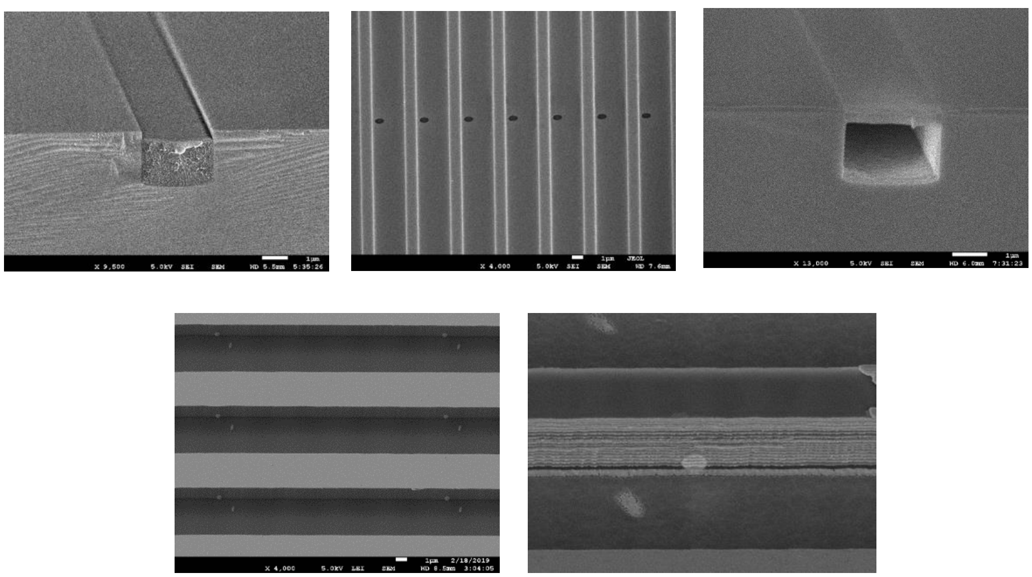

Figure 2. SEM images showing (a) planarized Si trench using LOR-20B; (b) patterns on ZEP-520A membrane; (c) hollow cavity after removal of LOR-20B; (d) gold pattern deposited on Si side wall; (e) closer look showing gold patterns.

References:

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