Fabrication of Aligned Substrates and Suspended Membranes

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Primary CNF Tools Used: Gamma automatic coat-develop tool, ASML 300C stepper, Anatech plasma etcher, Heidelberg DWL2000, Hamatech HMR

Summary of Research:

To support our efforts at Columbia University, we have ongoing projects at Cornell NanoScale Facility (CNF) to fabricate alignment marks on SiO2/Si wafers. To fabricate these wafers, the Gamma automatic coat-develop tool (Gamma) is used to coat the wafers with photoresist, as well as to develop the photoresist post-exposure. To pattern the wafers, ASML 300C Deep Ultra Violet Stepper was used to expose the photoresist. Post development, the wafers were descummed using the Anatech plasma etcher. The alignment metals were then evaporated using Nanobiotechnology Center’s (NBTC) bath evaporation system. Post evaporation, the wafers underwent lift off followed by a resist strip in both the bath and the Anatech plasma etcher.

The purpose of these alignment marks is to facilitate the electron beam lithography processes here at Columbia, where we prepare and transfer samples to the prepared wafers, and align them using the marks. By using the wafer scale processing at CNF, we are able to produce large numbers of wafers in a relatively short amount of time, speeding up our processes as a whole.

We also use CNF for the fabrication of a large number of square silicon/silicon nitride grids with a hole-patterned suspended silicon nitride membrane. The goal was to fabricate six different membrane types, each with a different set of alternating through-hole diameters: (1) 100 and 50 µm, (2) 50 and 25 µm, (3) 25 and 10 µm, (4) 10 and 5 µm, (5) 5 and 2 µm, and (6) 2 and 1 µm (see Figure 1).

Each membrane window was designed to be 500 µm and the grid itself to be 3 mm on the diagonal. The Heidelberg DWL2000 mask writer was used to write the patterns on each mask. After the masks were written, the photoresist was developed and the underlying chrome etched using the Hamatech HMR 900 chemical processes tool. The photoresist was removed and the masks were cleaned using the hot strip bath setup. A 220 nm thick low-stress nitride layer was grown on bare four-inch diameter silicon wafers using the LPCVD furnace after the wafers were MOS cleaned.

In CNF’s photolithography area, the top-side was spun coated and cured with a layer photoresist and then the SÜSS MA6-BA6 contact aligner was used to expose the wafer with the top-side mask (i.e., the membrane holes). The photoresist was developed effectively using a Hamatech HMR 900 chemical processes tool. The Oxford Plasma 81 was used to etch the exposed nitride until the underlying silicon was revealed.

Once the holes were confidently etched through the nitride with verification of the P-10 profilometer, the photoresist mask was removed and the wafer was cleaned again using the hot strip bath. This process was then repeated for the back-side of the wafer with the bottom-side mask (i.e. the membrane window and the grid break-lines).

Once the patterning was completed, the patterned nitride was used as a mask to etch the silicon in order to suspend the nitride membranes and break-lines. This was accomplished using CNF’s heated KOH etch setup and the chemical resistant wafer holder, used to protect the membranes during the process.

These membrane substrates will be used in nanoindentation tests for suspended graphene and graphene-based composites. The batch processing of the substrates allows us to expedite our experimental research here at Columbia.