Electrical Conductance Measurement of Graphene Nanoribbons

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Theoretically, the electrical conductivity of Graphene nanoribbon (GNR) has been predicted to depend on the width and edge structure. Based on the tight-binding approach, a GNR with armchair edge is either metallic or semiconducting depending on their width, while one with zigzag edge is metallic regardless of its width [1]. Recently, ab initio calculations predicted that GNRs with not only armchair edges but also zigzag ones are semiconducting [2]. In order to clarify such edge structure dependency, in-situ transmission electron microscopy (TEM) observations of GNRs have been carried out by several research groups. Qi et al. [3] found that the intrinsic conductance ($G_{BL}(w)$) of a sub-10nm bounded bilayer GNR can be expressed by $G_{BL}(w)\sim 3/4(e^2/h)w$, where w is the width of the GNR. Despite much efforts, the edge structure dependency is still remained uncertain. In this study, we aim to fabricate a two electrode nanoelectronic device using suspended GNRs with controllable width and edge structure.

We used a commercial silicon chip (200 μm in thickness) suitable for TEM observation, which is fully covered with 50 nm thick amorphous silicon nitride membrane and has a slot window transparent to electron beam. Gold electrodes and pads were fabricated using electron beam lithography (EBL) exposure and vacuum deposition. The nanogaps were cut at the center of the electrodes using focused ion beam (FIB). CVD graphene, which was grown on copper foil, was then transferred to the Si chip after etching of copper. The GNRs were patterned using EBL exposure with poly methyl methacrylate (PMMA) as the resist. Graphene except of the nanoribbon area were removed using O_2 plasma etching.

Three electrodes of 1.5 μm in width at the narrowest region were fabricated crossing the window on the silicon nitride membrane (Fig. 1(left)). And the gap of 70 nm was obtained by FIB (Fig. 1(right)). The GNR was suspended at such narrow gap as shown in Fig. 2. In Fig. 2, the width of the GNR was 430nm as indicated by yellow arrow, although it was designed to be 500 nm. This difference may be occurred by long time of O_2 plasma etching. We tried to thin and clean the GNR by focused electron beam, and measure the current-voltage characteristic with observing its edge structures.

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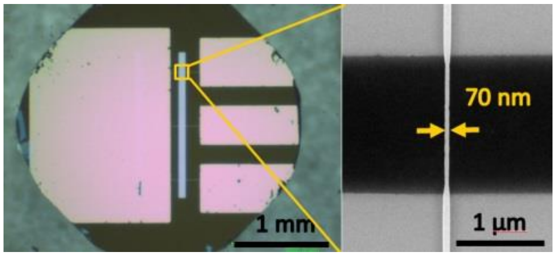

Fig. 1 Left: Si chip mounted with Gold electrodes and pads.
Right: TEM image of the nanogap

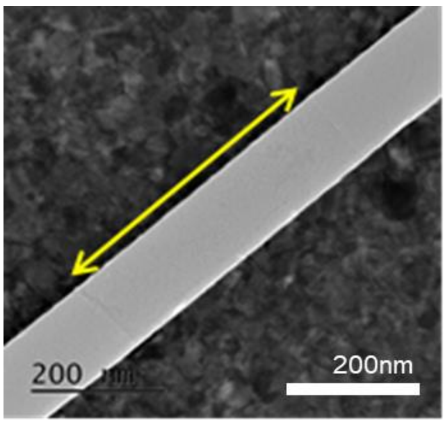

Fig. 2 TEM image of the Graphene Nanoribbon

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