The Fabrication of Suspended Graphene Nanoribbon for In-situ Transmission Electron Microscopy Observation

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Abstract: The peculiar aspect of a finite-size graphene nanoribbon (GNR) is that its electrical conductance strongly depends on the edge structure [1]. First principle calculation showed that the band gap appeared for both armchair and zigzag GNRs because of electron-electron interaction and quantum confinement effect [2]. Recently, this prediction has been verified [3]. However, structure-dependence on electrical conductance property of GNRs has been investigated rarely especially for a suspended GNR, which does not have interaction with the substrate. Hence, for exploring the structure-depended properties of GNRs, the fabrication of suspended GNR device which can be observed by in situ transmission electron microscope (TEM) is indispensable. In this study, we will focus on the fabrication of electrically contacted suspended GNRs with controllable width and edge structure on a suitable chip.

In this experiment, for in situ TEM observation, we used a silicon chip (Fig.1a) which has a slot window transparent to electron beam. Firstly, gold electrodes and pads are fabricated on the chip (Fig.1b) using electron beam lithography (EBL) and electron beam evaporation of Cr/Au. Secondly, the nanogaps (Fig.1c) are cut at the center of the electrodes using a focused ion beam. Then, chemical vapor deposition-grown monolayer graphene is directly transferred onto the prepared chip. Finally, the GNRs are patterned by using EBL with poly methyl methacrylate (PMMA) layer as mask, and followed with the O_2 plasma etching step for removing exposed graphene.

Figure 2a shows a TEM image of the suspended graphene across the nanogap with a width of about 550nm. In addition, from the electron diffraction pattern of the GNR (Fig. 2b), the sharp spots with six-fold symmetry clearly demonstrates this GNR is monolayer graphene.

Keywords: suspended graphene nanoribbon, structure-depended properties, in situ TEM observation

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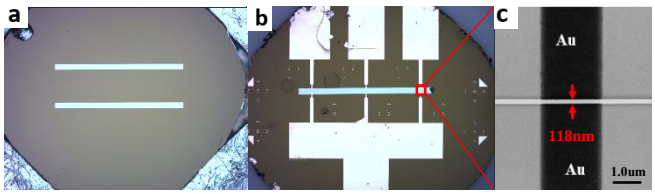

Fig 1. (a) The commercial silicon chip (200 μm in thickness) covered by 50 nm thick amorphous silicon nitride membrane, (b) The fabricated gold electrodes and pads on chip, (c) TEM image of the nanogap.

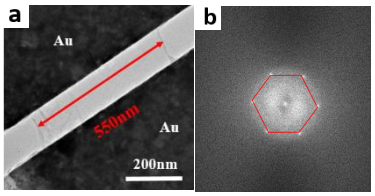

Fig 2. (a) TEM image of the suspended graphene nanoribbon. The width of GNR is indicated by red arrow. (b) The corresponding diffraction pattern of suspended graphene nanoribbon.