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Mechanism of persistent photo conductivity in functionalized graphene nanoribbons

Graphene nanoribbons (GNRs) combine the unique electronic and spin properties of graphene with a transport gap that arises from quantum confinement and edge effects. This makes them an attractive candidate material for the channels of next-generation transistors.

Up to now, we developed a novel method based on the advanced plasma CVD with nano scale Ni catalyst (Ni nanobar) for directly fabricating suspended GNRs devices [1]. Through the comparison of molecular dynamics simulation and phase diagram calculation with the systematically obtained experimental results, the growth dynamics of GNRs in our method has been also elucidated. By following this growth model, the yield of suspended GNR growth can be drastically improved (~98%) and wafer-scale synthesis of 1,000,000 suspended GNRs has been realized [2].

Recently, we found that our suspended GNRs include unique optoelectrical features [3]. The current in GNR can be drastically changed by photo irradiation (Fig. 1a) and the current change can be maintained for a long time (over 3 days) even after stopping the photo irradiation, which is known as a persistent photoconductivity (PPC). To further improve the PPC features such as sustain time and response speed, we attempted to elucidate the detailed mechanism of PPC in GNR. The PPC was often observed in samples which were kept in air for long period (Fig. 1b). Functionalized GNRs by O_2 plasma irradiation were also showed clear PPC features. These indicate that surface reaction of GNR device (GNR itself or Ni electrode) with oxygen and related species should be a key to cause PPC. To identify the surface structures of GNR device after O_2 plasma functionalization, detailed measurements were carried out by X-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM) (Fig. 1c-d), and optical absorption spectroscopy. These measurements reveal that the Ni electrode is converted to $Ni(OH)_2$, and the interface between GNR and $Ni(OH)_2$ can work as a carrier trapping center, causing the PPC. These results indicate the wafer-scale suspended GNRs array can be useful as a novel optical-memory device using interface control between metal and suspended GNRs.

References

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Figures

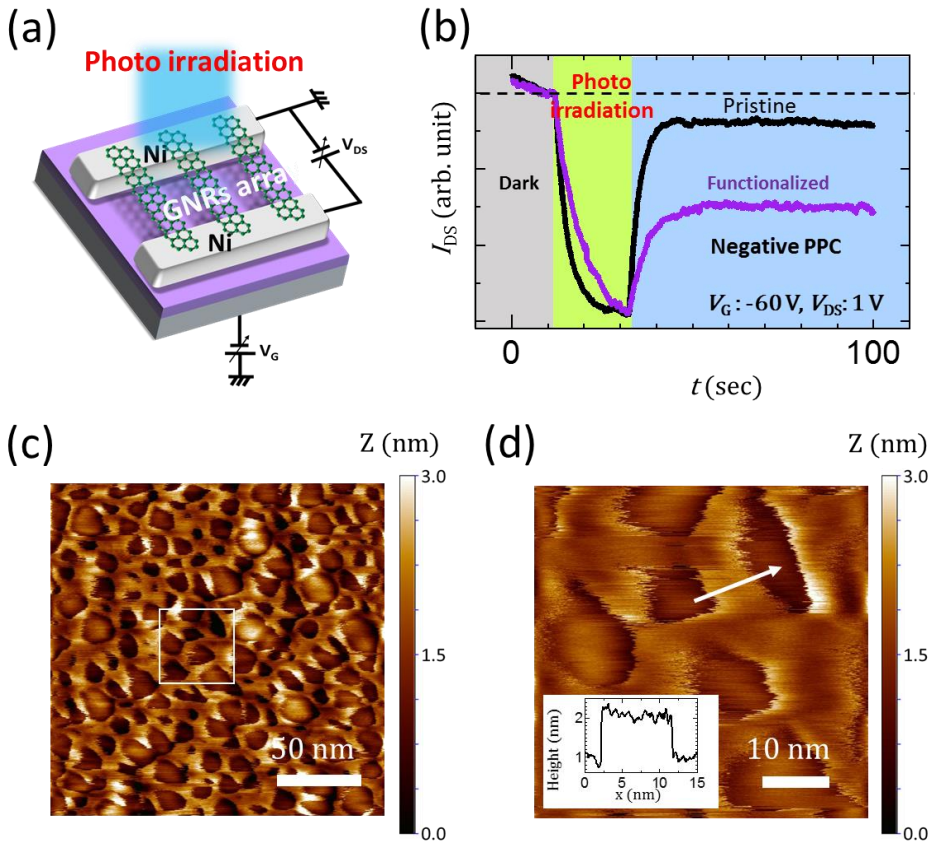

Figure 1: (a)
Schematic image of GNR array-FET under photo irradiation. (b) Comparison of photoresponce of pristine and functionalized suspended GNRs array. (c) Low and (d) high magnification AFM image of O_2 plasma irradiated Ni electrodes. Inset in (d) shows height profile along the arrow.