Contribution (Oral/Poster/Keynote)

The Electrical Properties of Fluorinated Graphene and its Application in Graphene-based Nanoelectronics

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Fluorinated graphene, the so-called fluorographene (F-Graphene),[1-3] exhibits a comparable mechanical strength to pristine graphene, while the conductivity can be adjusted from a semi-metallic character to insulator by tuning the stoichiometry, i.e., adjusting the carbon-to-fluorine ratio (C/F).[2] The theoretical calculation predicts that partial fluorination of graphene from $C_{32}F$ to C_4F is able to modify the energy bandgap from 0.8 to 2.9 eV, respectively. As a result, fluorographene is a promising candidate to be used in next-generation nanoeletronics.

To develop a transistor, it requires three types of materials: (a) the highly conducting materials for use in electrode and interconnection,(b) semiconducting materials for the formation of active area, and (c) insulator for isolation between devices and gate electrode. The traditional technique relies on the patterning and deposition of these three types of materials with stacking layered configuration. Now, the transistor could be fabricated on an atomic-layered material by selective functionalization of graphene with fluorine. The electrical properties of fluorinated graphene can be adjusted from conductive to insulator depends on the coverage and types of C-F bond formation. In this work, the wafer scale fabrication of atomic layered transistors are demonstrated by selective fluorination of graphene with a remote CF_4 plasma, where the generated F-radicals preferentially fluorinated graphene surface at low temperature (<200°C) while this technique lower the defect formation by screening out the ion damage effect. The resultant grapehene shows electrical semiconducting and isolation after subjected to the fluorination for 5~20min, respectively(Figure 1a). A back-gate transistor is then fabricated with a fluorination of graphene film on SiO_2 substrate. The chemical structure, C-F bonds, is well correlated to the electrical properties in fluorinated graphene by XPS, Raman spectroscopy and electrical meter. This efficient method provide electrical semiconducting and insulator of graphene with a large area and selective pattering, where it turns out the potential for the integration of electronics down to atomic layered scale.

Moreover, the graphene-based transistor was demonstrated with a vertically stacked architecture. To fabricate graphene-based field effect transistor, depositing gate dielectric with high quality and uniformity is required. In this work, the Fluorinated multilayer graphene film was applied as the gate dielectric layer in a graphene-based FET(Figure 1b). It was found out that extremely thin fluorographene (~5nm) exhibit a high breakdown electric field (above 10MV cm^{-1}) and high thermal stability. The present method is simple and scalable, which shows the potential to be used in the fabrication of next-generation of nano-electronics.

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References

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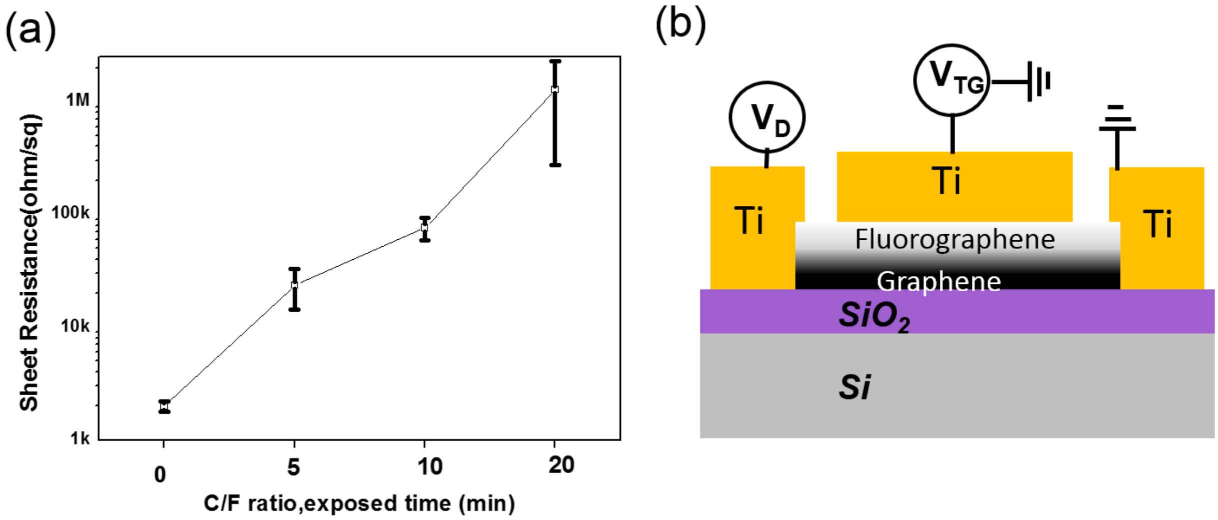

Figure1. (a) The sheet resistance for the F-Graphene samples with different exposure times. (b) An illustration of a graphene-based FET composed of a fluorographene gate dielectric.