Graphene formation on GaN substrates and electrical characteristics of metal/graphene/GaN structure

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Excellent carrier and heat conduction of graphene has much attention for electronic device applications. Combination of graphene and wide-band-gap material, GaN is one of candidates to improve source resistance, surface passivation and thermal dissipation. From a material point of view, because GaN has a nature of crystal polarization, the device performance is surface sensitive. Investigation of graphene/GaN interfaces is important, and providing a new technique for surface potential control is possible. This paper reports successful transformation of epitaxial graphene layers on GaN crystals and current-voltage (I-V) characteristics of metal contacts inserting the graphene layers.

We used transfer process [1], which is that a graphene layer on a sublimated SiC surface is transferred onto another material. Firstly, SiC substrates were heated in vacuum to form epitaxial graphene on the surface. Then, Ti metal and poly-methil-methacrylate (PMMA) were deposited on the graphene, and the graphene layer was exfoliated from the SiC substrate. Finally, the PMMA/Ti/graphene layer was put on the GaN surface, and the PMMA and Ti were removed by using acetone and HCl, respectively. The n-GaN layer was grown on a sapphire substrate by metal organic chemical vapor deposition. The electron concentration was 4×10^{17} cm^{-3}.

Figure 1(a) shows a typical microscope image of the GaN surface before the Ti removing. Most of the Ti surface is covered with PMMA. After the HCl etching (Fig. 1 (b)), only small portions of the Ti layer without PMMA were etched away, and the graphene layer successfully remained on the GaN surface. A typical size of the graphene layer is around 50 μm.

Figure 2 shows typical Raman spectra from the transformed graphene on GaN, and GaN substrate. In the spectrum from the graphene on GaN, the peaks from GaN, G'-, D-, G-band can be seen. The FWHM of the G'-peak is 50 cm^{-1}, and the peak ratio (I(D) / I(G)) is about 0.5. Therefore, it can be considered that one- or two-mono-layer graphene was transferred.

In order to investigate I-V characteristics of metal/graphen/n-GaN structure, Ni electrodes (50-nm thick) were deposited by electron-beam evaporation method. After that, an Oxygen plasma treatment was conducted for the isolation between the electrodes. For the comparison, conventional Ni/n-GaN Schottky diodes were also prepared. Figure 3 shows the forward and reverse I-V characteristics for both samples. The diodes with a graphene layer showed rectifying characteristics. Comparing with the sample without graphene, the Schottky barrier height decreased. The effect of the graphene insertion was confirmed as the potential control.

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Reference

[1] A. Hashimoto, H. Terasaki, K. Morita, H. Hibino and S. Tanaka. *International Conference on Silicon Carbide and Related Materials*, Tu-P-86, (2009).

Figures

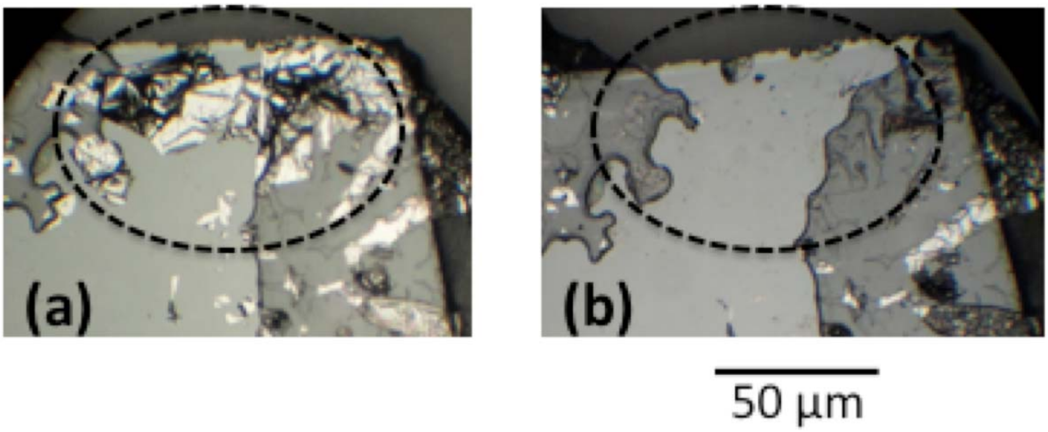

Fig. 1. Microscope images of the GaN surface (a) before and (b) after the Ti removing.

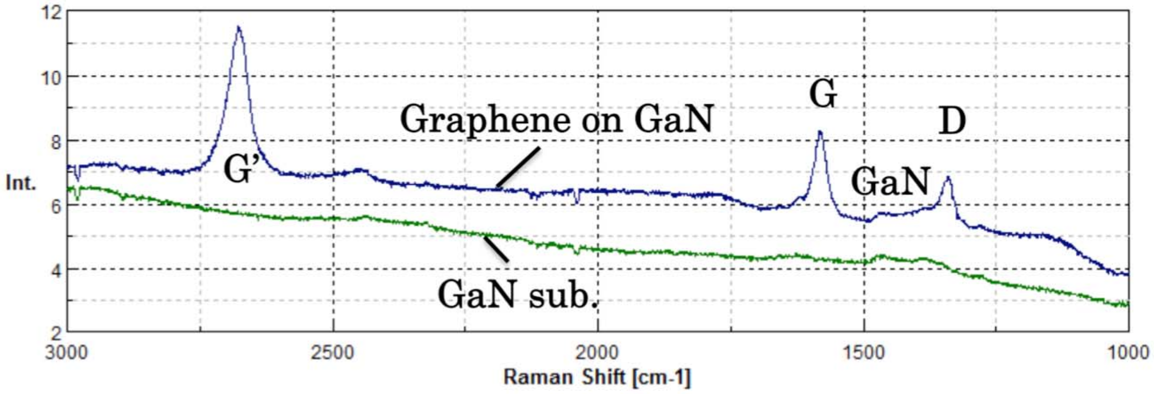

Fig. 2. Raman spectra from graphen/GaN and GaN.

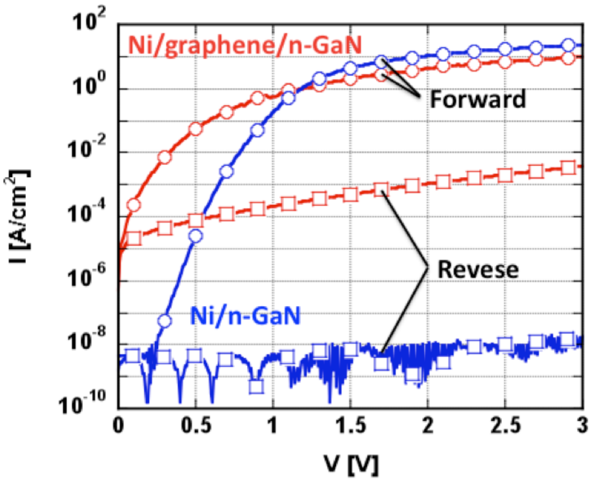

Fig. 3. I-V characteristics of Ni/graphen/n-GaN and Ni/n-GaN diodes.