Characterization of Graphene/ZnO Schottky Barriers Formed on Zn and O polar faces of ZnO substrates

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Graphene/semiconductor junctions have been in the forefront of intense research in recent few years. Such interest originates from relatively easy fabrication of the junctions and their unique properties enabling the study of new physical phenomena. Zinc oxide is a direct wide band gap semiconductor with a broad range of unique and technologically useful properties. However, a number of factors (crystallographic surface orientation, crystal defects, residual impurities, etc.) influence the formation of the Schottky contact on ZnO. Fabrication of graphene contact on ZnO and systematic analysis of such junctions is essential for deeper understanding of the physical phenomena occurring at the interface between 2D and 3D materials as well as for their potential optoelectronic applications.

In our previous work, we investigated the polar depended properties of graphite Schottky contacts on ZnO. We showed that the interaction between O- and Zn-polar face of ZnO and graphite contact strongly affects transport properties [1].

In this study, commercially available graphene monolayers (by Graphenea) prepared by CVD on a polymer support film were transferred onto bulk ZnO substrates (by CrysTec). To limit the area of the Schottky junctions to 10μm circles, trenches were milled into graphene by Ga^{+}focused ion beam (FIB).

The morphology of the graphene deposited onto ZnO was studied by atomic force microscopy (AFM, Nano Wizard 4, JPK Instruments) and scanning electron microscopy (SEM, Lyra 3 GM FIB/SEM, Tescan). The I-V characteristics of the graphene/ZnO structures were measured in the chamber of the SEM. The tip of tungsten needle handled by the nanomanipulator (Omniprobe 400, Oxford Instrument) served as the top electrode to the graphene layer while a drop of InGa alloy rubbed into ZnO substrate served as the second ohmic electrode.

We show that the FIB milling technique is a proper approach for prototyping of graphene-based electronic devices. We further demonstrate that the electrical properties of graphene/ZnO Schottky junctions strongly depend on the crystallographic orientation of the ZnO substrate, and we discuss in detail charge transport mechanisms in the graphene/ZnO junctions.

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[1] R. Yatskiv, S. Tiagulskyi, and J. Grym, Phys. Status Solidi A 216 (2019) 2.