Graphene/Bismuth Selenide Heterostructures for Thermoelectric Applications

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Graphene is modern 2D-material with unique physical properties - optical transparency, high electric and thermal conductivity, mechanical strength and flexibility. Due to these properties graphene is a perspective material for the use as electrode in opto- and thermoelectric devices instead of, for example, widely used indium tin oxide. Hexagonal crystal lattice of graphene is very similar to it of some best thermoelectric materials such as bismuth selenide (Bi_2Se_3). This similarity allows heteroepitaxial growth of Bi_2Se_3 nanoplates on the graphene surface, resulting in formation of graphene/Bi_2Se_3 heterostructures. Previously it was reported that crystallographic growth direction and crystallite size of pure Bi_2Se_3 nanostructures play significant role in improvement of its thermoelectric performance [1]. Likewise, the change of growth orientation of Bi_2Se_3 nanostructures from planar (or epitaxial) to non-planar relative to the substrate surface may enhance thermoelectrical performance of graphene/Bi_2Se_3 heterostructures.

This work is focused on application of vapour-solid deposition method [2] for fabrication of different in terms of continuity and growth orientation types of nanostructured Bi_2Se_3 layers on the surface of monolayer CVD graphene. During Bi_2Se_3 synthesis process short-term inert gas flow was used to change growth orientation of Bi_2Se_3 nanostructures [3]. The relation between synthesis parameters and quality of obtained on graphene surface Bi_2Se_3 nanostructured layers (chemical composition, crystal structure and coverage of graphene area) is discussed. Thermoelectric voltage, generated by obtained graphene/Bi_2Se_3 heterostructures in response to temperature gradient of 16 °C applied to it, is compared. The graphene/Bi_2Se_3 heterostructures, where Bi_2Se_3 layer consisted from both planar and non-planar nanoplates are found to be twice more effective than heterostructures with Bi_2Se_3 layer consisted only from planar nanoplates (Figure 1). Thus, graphene/Bi_2Se_3 heterostructures, where Bi_2Se_3 layer consists of mix of planar and non-planar nanoplates, is perspective material for application in thermoelectric devices.

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References

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Figures

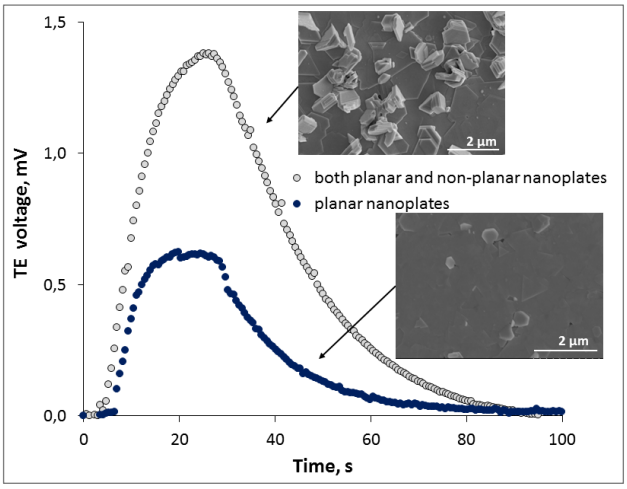

Figure 1. V-t curves illustrating thermoelectric response of the device based on graphene/Bi_2Se_3 heterostructures to the applied temperature gradient of 16 °C for 30 s.