Graphene/bismuth chalcogenide composites for thermoelectric applications

Jana Andzane[1], Margarita Baitimirova[1], Raimonds Poplausks[1], Donats Erts[1]

[1]Institute of Chemical Physics, University of Latvia, Latvia

e-mail: Jana.Andzane@lu.lv

Bismuth chalcogenides are well known as effective room-temperature thermoelectric materials. The nanostructuring of these materials in nanowires, nanoribbons and nanoplates is a promising way for increasing efficiency of their thermoelectric properties [1]. Recent research showed that bismuth chalcogenide nanostructures can be succesfully synthesized by catalyst-free vapor-solid deposition method onto the graphene substrates due to graphene and bismuth chalcogenide lattice hexagonal geometry similarity (mismatch ~ 2.9 %) allowing epitaxial growth [2]. At the same time, graphene is excellent candidate for use as electrodes due to its high mechanical strength and elasticity, great electrical and thermal conductivity and transparency for visible and near-infrared irradiation.

Here we present layered graphene/bismuth chalcogenide composites that may find applications in advanced energy conversion and storage devices, including solar cells, thermo-generators, Li-ion batteries, micro-coolers and infrared detectors.

Graphene of necessary shape and monolayer number for the bottom and top electrodes were prepared using chemical vapor deposition (CVD) technique. The bismuth chalcogenide nanostructures were synthesized directly on the graphene electrode surface by catalyst-free vapor-solid deposition method. This method allows to synthesize nanoplate-seeded free-standing nanoribbons and vertically aligned nanoplates, which is more preferably for layered sandwich-like composites. The top graphene electrode was transferred onto the synthesized bismuth chalcogenide nanostructures using polymer-based transfer technique. During the preparation, quality of graphene and bismuth chalcogenide nanostructures was inspected by scanning and transmission electron microscopes, X-ray diffraction, Raman and energy-dispersive X-ray spectroscopy. Electrical and thermo-electrical measurements were carried out to study efficiency of fabricated graphene/bismuth chalcogenide composites.

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References

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