Application of multilayer graphene for modification of the properties of composite materials

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The paper presents results of studies into possible application of multilayer graphene (MLG) as an addition to composite materials. Investigations have been performed with two groups of materials. The first one comprised thermoelectric materials based on $CoSb_3$ skutterudite used for construction of thermoelectric generators and the second consisted of copper matrix composites intended for use as potential sliding materials. All materials have been produced by powder metallurgy methods.

Base thermoelectric material $CoSb_3$ has been synthesized by mechanical alloying of pure Co and Sb powders. At the final stage of the milling process 0.5 – 1.0% wt of MLG has been added to the synthesised compound. Then sintering has been performed at temperature of 540°C under pressure of 20MPa. The microstructure of resulting materials has been studied with SEM. It has been observed that patches of aggregated MPL flakes took order perpendicular to pressing direction. Their distribution was homogeneous across investigated areas.

The thermal conductivity coefficient measured for material with 0.5% wt content of MLG was significantly lower (approx. 20%) than for pure sintered material. Preliminary results of measurement for samples cut parallel and perpendicularly to compression axis showed that addition of MLG introduced anisotropy of heat transport. This effect can be explained by deterioration of local heat conduction in the region of aggregated MLP flakes. Such structures decrease thermal conductivity because of low long-range-order degree. Measurements did not show significant influence of MLG addition on the Seebeck constant.

In the case of copper-based composite materials, mixing of copper powder of dendrite structure with MLG particles in amount from 0.5 to 3% wt, and subsequent consolidation through isostatic pressing and sintering at temperature of 950°C were included in production process. Produced compacts were extruded by KOBO method with a reversibly rotating die. In this process 2.5 mm diameter wires were produced. Mechanical properties and structure were determined by static tensile strength test, Vickers hardness measurement and structure quantitative analysis. Research results showed that multilayer graphene particles were evenly distributed in the section. In the results of compression forces the structure was significantly hardened and high mechanical properties were observed in the prepared wires.