High thermal conductivity diamond-copper composites

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A composite material with high thermal conductivity of 600-900 W/(m K), as well as a process for fabricating a composite material is developed [1].

Diamond-copper composites are obtained from monodisperse fillers having the following characteristics:
- thermal conductivity is up to 800-900 W/(m*K) for diamond particles of 200-400 mkm size;
- diamond volume fraction ~62 %;
- composite density ~5,5 g/cm^3;
- coefficient of thermal expansion 5 ppm/K at 20°C and 8 ppm/K at 200°C;
- longitudinal speed of sound ~9 km/s;
- Young modulus ~300 GPa;
- specific electrical resistivity 5-10 mkΩ cm.

For comparison, the thermal conductivity of copper is 390 W/(m K). In regard to their characteristics the obtained materials do not inferior to or superior the diamond-metal composites fabricated by all other known means (pressure-assisted infiltration of copper alloys containing carbide-forming additives; sintering with copper or infiltration at high pressures more than 1 GPa).

The diamond-copper composite material is made by a method of capillary (spontaneous) infiltration of copper melt in a bed of diamond particles with preliminary applied coating of carbide-forming metal. The coating thickness is about 100-300 nm. Raw materials are available (powders of synthetic diamond and copper, alloys are not used). The infiltration is carried during short time (several minutes) and the process has almost no restrictions as to the form and sizes of product items. The products can be manufactured in final or close to the final form and can have cavities, ledges and through apertures in them. The product material can be easily jointed to other constructive elements by means of soldering.

The proposed composite material can be used in heat exchangers, heat sinks, heat spreaders for semiconductor and vacuum electronic devices, in high-heat-flux systems, for example, in synchrotron radiation sources, elementary particles accelerators and nuclear fusion reactors, etc.

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