Fracture toughness of the material for aircraft construction is increased by 1.5 times

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Scientists from NUST MISIS have found a way to increase the fracture toughness of silicon carbide, a promising structural material for the production of refractory parts, by 1.5 times. These results were achieved due to the formation of reinforcing nanofibers in the structure. In the future, the technology will expand the scope of silicon carbide application as a structural and refractory material, including for the aircraft construction. Articles about the development have been published in *Ceramics International* and *Materials*.

The global silicon carbide market as of 2019 is estimated at $ 2.58 billion and is projected to grow by 16% per year. Silicon carbide is rarely found in nature; therefore, this promising material is synthesized artificially.

Silicon carbide is increasingly used in various industries as a semiconductor, construction material, abrasive and refractory material. For example, its use for the manufacture of turbine blades and parts for internal combustion engines would significantly raise the operating temperatures in engines and significantly increase their characteristics: power, tractive power, efficiency, environmental friendliness, etc. Also, silicon carbide ceramics produced from cheap feldspar and quartz sand can successfully replace parts from alloys containing scarce cobalt, nickel, and chromium, which are used in motor engineering.

The key problem of silicon carbide ceramics is that it works well in compression, but is very sensitive to structural defects and therefore often has low tensile and bending strengths, as well as low crack resistance.

Scientists from NUST MISIS have found a way to improve sintering ability and increase the flexural strength and fracture toughness of silicon carbide ceramics by forming reinforcing nanofibers in it using the technology of self-propagating high-temperature synthesis. The synthesis was carried out in several stages. First, powders of silicon, carbon, tantalum and PTFE were mixed in a planetary mill, then the resulting mixture was burned in a reactor. Nanofibers formed during the combustion process. At the last stage, the product was sintered in a vacuum oven.

"Thanks to the effect of the combined addition of tantalum and PTFE, we were able to synthesize a material with a silicon carbide matrix reinforced with silicon carbide nanofibers. These nanofibers activate the sintering of the ceramic and increase the sintered material strength characteristics since they serve as a barrier to fracture propagation," says the main author, Dr. Stepan Vorotilo from SHS Center in NUST MISIS.

Nanofibers decreased the required sintering temperature and duration from multiple hours at 1800-2000°C to 60 min at 1450°C.

The scientists plan to continue work on increasing the fracture toughness and strength of the material. The combination of good mechanical characteristics and cost-effectiveness of the production process will expand the scope of silicon carbide application as a structural and refractory material.

More information: S. Vorotilo et al. Combustion synthesis of SiC-based ceramics reinforced by discrete carbon fibers with in situ grown SiC nanowires, *Ceramics International* (2019). DOI: 10.1016/j.ceramint.2019.12.005

Stepan Vorotilo et al. Effect of In Situ Grown SiC Nanowires on the Pressureless Sintering of Heterophase Ceramics TaSi2-TaC-SiC, *Materials* (2020). DOI: 10.3390/ma13153394

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