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T: Materials Science: metals with diamonds

Utl.: An Inter-Faculty research team at the Vienna University of Technology is examining dimensionally stable and thermoconducting material combinations for nuclear fusion.

Vienna (TU). - Material scientists are developing composites which are made of dissimilar materials in order to be able to offer new customised application profiles. Researchers at the Vienna University of Technology (TU) have examined promising metal-matrix composites, which are very good conductors of heat and are able to withstand mechanical loads at elevated temperatures of up to 550 degrees and expand only very little with increasing temperature. These material combinations may be used in the ITER nuclear reactor, which is currently being constructed at Cadarache, France, and where they are intended to be used in cooling the first wall of the experimental reactor. Enhanced heat removal is playing an increasingly important role in the field of power electronics for engines and computers. Unless excess heat can be dissipated, the power of computers can no longer be increased. Last but not least, metal matrix composites can be used as cooling materials in rocket engines.

Four TU institutes are working on material combinations as part of an EU project of the 6th Framework Programme called ExtreMat (http://www.extremat.org/), which stands for “New Materials for Extreme Environments”. “We examined some metal matrix composites and their interfacial bonding which are promising for use in nuclear reactor heat sinks, rocket engines or in power electronics. The characterisation of these heterogeneous materials falls within our area of competency", says Professor H. Peter Degischer, Head of the Institute of Materials Science and Material Technology at the TU Vienna. Copper and silver are efficient conductors, but due to their relatively high coefficient of thermal expansion, do not provide enough inherent strength when changes in temperature occur. In addition, their mechanical strength is sharply reduced at elevated temperatures. Copper deforms like butter from 300 degrees onwards". Strengthening with silicon carbide or tungsten fibres with some 0.1 millimetres or carbon fibres with less than 1/100 millimetres diameter increases the strength and the form stability without reducing conductivity. Degischer believes that a combination of silver with diamond particles of approx. 0.1 millimetres of diameter which are connected by means of thin silicon

bridges holds the most promise for power electronics.

By using simulation calculations, both the internal stresses and the thermal conductivity were predicted for given internal arrangements of composites. The Austrian company PLANSEE SE could set up industrial production for these new materials. “During our investigations with a synchrotron, a particularly brilliant X-ray source, in Grenoble we were able to see how the composites’ components, which are arranged three-dimensionally, deformed in different ways upon being repeatedly heated up and cooled down. Furthermore, we were able to ascertain the point at which debonds on the interface between metal matrix and diamond particles become visible in micro-tomography. These debonds are a consequence of local tensile stresses during changes in temperature. The conducting bond to the cooling plate was produced using a new coating procedure", says Degischer.

Chemists (Ass. Prof. C. Edtmaier), physicists (Prof. C. Eisenmenger-Sittner), micro-mechanicists (Prof. H. Böhm) and material scientists from the TU collaborated with two Austrian partners and 35 other European research institutes and companies on the research project “ExtreMat”. Four doctoral students successfully carried out the scientific work for the project part on behalf of the TU. Almost 1 million euro has been spent on the project over the past 4 years, 50 percent of which was financed by the European Commission.

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