Russian technologists investigate the way quenching pressure affects the parameters of a copper superconductor

The scientists studied the way increasing pressure in a plasma-chemical reactor affects the physical and magnetic properties of copper oxide nanoparticles synthesized in it. The properties of particles formed at 0.0004 atm turned out to be similar to those of the bulk material obtained by the conventional technologies, while the nanoparticles synthesized at 0.002 atm exhibited unusual properties.

The Russian scientists' studies show that it is possible to affect the size and properties of such systems during their production. The use of such nanoparticles will increase the efficiency and reliability of high-temperature superconductors and devices based on these nanoparticles. The scientists reported on their study in JOM journal. The research was supported by RSF grant No. 16-19-10054-П.

Copper oxide (CuO) nanoparticles attract scientists' attention because of their unusual magnetic properties which can be used to create high-temperature superconductors, electrolytes, and highly sensitive sensors. CuO nanoparticles are a semiconductor with antiferromagnetic ordering, at which the magnetic moments of neighboring atoms are compensated at the expence of their opposite direction. However, with a decrease in size of particles, the researchers observed such properties as ferromagnetism (magnetic moments are parallel) at room temperature, the effect of exchange bias (a feature of the magnetization reversal curve), and change in the temperature of antiferromagnetic ordering. Ccopper oxide particles are synthesised in a plasma chemical reactor with a gas, where an increase in the pressure accelerates the synthesis and allows varying the particle size up to 40 nanometers (which is about 2500 times thinner than a human hair). In their work, the researchers studied the properties of nanoparticles obtained at different pressures.

> *"We performed the plasma-chemical synthesis of copper nanoparticles on an arc evaporator. Argon served as a plasma-forming gas, which was supplied to the chamber together with oxygen and formed a shell around the plasma torch. Then, we studied the composition of the nanoparticles with an electron microscope, and carried out the structural analysis using an X-ray diffractometer,"* says **Anatoly Ushakov**, an RNF grant participant, Doctor of Engineering, a researcher of the Krasnoyarsk Scientific Center (SB RAS) and Siberian Federal University.

The scientists obtained two groups of particles which were synthesized at 0.0004 and 0.002 atm. At lower pressures, the size of nanoparticles varied from 15 to 60 nanometers, and their magnetic properties hardly differed from the parameters of the bulk material. In the case of 0.02 atm, the sizes fluctuated from 15 to 45 nanometers, and the parameters of copper oxide changed greatly. CuO had magnetic hardness: it retained its magnetization, which also turned out to be increased, for a long time. According to the researchers, this was due to the formation of ferromagnetic dendritic (tree-like) shells on the nuclei of the nanoparticles synthesized at a higher rate.

Different sectors of industry demand different conductive materials with different parameters. In many situations, additional properties may be required, and sometimes one can do without them, simplifying the process of copper oxide production. The research of the Russian has shown that the dimensions and properties of an electrical conductor can be altered by changing the pressure in the reactor.

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