SibFU scientists study the synthesis of nickel oxide nanoparticles

Scientists of Siberian Federal University, Krasnoyarsk Research Center of the Siberian branch of the Russian Academy of Sciences and Kirensky Institute of Physics showed the efficiency of the synthesis of nickel oxide nanoparticles in the oxygen plasma of a low-pressure arc discharge. This method of production will allow controlling the magnetic properties of nanoparticles which make them suitable for use in computer memory and signal recording devices.

The research results supported by the RSF grant were published in Physica E: Low-Dimensional Systems and Nanostructures journal. In their further studies, also supported by the RSF grant and published in IEEE Transactions on Dielectrics and Electrical Insulation journal, the scientists determined how the properties of nickel oxide nanoparticles depend on the conditions for this synthesis method.

Due to their very small size (10^{-9} m) nanoparticles have a number of unique electrophysical, chemical, and optical characteristics. Magnetic nanoparticles with antiferromagnetic ordering are of scientists' main interest. Electrons behave like small magnets, and in such nanoparticles, the magnetic moments of neighboring electrons are oriented antiparallelly, so the total magnetization of the body is close to zero. The opposite situation is observed in ferromagnets, where the magnetic moments of the electrons are parallel and add up to the total magnetization of the body. Antiferromagnetic nanoparticles can be used as magnetic memory devices and for recording audio and video signals such as magnetic tapes and hard drives. Devices based on these nanoparticles consume less energy and can be very small. Typically, memory devices need electricity to operate, but antiferromagnets do not need it to perform write operations. In addition, they are protected from the erasure of information under the influence of an external magnetic field. The most popular are antiferromagnets based on transition metal oxides: nickel, copper, and manganese. To obtain them, various physical and chemical methods are used. The plasma-chemical method is distinguished by high productivity and allows controlling the size of nanoparticles, their structure, and composition.

The Russian scientists have shown for the first time that the production of nanoparticles in the oxygen plasma of a low-pressure arc discharge is an effective tool for the synthesis of nanocrystalline particles of nickel oxide (NiO). The synthesis takes place inside a reactor filled with gas (argon). A nickel cathode is heated to the point that it emits electrons and ionizes the gas inside the reactor. This gas forms plasma that fills the entire volume. After that, oxygen is supplied to the chamber, which creates a shell around the cathode, where NiO nanoparticles are synthesized due to the plasma energy.

> *"The development of a method for the synthesis of nanoparticles in the plasma of a low-pressure arc discharge will make it possible to increase the variety of nanoparticles produced by this method for different purposes. In particular, nickel oxide is a suitable magnetic material for recording devices because it can miniaturize them and increase the recording density,"* said **Anatolii Ushakov**, Doctor of Sciences in Engineering, specialist of the Krasnoyarsk Research Center, SB RAS and Siberian Federal University. *"Nickel oxide nanoparticles exhibited complex magnetic behavior depending on the magnetic field strength and temperature during synthesis. All the results obtained indicate that nanoparticles have a noticeable magnetic response, and therefore can be used in recording devices."*

In subsequent studies, the scientists examined the structural features of NiO nanoparticles obtained by the above method. Despite the fact that the electrical properties of the oxide of this metal are well studied, so far there have been no established ideas about the movement and location of charge carriers in nanoparticles. This is due to the fact that the properties of such materials strongly depend on the conditions for their preparation. Scientists have shown that the characteristics of NiO nanopowder synthesized in the plasma of a low-pressure arc discharge are mainly determined by processes occurring near the cathode and depend on the rate of gas ionization. The synthesized samples were distinguished by their internal structure and high values of the dielectric constant in the region of low frequencies of electromagnetic waves. Such materials can be used as sensors, fuel cells, and electrolyzers.

For the first time the news was posted on the RNF site.

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