

Nanoscale analysis of materials for future fusion reactors

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Credit: National Research Nuclear University

Scientists from the National Research Nuclear University MEPhI (Russia) have clarified how changing the nanostructure of materials for future energy fusion reactors influences their plasticity, heat resistance and other important properties.

Developing fast-neutron reactors and an efficient fusion reactor are promising nuclear power engineering projects. The former will make it possible to close the [nuclear fuel cycle](#) and make the nuclear power industry more environmentally friendly. The latter will enable the creation of a fundamentally new method of energy production. The most well-known project designed to expedite the emergence of energy-

producing fusion reactors is the International Thermonuclear Experimental Reactor (ITER).

It is difficult to create new energy devices because they involve creating extreme conditions. Incredibly high demands are made on [materials](#) for new reactors. Exposed to high temperatures and streams of high-energy radiation, existing materials tend to degrade quickly. The most durable of these can sustain radiation doses, in which each atom is displaced between 80 and 90 times. This parameter should be twice as large for thermonuclear energy installations. Material stress resistance determines whether a reactor can be considered efficient and safe.

MEPhI researchers addressed this problem using nanotechnologies. Ferrite-martensite steels based on Fe-Cr alloys and oxide dispersion-strengthened steels are regarded as the most promising materials for future energy installations. MEPhI researchers have demonstrated experimentally how these materials could be restructured at the atomic level and how the atoms were redistributed, leading to a substantial rise in fragility and loss of plasticity. The research was published in the *Journal of Nuclear Materials* and the *Journal of Nuclear Materials and Energy*.

Changing the nanostructure of a material can change its properties, and as a consequence, significantly reduce the life cycle of active zones. In some cases, however, scientists can select nanostructure changes that provide materials with unique properties such as high heat resistance. During the experiments, Fe-Cr model alloys and oxide dispersion-strengthened (ODS) steels were exposed to various impacts, during which nanoscale changes in properties were recorded with the help of atom probe tomography.

Sergei Rogozhkin, deputy head of the Department of Extreme States of Matter Physics at the MEPhI Institute of Nuclear Physics and

Technologies, said that they had analyzed the nanoscale state of the materials and their restructuring under various impacts: "We induced thermal aging and used beams of metal ions to establish that their influence could lead to the breakage of nanostructure."

According to S. Rogozhkin, this research could be used to create materials for ITER and for [future energy](#) installations. "ITER is meant to demonstrate the efficiency of the thermonuclear reactor concept. Requirements on materials are high at this stage, but a next-generation thermonuclear installation will create even more extreme conditions, so fundamentally new materials, including those we are studying now, are being developed precisely for these requirements," he explained.

Provided by National Research Nuclear University

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