New material for thermonuclear fusion reactors

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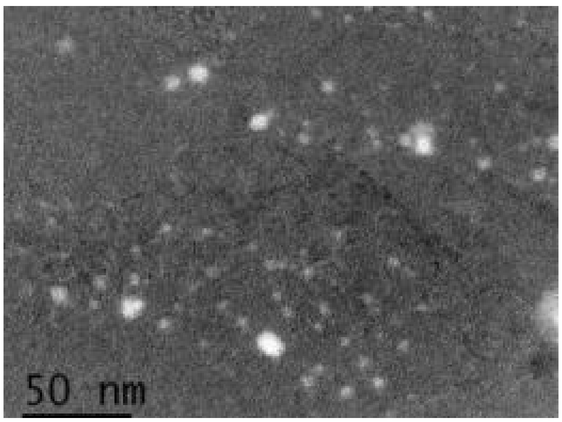

Scientists at Universidad Carlos III de Madrid, Oxford University and the University of Michigan have joined efforts to develop new materials for thermonuclear fusion reactors. Their research focuses on characterization of oxide dispersion-strengthened, reduced-activation steel for the reactor structure. The image shows disperse Y2O3nanoparticles in ODS/Fe12Cr steel. Credit: UC3M

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Thermonuclear fusion promises to be a possible solution to the current energy crisis. It is produced when two atomic nuclei of light elements combine to produce heavier elements, which give off a huge quantity of energy. So that this reaction can occur, it is necessary to supply an enormous amount of energy, so that temperatures of many millions of degrees can be reached, allowing the nuclei to come close enough to overcome their natural repulsion and become condensed in a plasma state. "This plasma, which reaches temperatures near that of the stars, around 100 million degrees, does not touch the walls of the reactors because they would melt," explained one of the project researchers, Vanessa de Castro, from the UC3M Physics Department. In order to confine the plasma, it is confined within the reactor by the magnetic fields. "Even so the walls must resist some very high temperatures as well as the effects of the irradiation from the neutrons from the reaction, for which we have to produce new materials that can withstand these extreme conditions," the Professor remarked.

The ITER project (under construction) and its successor, DEMO (scheduled for 2035) propose development of fusion reactors that are economically viable. This work depends on, among other things, the development of these new structural materials capable of withstanding damage by irradiation and elevated temperatures resulting from the fusion reaction. The scientific community has begun to develop new reduced - activation material for use in these reactors, but it is still not known if some of them will be viable under such hostile conditions. Along these lines, one of the most important candidates is oxide dispersion-strengthened, reduced-activation ferrite steel, called ODS steels.

The mechanic behavior of the ODS steels depends enormously on their microstructure, which until now has not been rigorously controlled. Until recently, studies on the microstructure of these steels have been on the micrometric scale. However, the nanometric scale is more relevant in understanding the phenomena that occur under irradiation. "We are now using our knowledge in nuclear structural materials and in advanced techniques of nanoanalysis to characterize diverse new generation ODS steels on the nanonmetric scale," noted the researchers, who have added nanometric particles to these steels (between 1 and 50 nm), which help to improve the mechanical properties and increase their resistance. The results of the research have been recently published in a special number of the journal Materials Science and Technology dedicated to the atomic scale characterization of steels.

The characterization of these materials is carried out using nanometric scale techniques. For example, with a transmission electron microscope, particles can be seen which are added to the material, even the smallest one of a nanometer (one millionth of millimeter). Because of this the following can be studied: if the distribution of the particles is optimum, its chemical composition, or if by changing it, better material is obtained or if interaction of these particles with the defects produced in the material is improved. "From there we extract the information that allows us to explain why material behaves in one way or another, because the fact that it has bad mechanical properties could be related to the particles not being well-distributed", ESTRUMAT's Professor de Castro, pointed out. The objective of this Advanced Structural Materials consortium, composed of five research groups from four universities and a Madrid Region research institute, is to provide a framework of scientific-technological activity in the area of advanced materials structures for applications in engineering.

This research, funded by the Ministry of Science and Innovation, is focused on the study of oxide nanoparticles which are present in these steels, and the damage caused by radiation of these materials. The analyses carried out up to now show, for example, that the particles have a core-shell type structure consistent in an yttrium(Y) -rich nucleus surrounded by a chrome (Cr)-enriched area.

More information: Title: Analytical characterisation of oxide dispersion strengthened steels for fusion reactors, de Castro, V. Lozano-Pérez, S. Marquis, E. A Auger, M. A. Leguey, T. Pareja, R. *Material Science and Technology*. 27: 719-723. ISSN: 0267-0836

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