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EFFECT OF THE GRAIN SIZE ON THE PRECIPITATE DISTRIBUTION OF THE DISPERSION-STRENGTHENED CuCrZr ALLOY

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Copper and copper alloys are widely used where high thermal conductivity is required. High heat flux is a major challenge for various fusion devices because of the extremely high energy density required in controlled thermonuclear fusion. Specifically, copper alloys are prime candidates for the ITER first wall and diverter components cooling system [1]. Materials with high conductivity are needed to assist heat transfer to the coolant and to reduce the thermal stress for pulsed mode of operation. At the same time these materials will be under various types of radiations and experience thermo-mechanical cyclic loading [1]. Thus, a number of issues must be considered in the selection of materials for high heat flux applications in fusion reactors. The use of unalloyed copper is often limited by its low strength. The strength of copper can be improved by various strengthening methods. Precipitation hardening (PH) and dispersion strengthening (DS) are the two most viable methods for improving the strength of copper while retaining its high electrical and thermal conductivities.

Effect of the grain size on the precipitate distribution of the dispersion-strengthened CuCrZr alloy has been investigated. The complex of optical methods has been used. The sputtering process by deuterium ions was chosen as an instrument for examining of alloy structure. The combination of equal channel angular compression (ECAP) and quasi-hydrostatic extrusion (QHE) worked as the strengthening methods. A difference in sputtering yields of matrix (copper) and precipitates (Cr and Zr) allowed visualizing layer by layer the alloy structure at total depth ~1μ. It is shown that the real structure is the dispersion-reinforced composite based on copper alloy. The main peculiarity of microstructure is connected with the high density of small chromium precipitates, which determines the surface roughness completely. Distribution of second phases in matrix pays the main role in forming optimal combination of functional characteristics. Cr and Zr create effective doping complex for copper alloy which allows getting the best combination of mechanical strengths and thermal conductivity. It is shown that the grain boundaries are the most effective concentrators for precipitators at the grain size ~30…40 μm [1, 2]. But if the grains size is < 300 nm, precipitate distribution determines only by the dislocations and other defects distribution.

It is shown that the combination of equal channel angular compression and quasi-hydrostatic extrusion allows raising micro hardness of CuCrZr alloy especially under low-temperature (77 K) QHE treatment.

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