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Upscaling production of SMART Material for Fusion Reactor using Field-Assisted Sintering

Self-passivating Metal Alloys with Reduced Thermo-oxidation (SMART) with a composition of W-11.4Cr-0.4Zr-0.6Y (in wt.%) are promising candidate materials for first wall applications in fusion reactors. Previous studies have demonstrated the oxidation resistance of SMART alloys at 1000 ℃ in humid air. However, these investigations were limited to small-scale specimens.
In this study, results on scaling up the SMART material to square-shaped ingots with dimensions of 10 × 10 × 0.5 cm are presented. It was found that increasing the sintering temperature from 1460 ℃ used at laboratory scale to 1550 ℃ was necessary to attain a relative density above 97%, comparable to that of smaller ingots. At the same time, residual porosity remained in the corner regions. The grain size changes across in the ingot, with an average size decreasing from 361 μm at the center to 103 μm toward the farthest corners along the diagonal. A single -phase W-Cr alloy was obtained within a central region of about 2 cm radius. Beyond this area the precipitation of the secondary Cr-rich phase occurred. Modelling of the sintering process revealed a temperature difference of up to 105 ℃ across the square ingot after 10 minutes holding at 1550 ℃, a significant contributor to the observed microstructural gradient. Moreover, oxidation tests were performed on samples from different regions of the ingots and the fabrication of hexagonal ingots with a corner-to-corner distance of 10 cm was also explored.

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