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Temporary stagnation in the recrystallization of warm-rolled tungsten in the temperature range from 1150 ℃ to 1300 ℃

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Pure tungsten is a potential candidate for armor material of fusion reactors as it possesses superior thermal properties and radiation resistance. Application at the desired operation temperatures for longer times will result in a loss of strength accompanied by embrittlement due to thermal activated changes in the microstructure, in particular due to recrystallization, undermining tungstens outstanding performance. Investigating the thermal stability of tungsten depending on the manufacturing process is therefore considered crucial. The thermal response of a sintered, hot isostatic pressed tungsten plate warm-rolled to 80% thickness reduction is assessed in the temperature range from 1150 ℃ to 1300 ℃. The restoration processes occurring during annealing are tracked by changes in mechanical properties through hardness testing and identified by supplementary orientation mapping by means of EBSD. Isothermal annealing treatments were performed at six different temperatures. With increasing annealing time, the macro hardness decreased continuously; different stages corresponding to different stages of the microstructural evolution (recovery, recrystallization and grain growth) could be identified and confirmed by the microstructural information gained by EBSD. For the time to half recrystallization, an activation energy comparable to the activation energy of bulk self-diffusion is obtained. The correspondingly extrapolated times to half recrystallization would not allow to operate the material at temperatures above 1100 ℃. Nevertheless, for all annealing temperatures a stagnation period in the evolution of the macro hardness was observed where the hardness loss and hence the degradation of mechanical properties halted for a significant amount of time, before it resumed. EBSD investigations revealed that the stagnation occurred when tungsten was still only partially recrystallized, and that recrystallization recommences afterwards. Such a temporary resistance against complete recrystallization and revealing its microstructural origin is of uttermost importance as its understanding could provide interesting insight in opportunities for designing tungsten material with improved thermal stability.

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