Halted recrystallization of warm-rolled tungsten in the temperature range from 1150 °C to 1300 °C

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Halted recrystallization of warm-rolled tungsten in the temperature range from 1150 °C to 1300 °C

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Pure tungsten is a potential candidate for armor material of fusion reactors and application at the desired operation temperatures for longer times will result in changes in the microstructure, in particular due to recrystallization, undermining tungsten’s outstanding performances. 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 °C to 1300 °C. Isothermal annealing treatments were performed at six different temperatures. With increasing annealing time, the macro hardness decreased and different stages corresponding to different stages of the microstructural evolution of recrystallization could be identified and confirmed by EBSD. For the time to half recrystallization, an activation energy comparable to the activation energy of bulk self-diffusion is inferred. For all annealing temperatures a stagnation period in the evolution of the macro hardness was observed where the degradation of mechanical properties halted for a significant amount of time, before it resumed. EBSD investigations revealed that this stagnation occurred when tungsten was still only partially recrystallized.

Recrystallized condition
- Fully recrystallized condition at an average of 357 HV10.

Microstructural evolution
- Hardness evolves with the microstructure:
  - Recrystallization causes softening
  - Recrystallization seemingly halted
  - Hardness evolution stagnates when partially recrystallized and halting period increases with decreasing temperature
  - Non-monotonous decrease in hardness prevents conventional JMAK kinetics studies.

Recrystallization
- Complete recrystallization takes place two halt stagnations
- Activation energy for recrystallization can only be inferred for times to half recrystallization

Plate / Microstruct. phenomenon | Activ. En. in kJ/mol
--- | ---
W/67 | 579 ± 7 %
W/80 | 548
W/90 | 352 ± 4%
Self-diffusion | 628 – 586
Grain boundary diffusion | 460 – 377

Table 1: Activation energies for recrystallization in plates rolled to different reductions and main diffusion mechanisms

Conclusions and Outlook
- Recrystallization in the plate takes place through stagnation and resume
- Texture analysis can provide insights on mechanical properties stagnation in time.