TEM characterization of self-ion damaged polycrystalline W and W alloy

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Introduction

W and W alloys are proposed as promising candidates for plasma facing components in fusion TOKAMAKS. However, the microstructural aspect of their radiation damage behaviour has not been systematically investigated. This work aims to contribute by a series of TEM experiments on self-ion-irradiated tungsten alloys, to investigate the influence of grain orientation, material purity and alloying elements on the damage produced, and the underlying damage mechanisms.

Experiment

Materials (~150μm foils supplied by Plansee Gruppe)

- Commercial grade polycrystalline W (>99.97wt%; C: 30ppms; P, Si, O: 20ppms each)
- Ultra high purity polycrystalline W (>99.9999wt%; C: 10ppms; P: <10ppms; Si: 5ppms)
- W-5wt.%Re
- Annealed at 1400°C for 20hrs prior to irradiation.

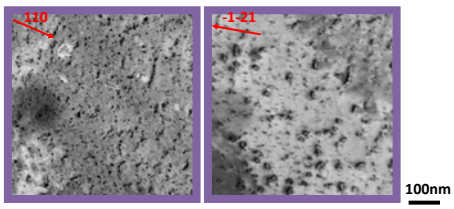
Irradiation

- Self-ion implantation as an analogue of neutron irradiation.
- Condition: 2MeV W^+, 500°C, $3.3\times10^{13} W^+/cm^2$ (~0.5dpa)

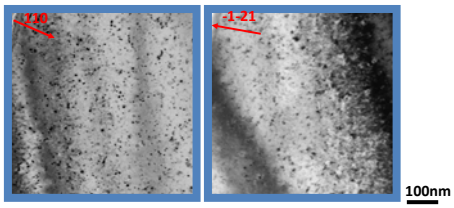
Microstructure

Commercial grade poly-W

- *(113)-oriented grain*



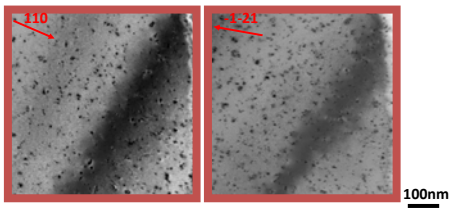
- *(001)-oriented grain*



Effect of grain orientation:
Loop coalescence is significantly favoured in (113) grain orientation.

Ultra high purity W

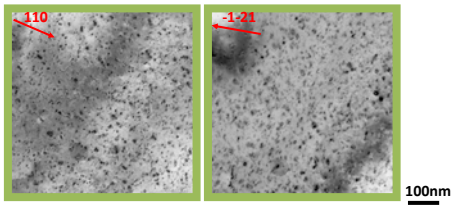
- *(001)-oriented grain*



Effect of material purity:
Loop size increases, density decreases with the increase of purity level.

W-5wt.%Re

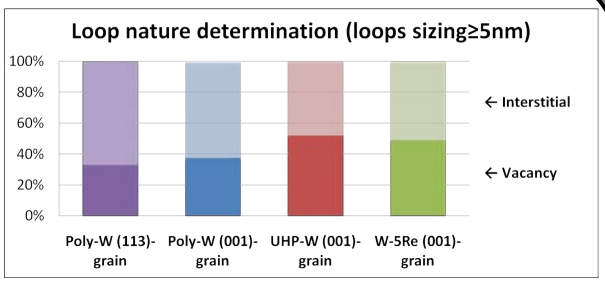
- *(001)-oriented grain*



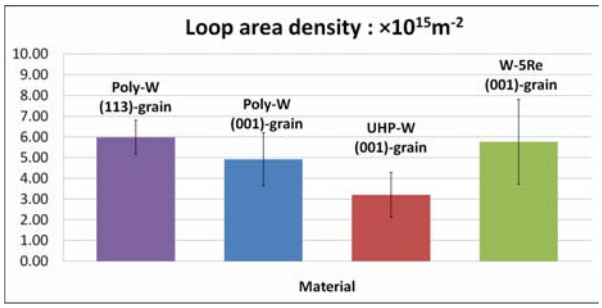
Effect of alloying element Re:
Re suppresses loop growth and coalescence.

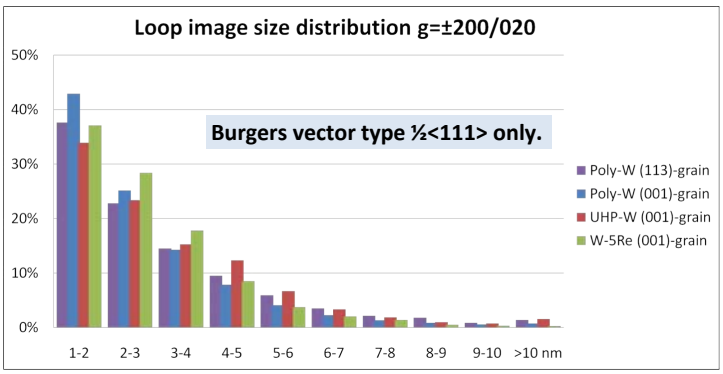
Loop characterization

(113)-grain, poly-W
⅔ loops are interstitial , corresponding to coalesced loop strings. Loops sizing restriction due to inside-outside contrast may be responsible for the small Va loop content detected.



(001)-grains
Va and I-type loops are nearly equal in quantity. Both Re and impurities suppress loop growth and results in higher loop density than UHP-W. Impurities in poly-W show a slightly stronger suppression effect.





Conclusions

½<111> loops only are observed in self-ion damaged W and W alloys at 500°C; nearly equal number of Va and I-type loops are present in (001)-grains.
(113)-orientation favours loop coalescence among interstitial type loops.
Both Re and impurity atoms suppress loop growth; impurities have the stronger effect.

Acknowledgements

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