

Towards viable nuclear fusion reactors 2

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Towards viable nuclear fusion reactors

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Research goal: Can the heat extractor (divertor) withstand the extreme loads in a future fusion reactor for a sufficient amount of time?

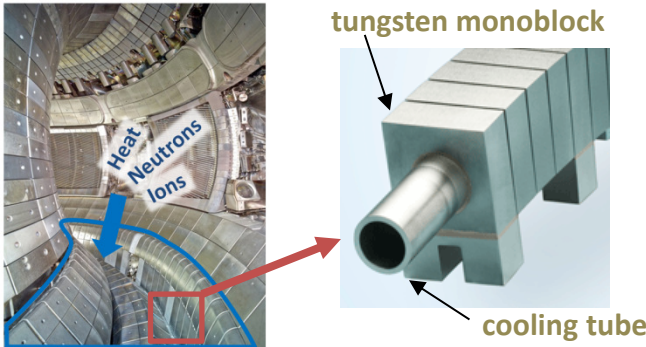
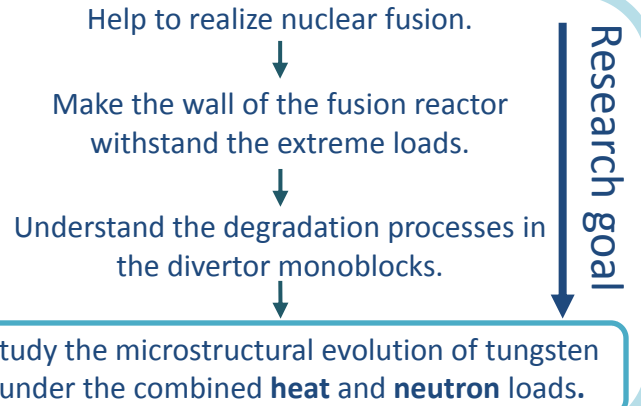
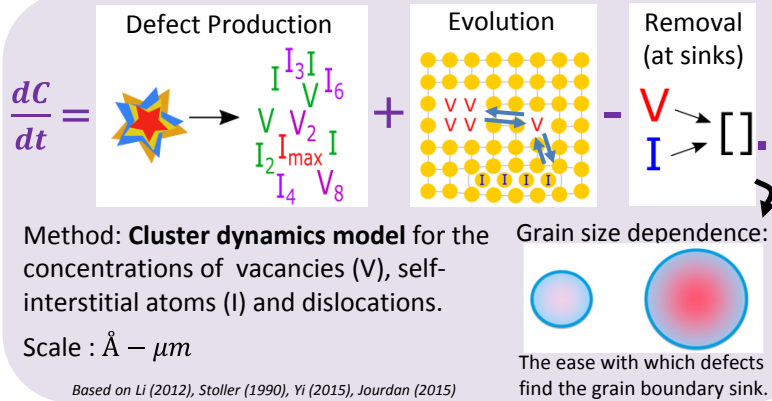


Figure 1: the divertor in the JET reactor (www.iter.org, left) consists of many tungsten monoblocks (on the right).



Method 1 Grain level: neutron damage



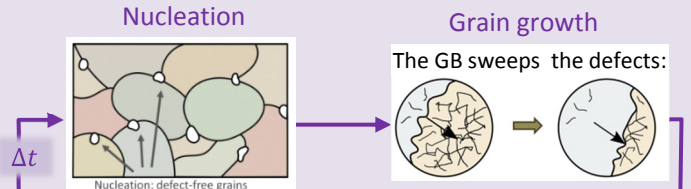
2 Polycrystal level: recrystallization

Mean-field model (Scale 1-100 μm)

Microstructure: a set of representative grains.

- Radius r
- Defect densities ρ, C_I^m, C_V^n
- # of represented grains N

Each grain interacts with the average microstructure medium.



Nucleation depends on:

- GB (grain boundary) mobility
- Defect density: **stored energy**
- GB surface area

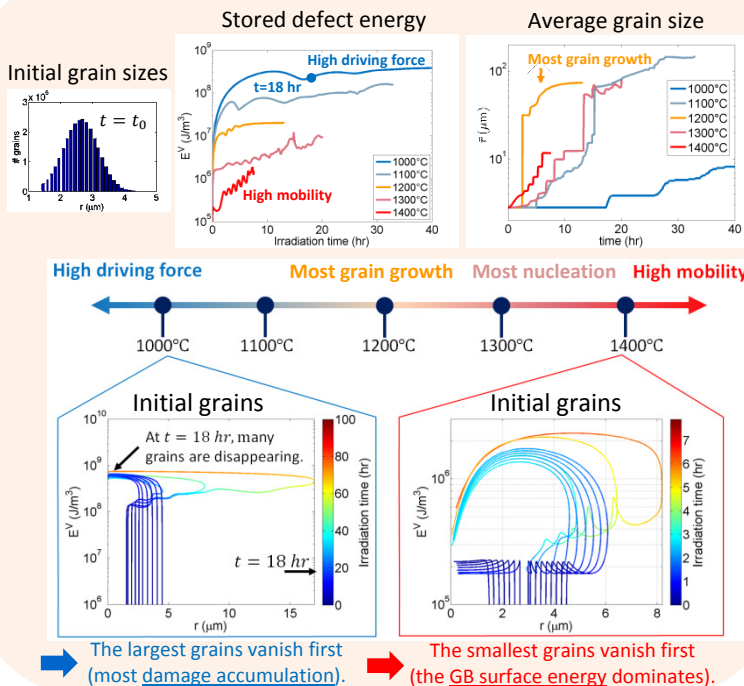
Grain growth is based on the velocity of the grain boundaries:

$$v = m(T) \Delta E_{\text{average}} / \text{grain}$$

GB mobility \swarrow Defect density \searrow

Based on Bernard (2011), Lopez (2015)

Results Microstructural evolution



Damage accumulation vs. recovery



- Defect accumulation / GB mobility / point defect mobility / nucleation rate / individual grain behavior can all be studied with this model.
- Pace of renewal of the microstructure.

Conclusions/Outlook

- The multi-scale model for the microstructural evolution of tungsten under heat and neutrons shows to be a versatile tool to study the temperature dependent **stability** of the original microstructure and the **competition** between the various processes for **damage** and **recovery**.
- In future, **lifetime** of the divertor monoblocks will be studied by combining the (stress-dependent) microstructural model with a mechanical **FE analysis**.