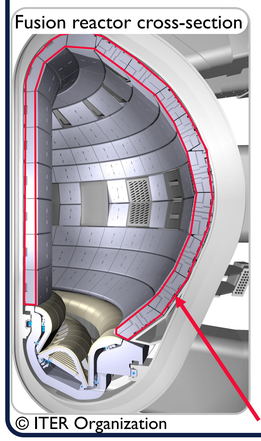
New Zirconium Alloys for Nuclear Fusion Applications

Bradley Young*; Junliang Liu; David Armstrong; Chris Grovenor
Department of Materials, University of Oxford, Parks Road, Oxford, OX1 3PH; *bradley.young@materials.ox.ac.uk

1. Engineering Context



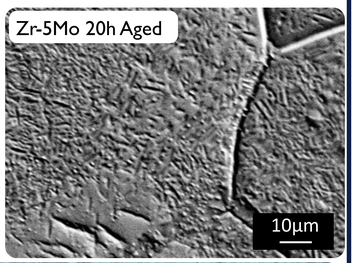
Generating electricity from fusion power will require materials to perform in challenging environments.

I am exploring whether new zirconium alloys could hold the answer to realising a liquid lithium breeder blanket design.

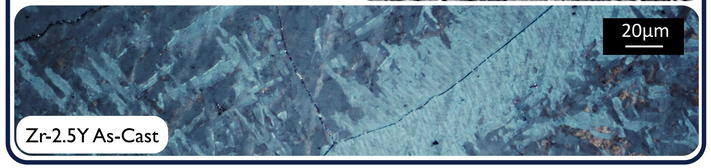
Breeder blanket modules

2. Techniques

Promising high temperature alloys are cast and thermo-mechanically processed.

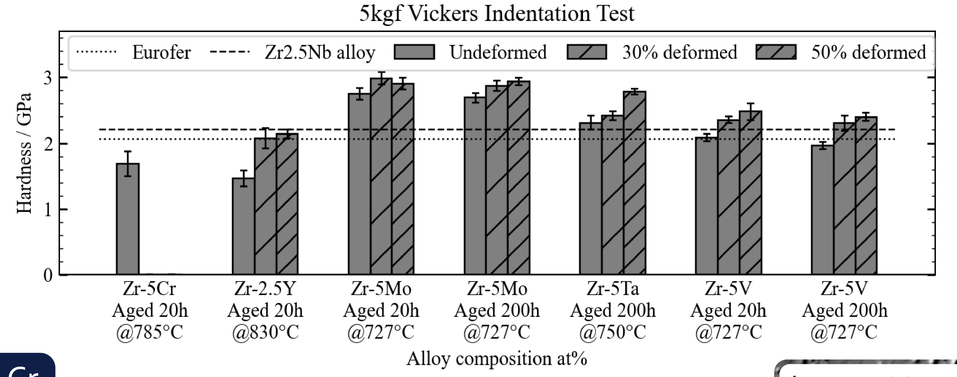


Microstructural characterisation of all alloys using OM, SEM, EDX, XRD, and mechanical testing.



3. Results

Alloys aged 50°C below first phase transformation temperature in binary phase diagram



Zr-Cr

Very small strengthening effect. Solute segregation to grain boundaries upon ageing.

Zr-Mo

Metastable omega phase presence decreases with ageing, increases hardness but probably reduces ductility.

Zr-Ta

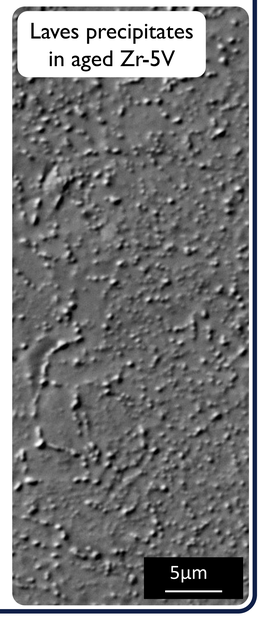
Promising mechanical properties.
α-β-phase strengthening rather than laves phases.

Zr-Y

Poor strengthening but promising at higher temperatures.
Grain boundary effects appear significant.

Zr-V

Promising mechanical properties. Good precipitate distribution. No significant grain boundary effects.



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4. Conclusions

Zr alloys show promise for fusion applications

Most Promising

Zr-Ta Zr-V Hardness greater than commercial alloys, further testing required.

Zr-Mo High hardness due to metastable ω-phase, formation of ω needs preventing.

Zr-Y Poor hardness becomes moderate with deformation.
Promising for higher temperature testing.

Zr-Cr Solute segregation and poor strengthening; investigation discontinued.

Least Promising

5. Further work

Zr-Al Research dilute Zr-Al system.

Thermo-mechanical processing to mirror commercial microstructure. **Processing**

Liq. Li Investigate corrosion behaviour in liquid Li.

Microstructural stability at elevated temperature for extended times. **Stability**

Creep Creep and/or stress relaxation testing.

Mechanical testing at elevated temperature: Hardness, Creep, etc. **High Temp**