Karlsruher Institut für Technologie

Microstructural characterizations of hot rolled ferritic ODS alloys

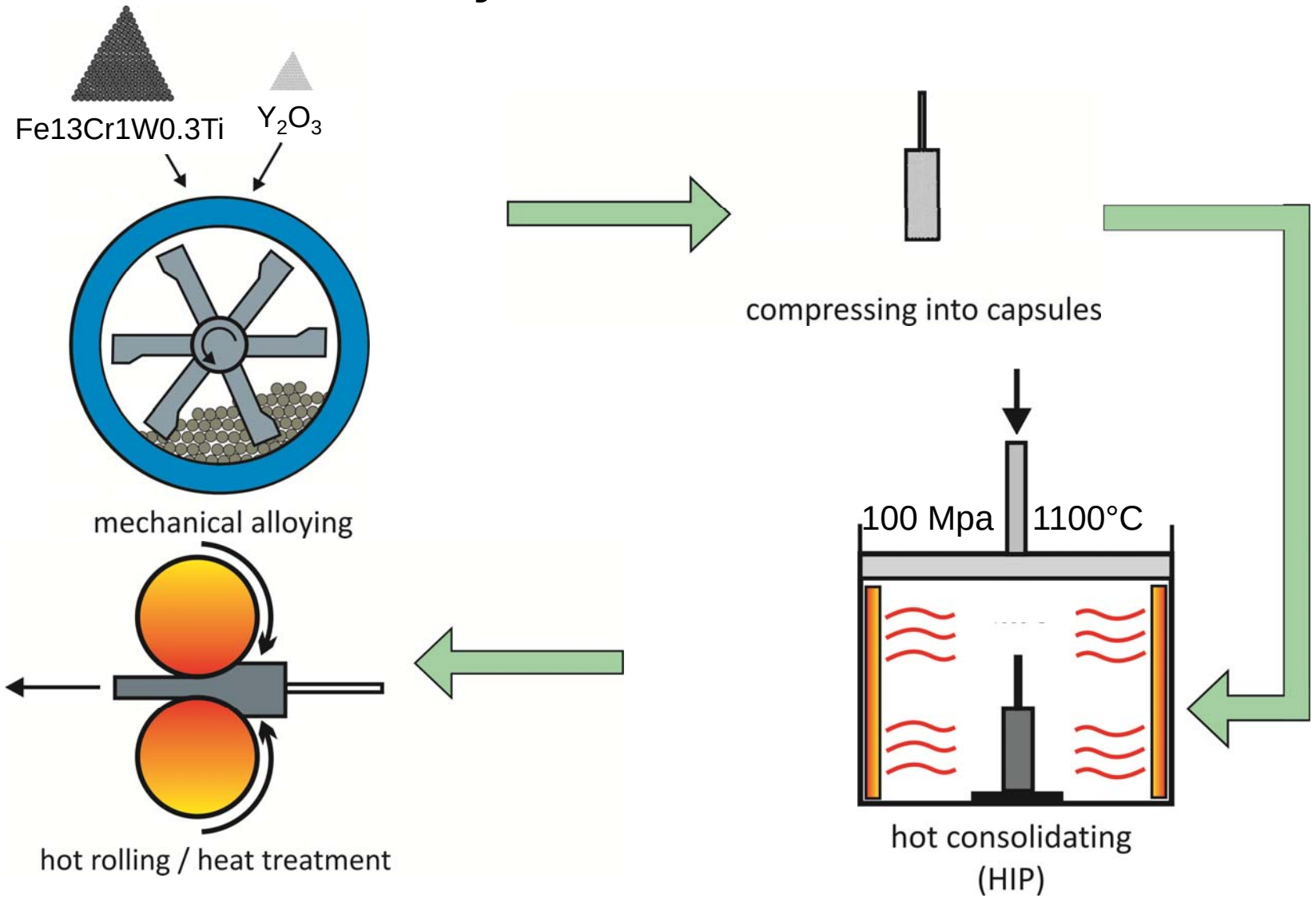
Jan Hoffmann

Institute for Applied Materials (IAM-AWP)

Contents

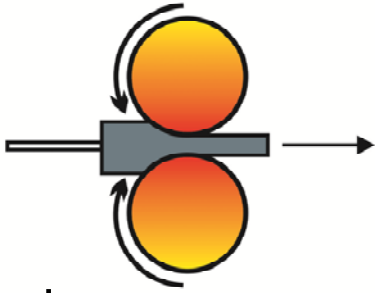
- Introduction
- Production of ODS alloys
- Mechanical tests
- EBSD measurements
- Outlook

Production of ODS alloys



Production of ODS alloys

Compacting of the powders containing the different oxides:



- HIP at 1100°C / 100 MPa for 2 hours
- Hot-rolling at 1100°C
- Reduction from 45 mm diameter to 6 mm thickness
- 5 passes needed for final shape, with reheating after each pass

TU Clausthal

Alternative ODS particles

Pre-alloyed powder:

Fe13Cr1W0.3 + 0.3 wt.% *oxide*

oxide	Y_2O_3	La_2O_3	Ce_2O_3	ZrO_2	MgO
atomic weight of oxide [g/mol]	225.8	325.8	328.2	123.2	40.3
atomic percent of oxide in alloy [at.%]	0.074	0.051	0.051	0.136	0.414

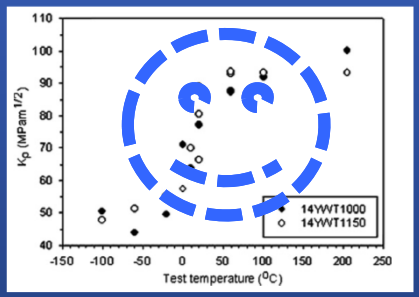
- 0.3 wt% of oxide powders added for mechanical alloying

Conclusion and Outlook

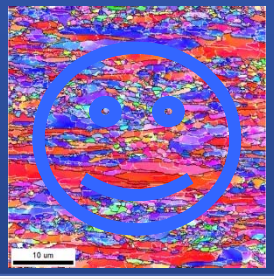
work ~~planned~~ done at the Materials Department

FIB (Channeling)
microstructure char.

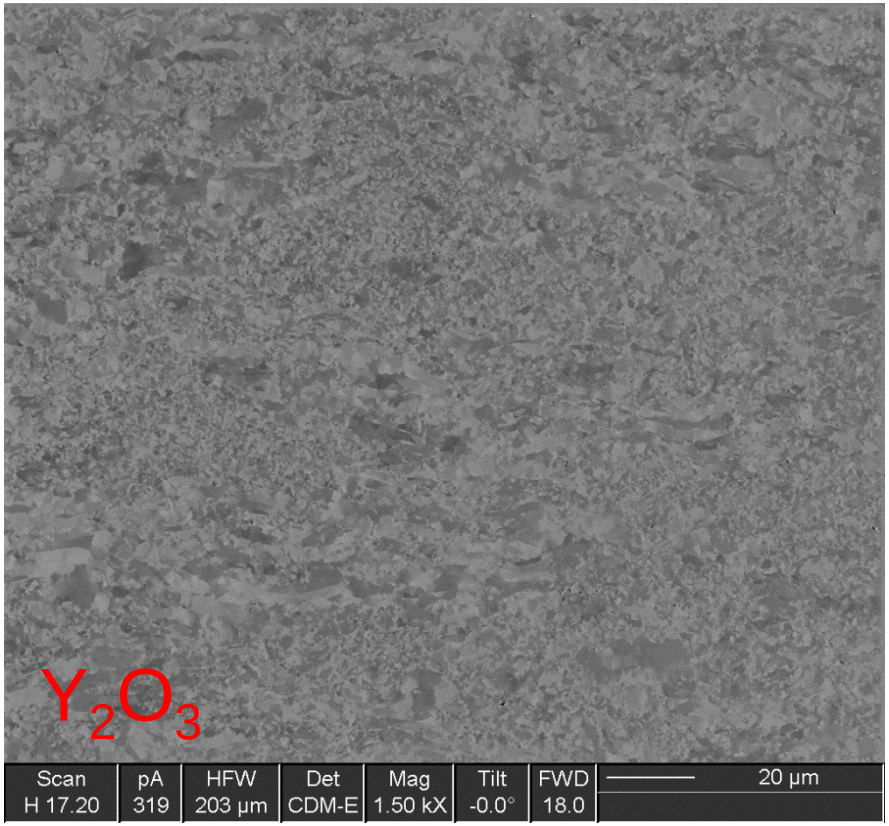
4-point-beding-tests
(fracture-toughness)

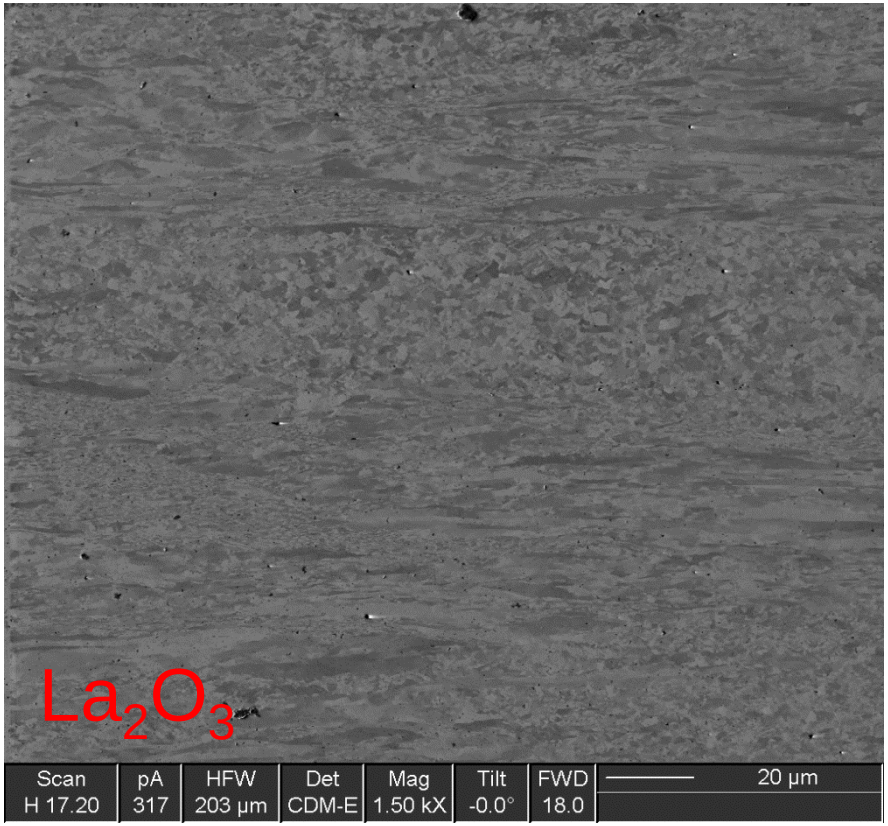


EBSD
on rolled and extruded
materials



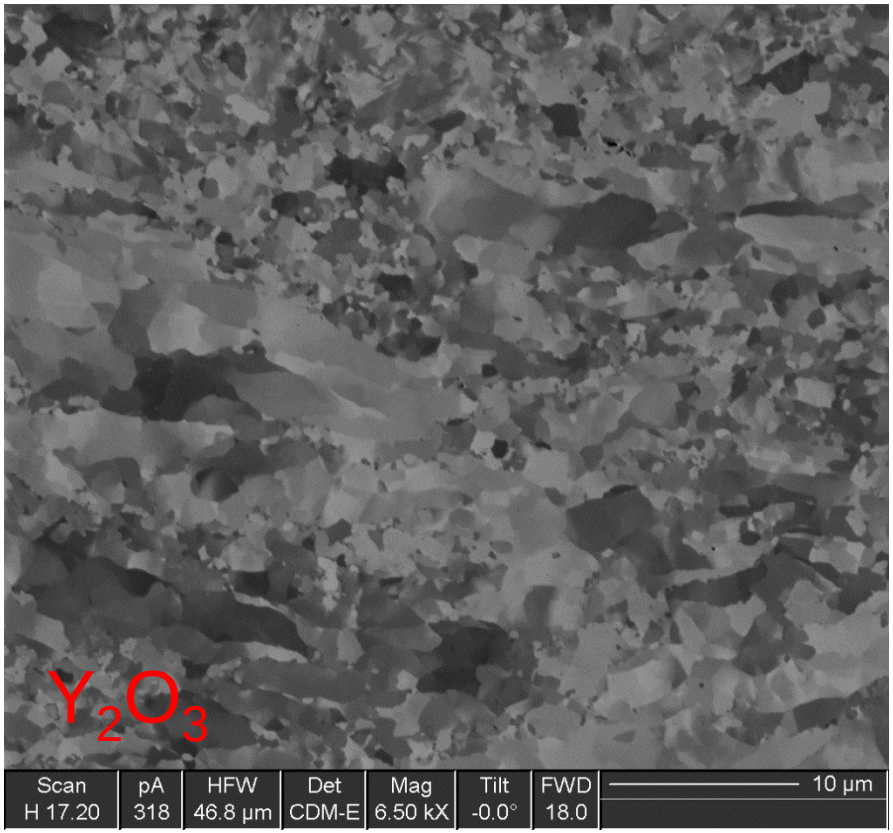
Alternative ODS particles - FIB

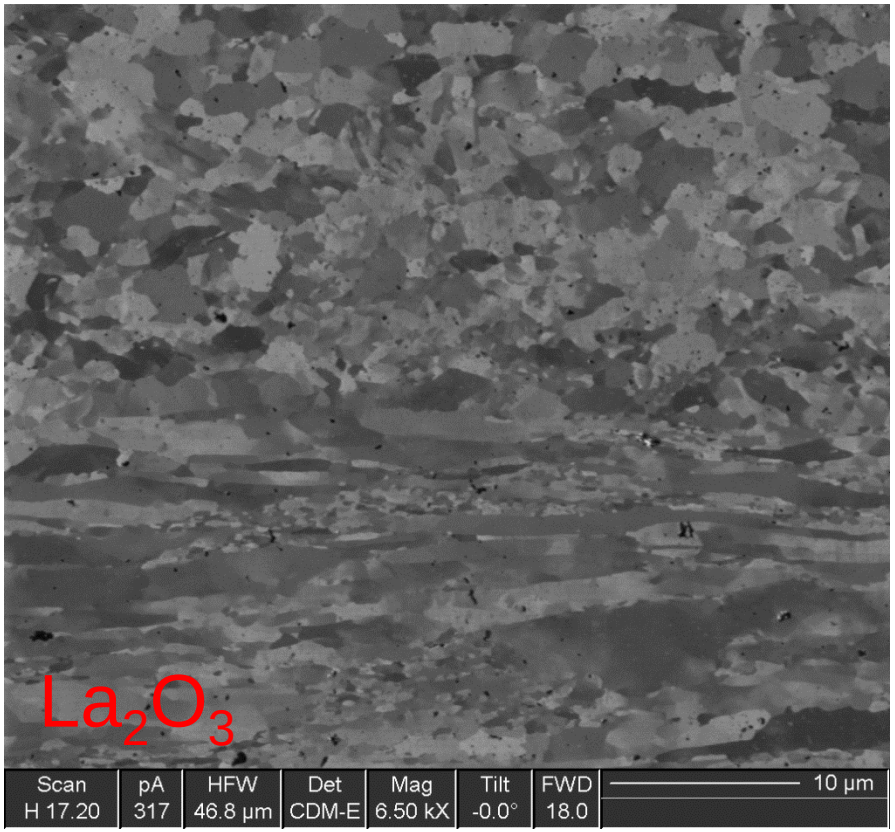




- bi-modal microstructure
- elongated + equiaxed grains

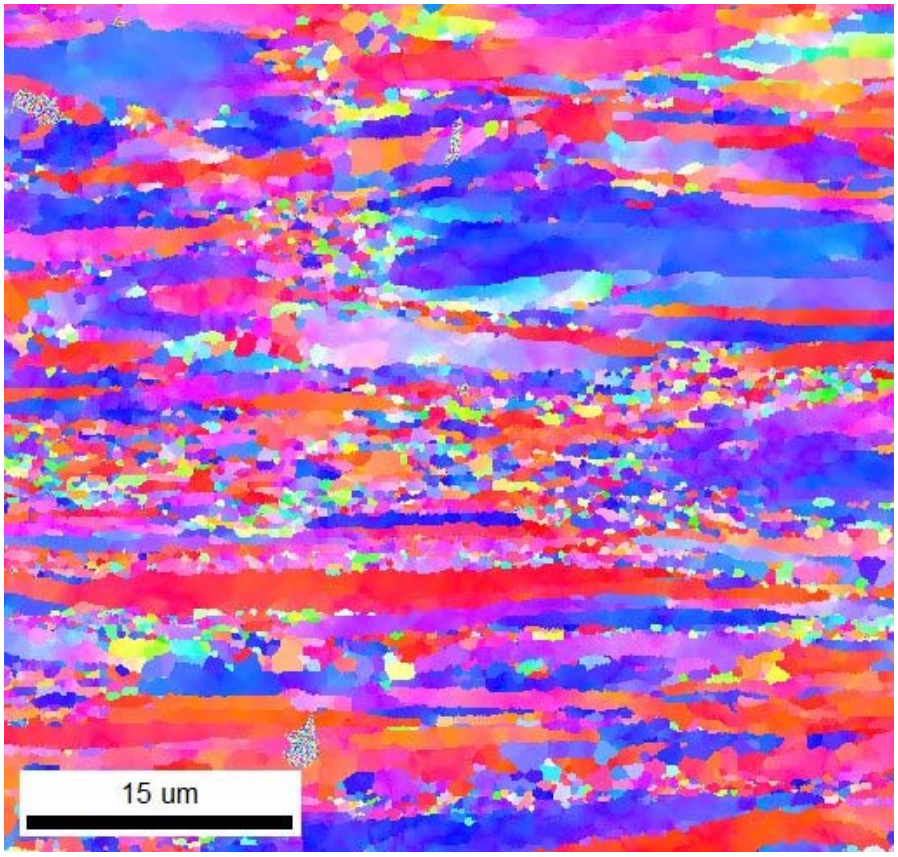
Alternative ODS particles - FIB





- recristallized grains surrounding elongated, unrecrystallized grains

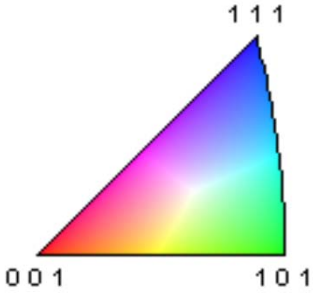
Alternative ODS particles - EBSD



Fe13Cr1W0.3Ti + La_2O_3

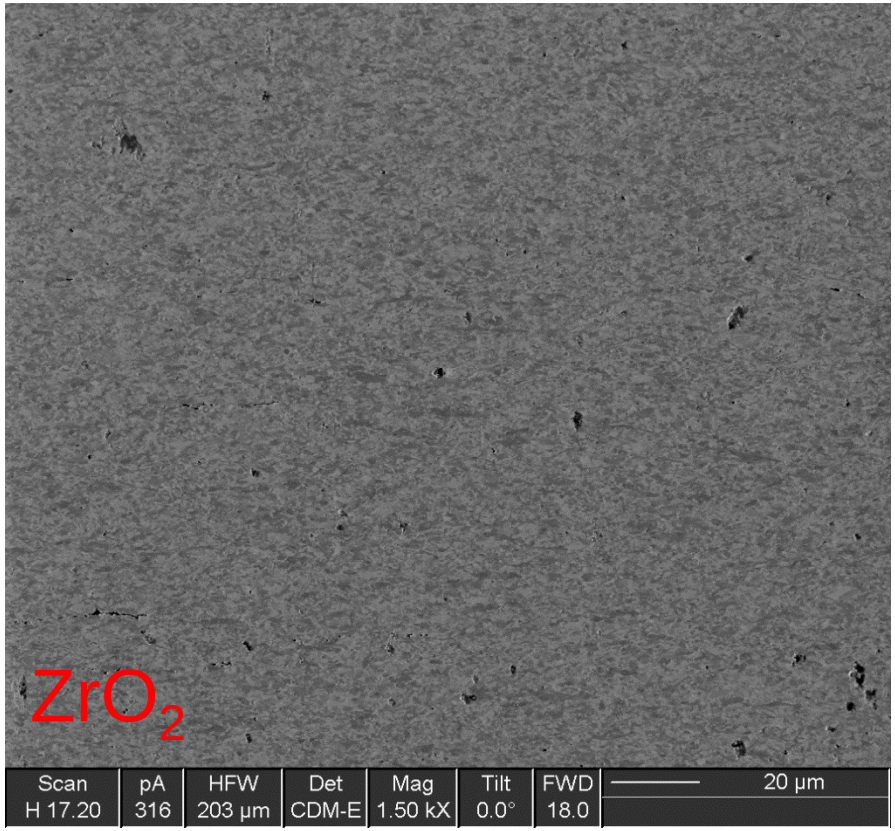
Color Coded Map Type: Inverse Pole Figure [001]

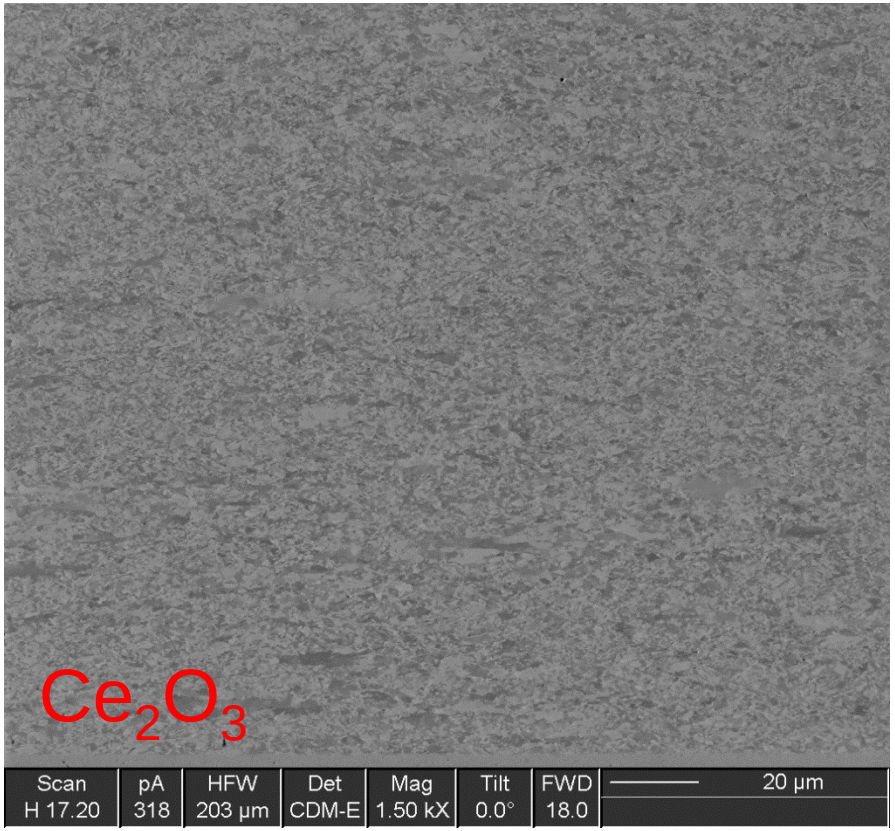
Iron - Alpha



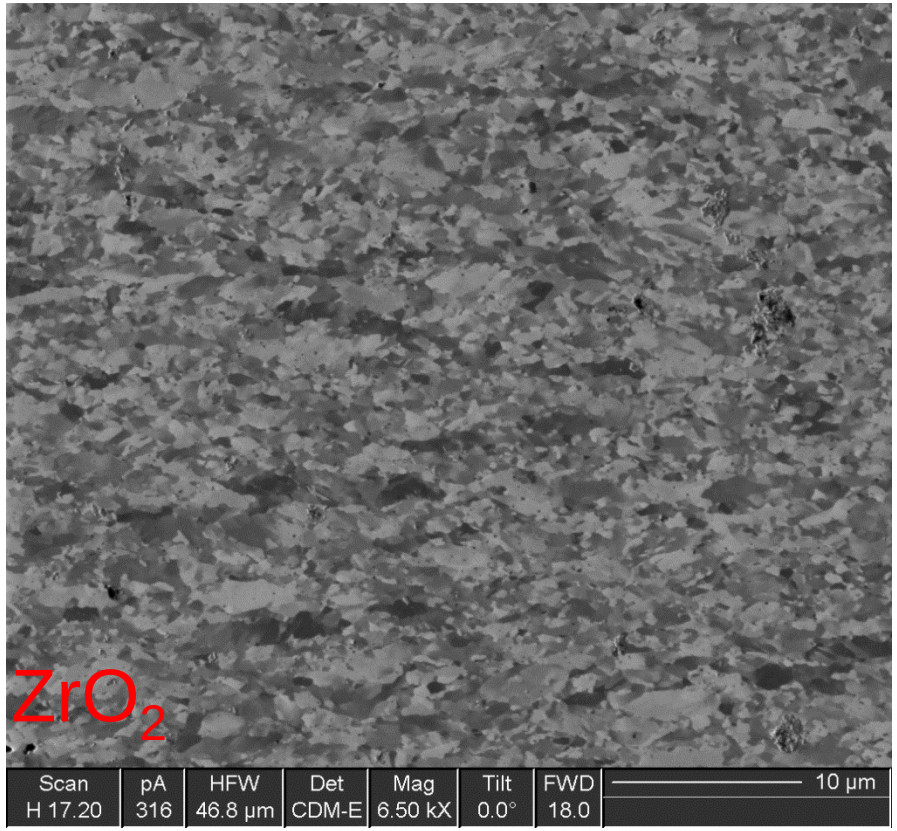
RD

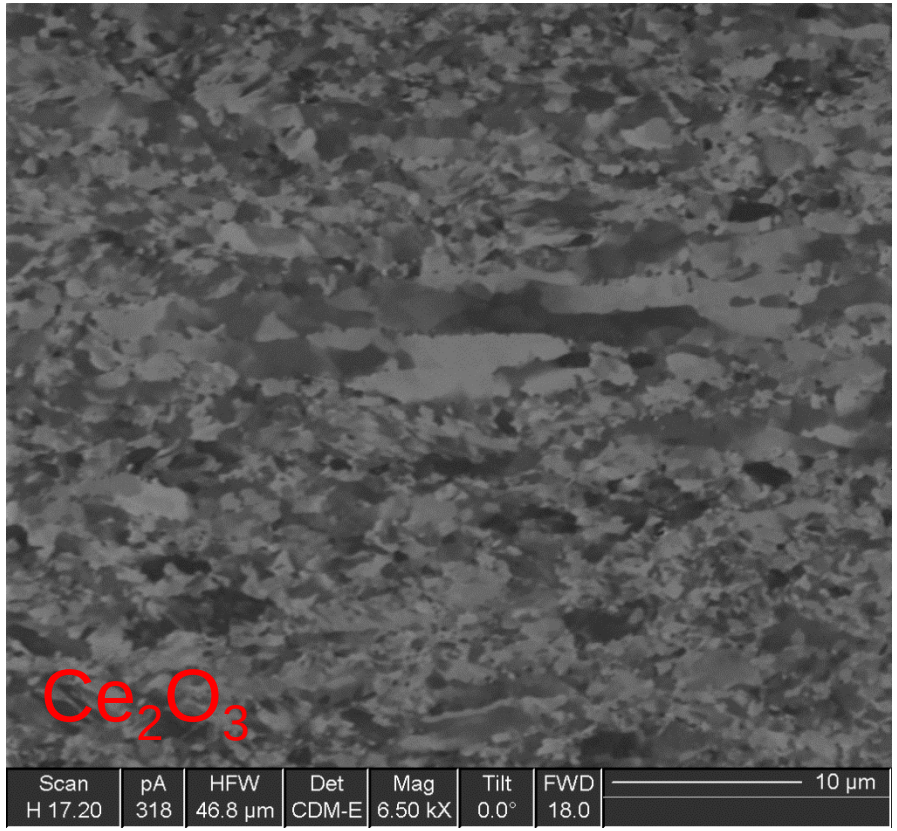
Alternative ODS particles - FIB





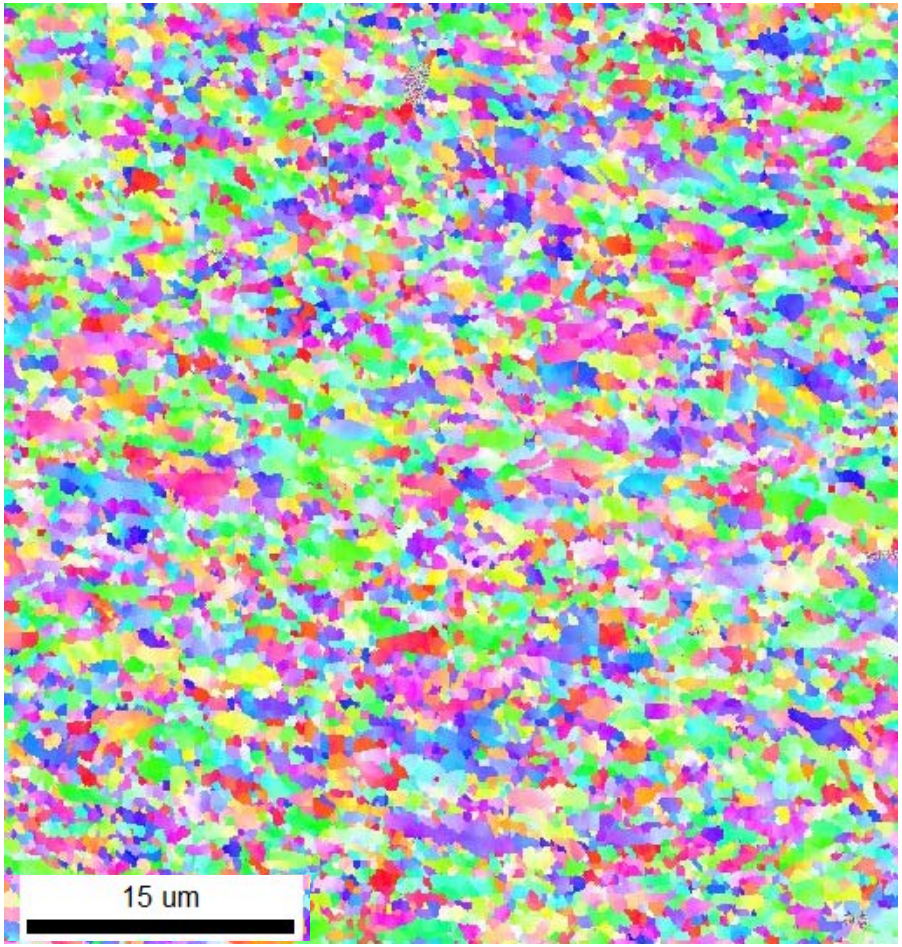
Alternative ODS particles - FIB



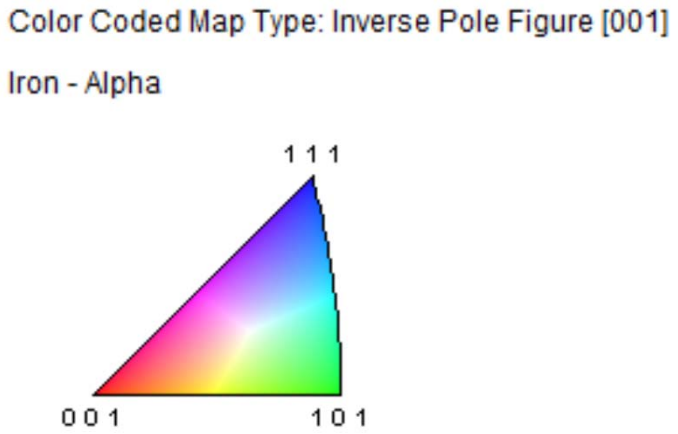


- (nearly) fully recrystallized structure
- only very little elongation visible

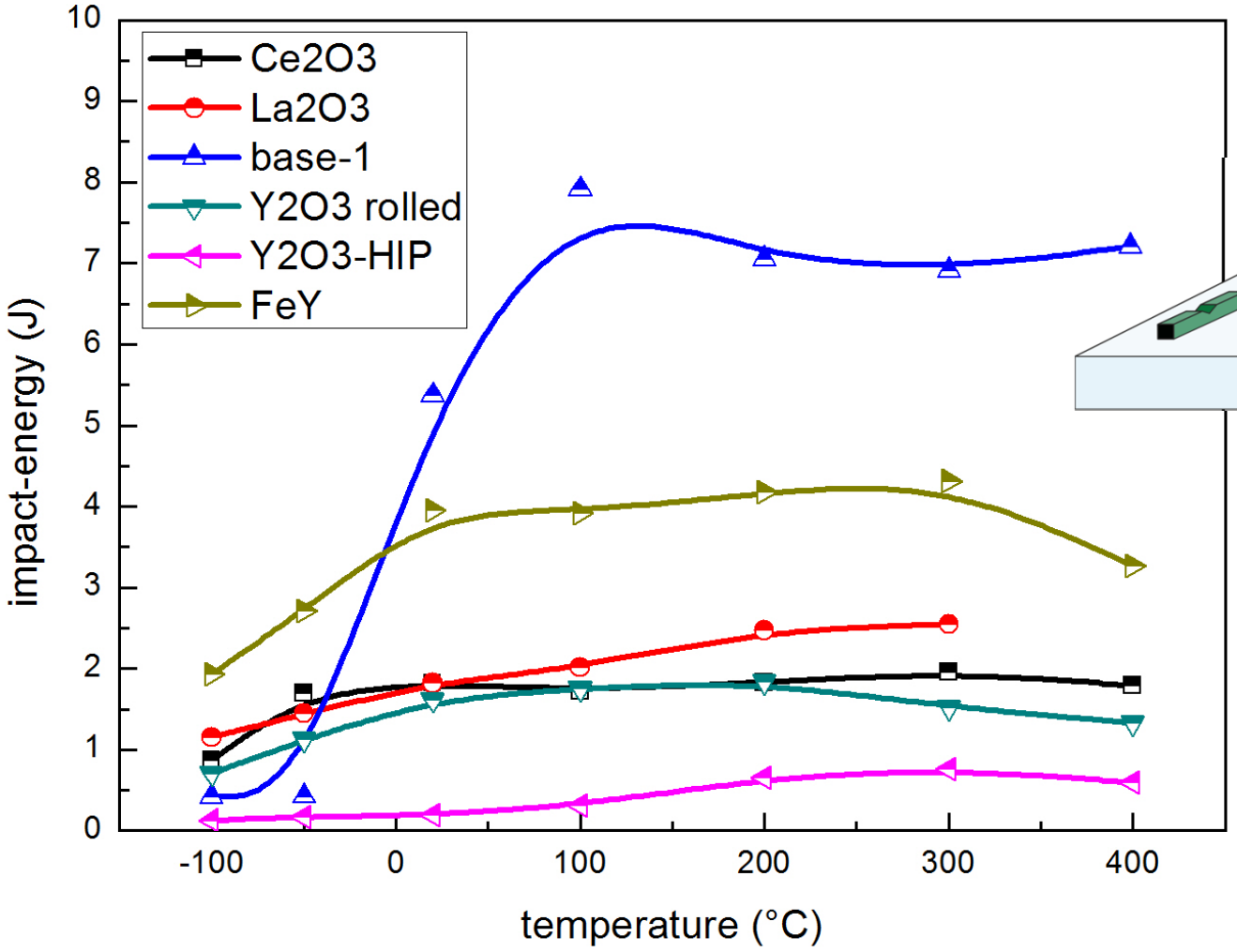
Alternative ODS particles - EBSD

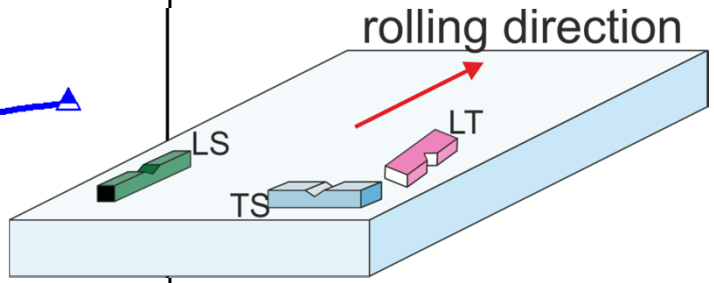


Fe13Cr1W0.3Ti + $\mathbf{ZrO_2}$



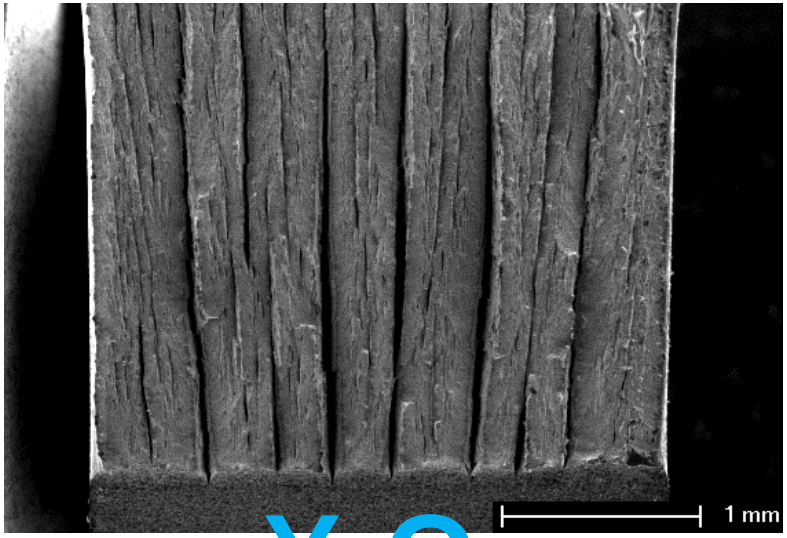
Mechanical tests (charpy-impact test)





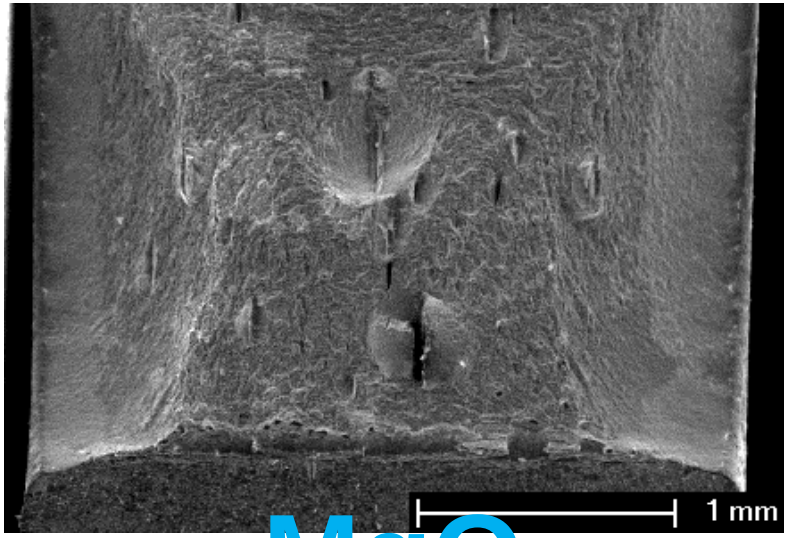
All specimens
in LT- orientation

Mechanical tests (charpy-impact test)



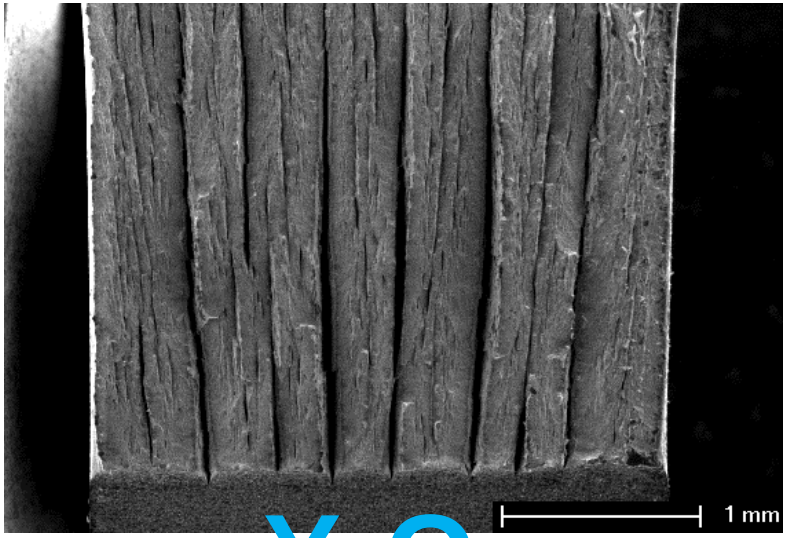
Y_2O_3

RT

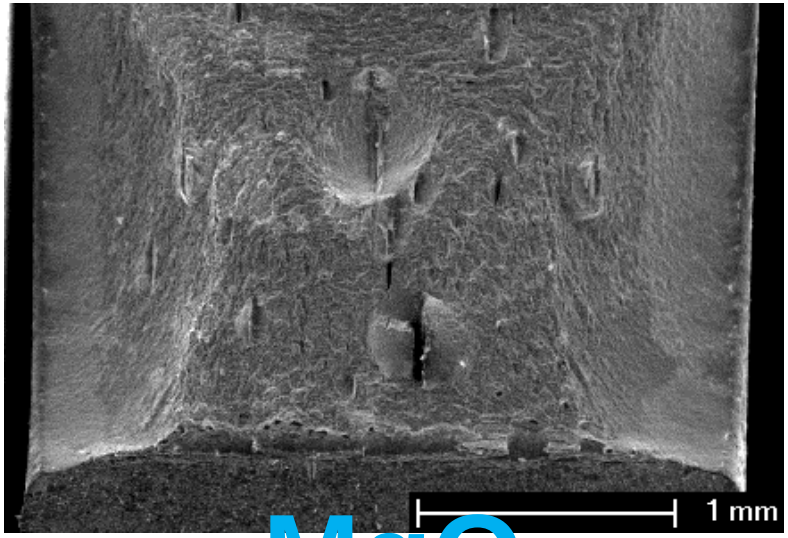


MgO

Mechanical tests (charpy-impact test)

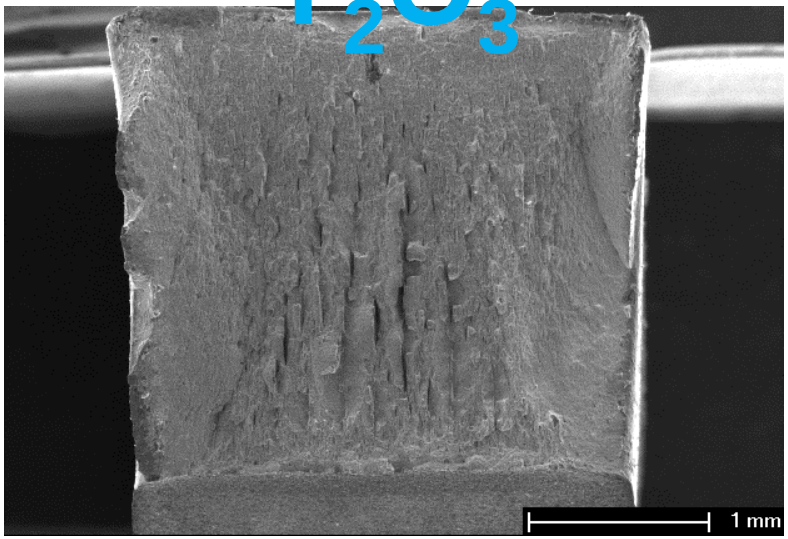


RT

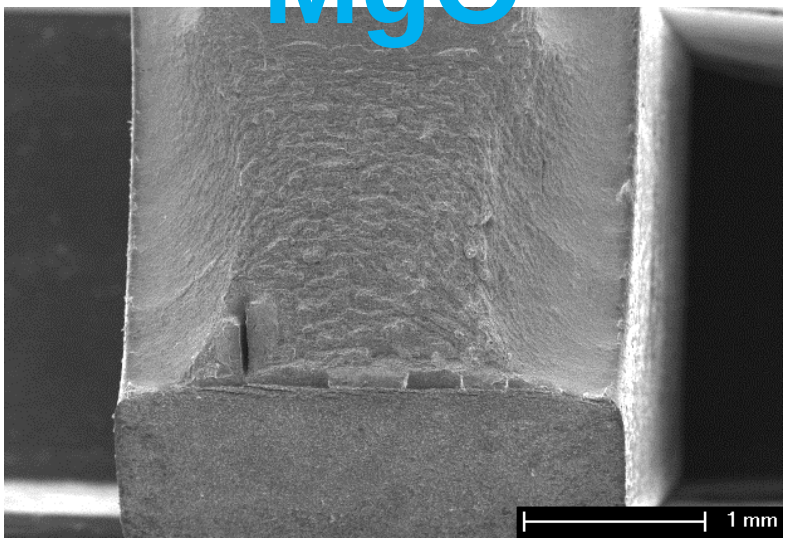


Y_2O_3

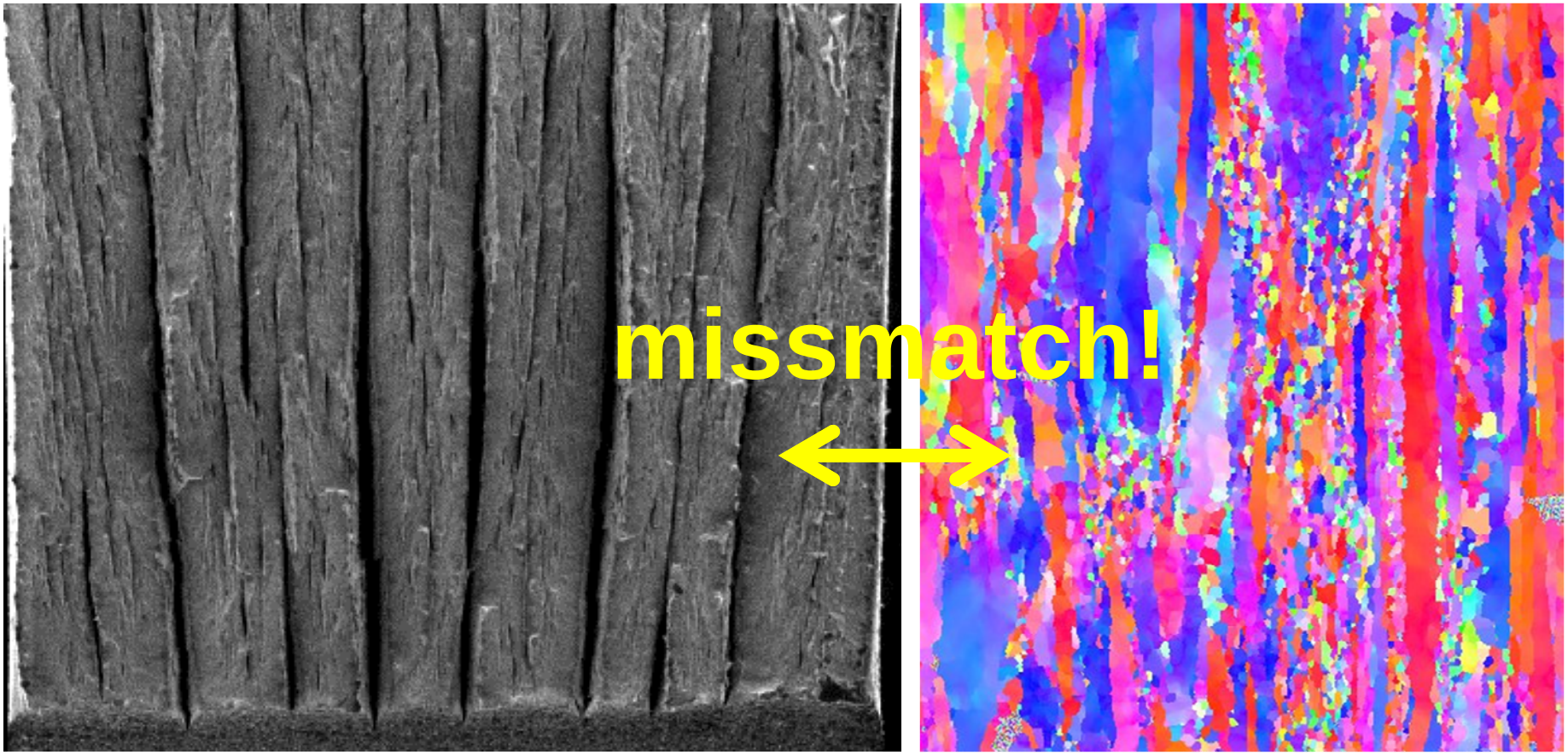
MgO



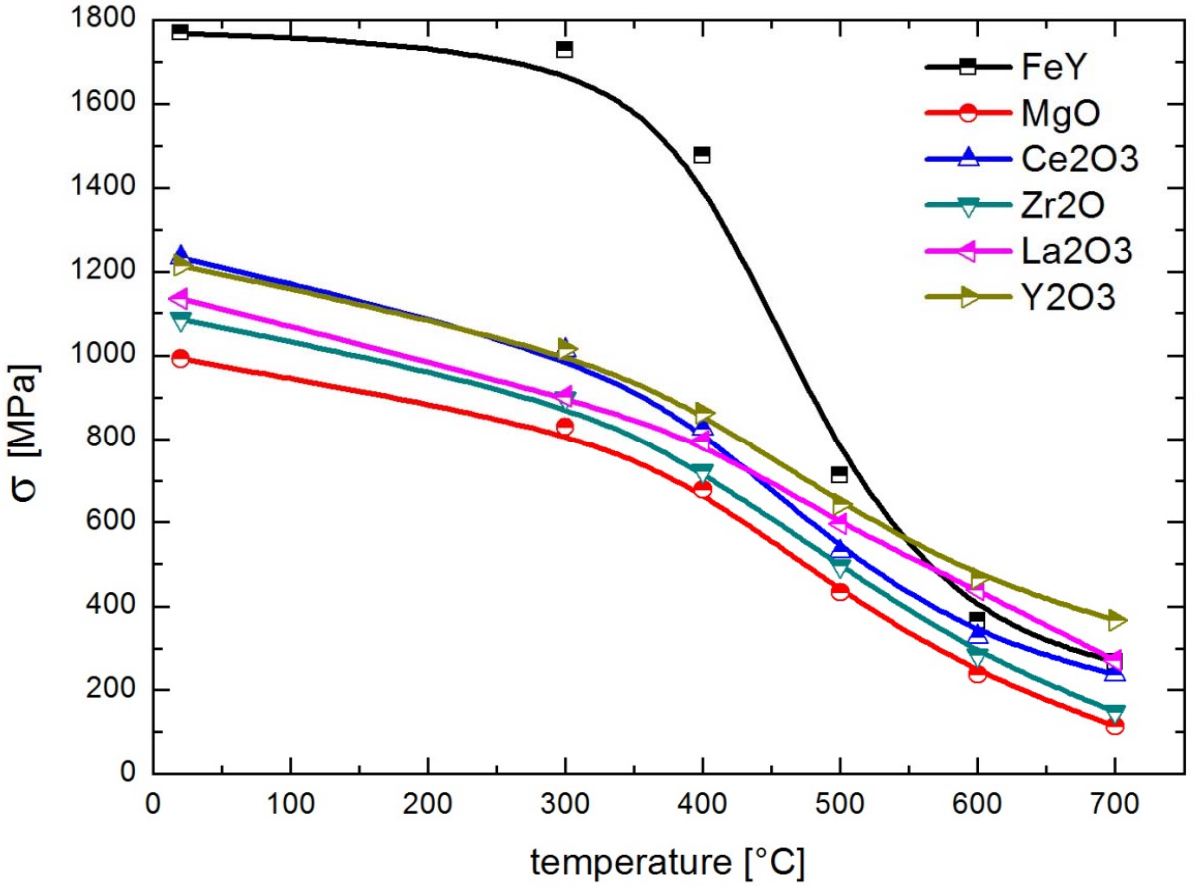
300°C



Mechanical tests (charpy-impact test)

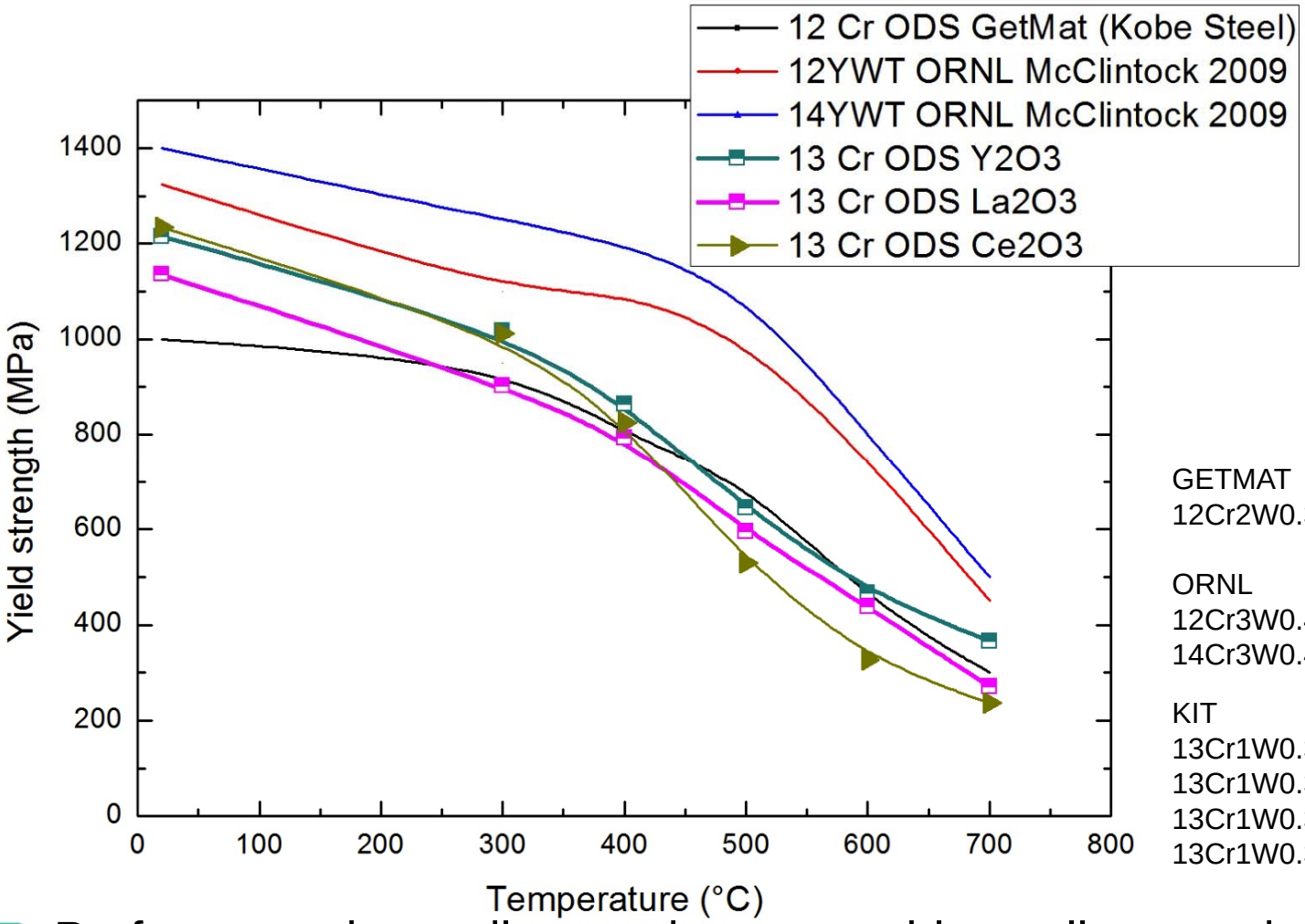


Mechanical tests (tensile tests – yield strength)



- Y-containing alloys show the best results
- Most alloys perform in a similar way

Comparison of 12Cr, 13Cr and 14Cr ODS



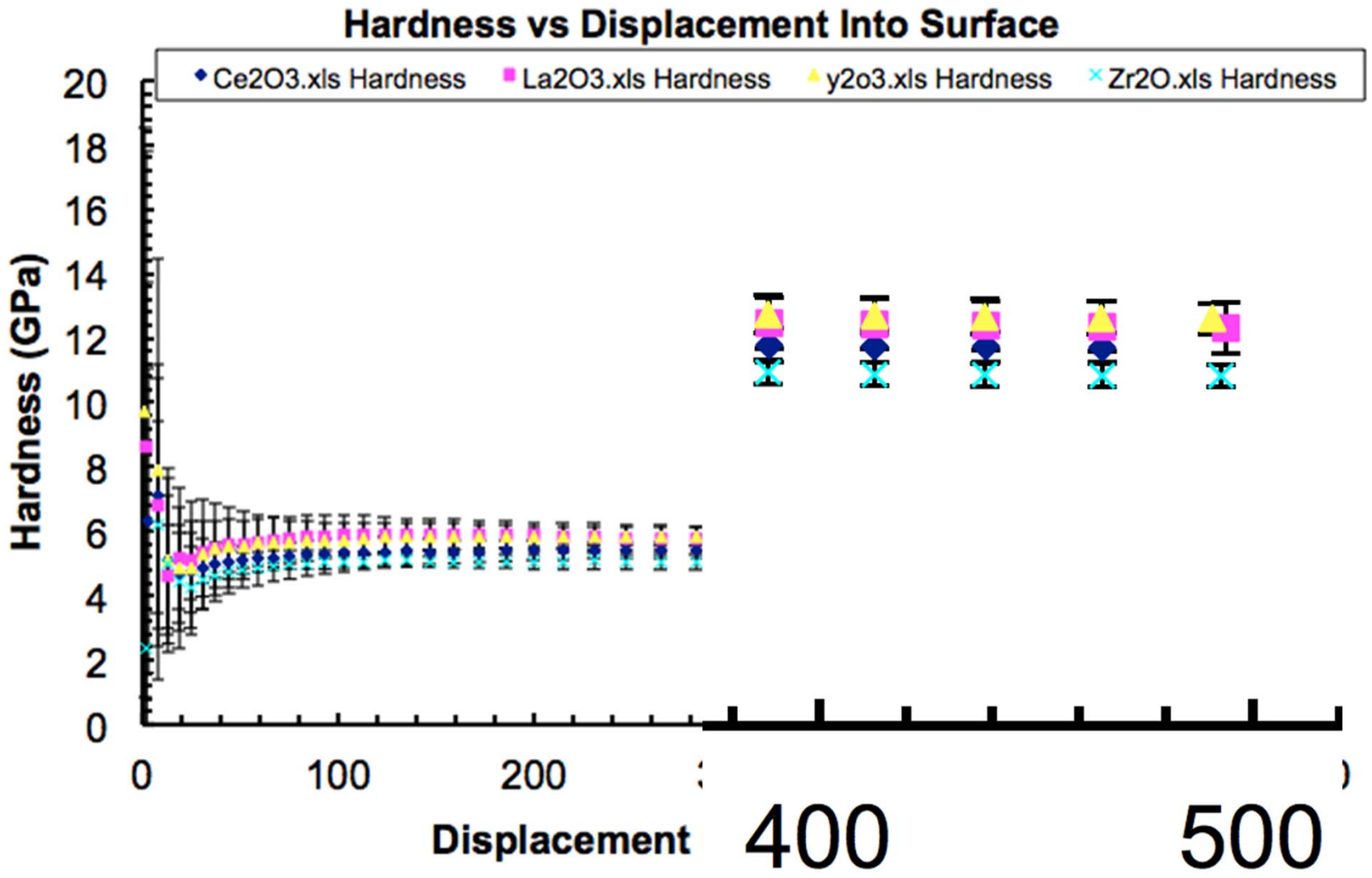
GETMAT
12Cr2W0.3Ti 0.2 Y_2O_3

ORNL
12Cr3W0.4Ti 0.25 Y_2O_3
14Cr3W0.4Ti 0.25 Y_2O_3

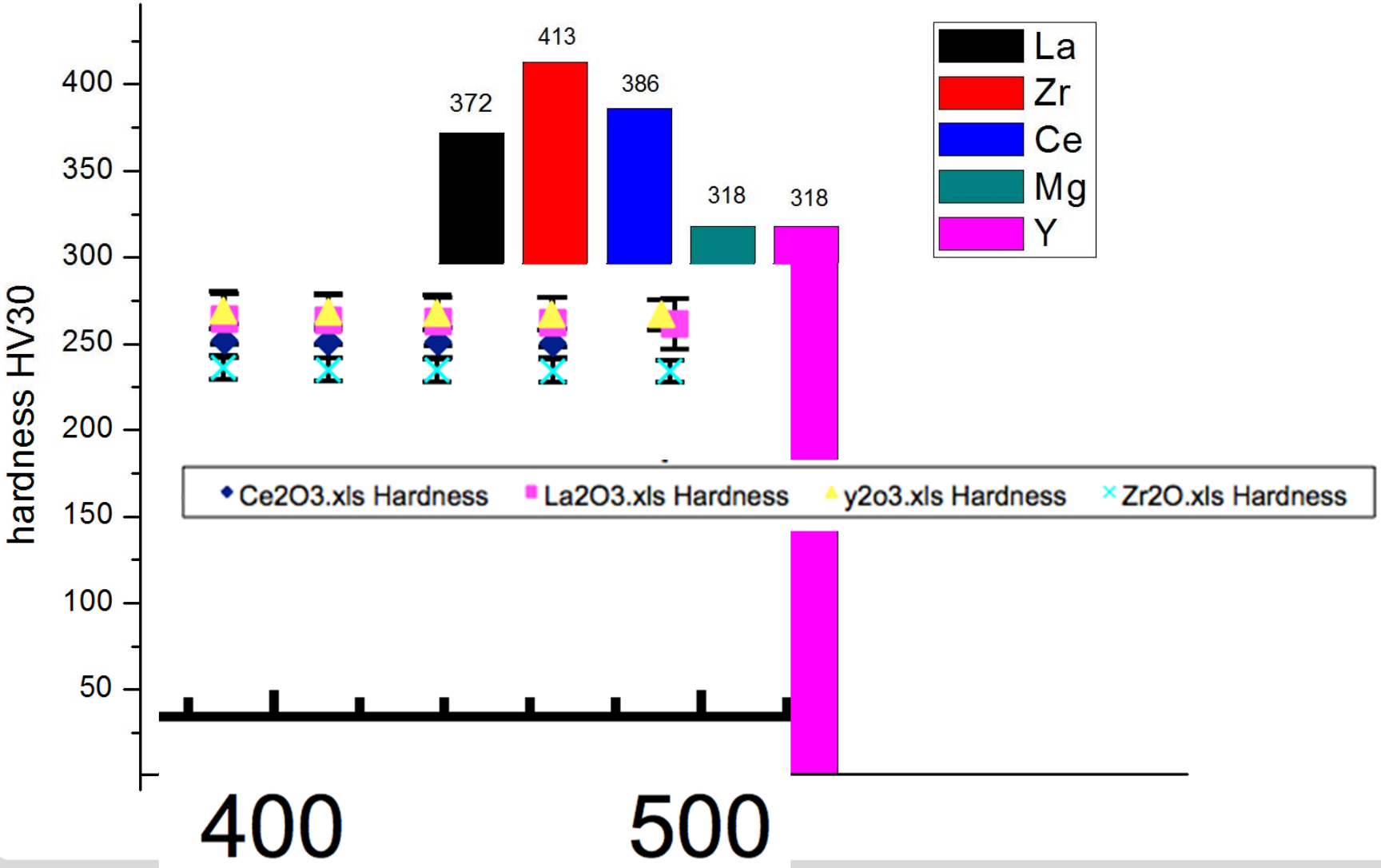
KIT
13Cr1W0.3Ti 0.3 Y_2O_3
13Cr1W0.3Ti 0.3 La_2O_3
13Cr1W0.3Ti 0.3 Ce_2O_3
13Cr1W0.3Ti 0.3 Fe_2Y

- Performance in tensile tests is comparable to alloys produced at other facilities

Nanoindentation / Hardness



Nanoindentation / Hardness (Vickers)



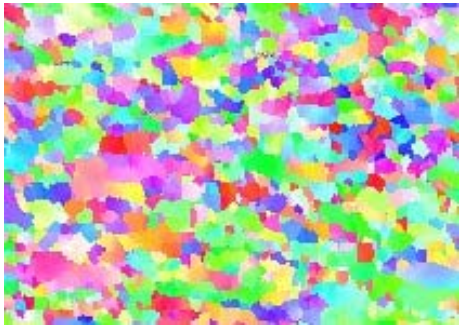
Summary (1)
Two different types of microstructure

elongated / equiaxed bi-modal structure **$La_2O_3 + Y_2O_3$**

- bi-modal grain sizes (sub-micron + several micron)
- partially recrystallized

uniform (equiaxed) structure **$Ce_2O_3 + MgO_2$**

- uniform grain size distribution (~ 1 – 2 µm)
- homogeneous microstructure
- not fully recrystallized



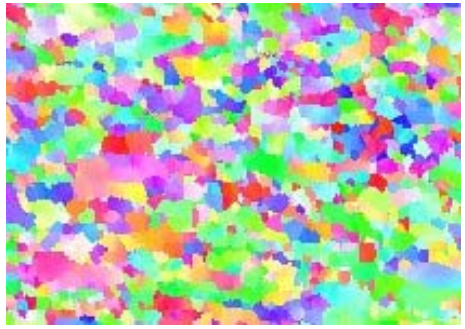
Summary (2)
Different mechanical properties

elongated / equiaxed bi-modal structure **$La_2O_3 + Y_2O_3$**

- good mechanical properties
- moderate charpy impact results
- lamella structure not caused by bi-modal structure
- best tensile results

uniform (equiaxed) structure **$Ce_2O_3 + ZrO_2$**

- nearly no charpy impact energy (ZrO_2)
- not fully recrystallized



Summary (3)
open questions

- recrystallized structure, or immediate microstructure?
- cause of the elongation of some grains?
- cause of the lamella structure on the fracture surfaces?
  - comparison with other bcc metals (tungsten)?
- qualitative difference of micro-hardness and Vickers-hardness?
  - Strain rate dependant?

final conclusions

final conclusions to be drawn at the Royal Oak, today at 5pm

Thank you for your attention!