Karlsruher Institut für Technologie

# Current status of the KIT ODS steel development programme

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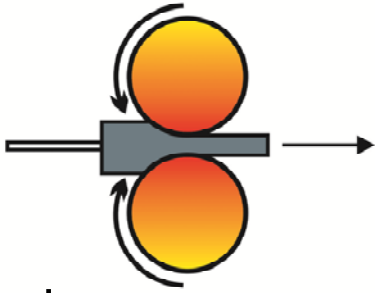
Institute for Applied Materials (IAM-AWP)

## Contents

- latest production of ODS alloys
- microstructural characterization
- mechanical tests

# Production of ODS alloys

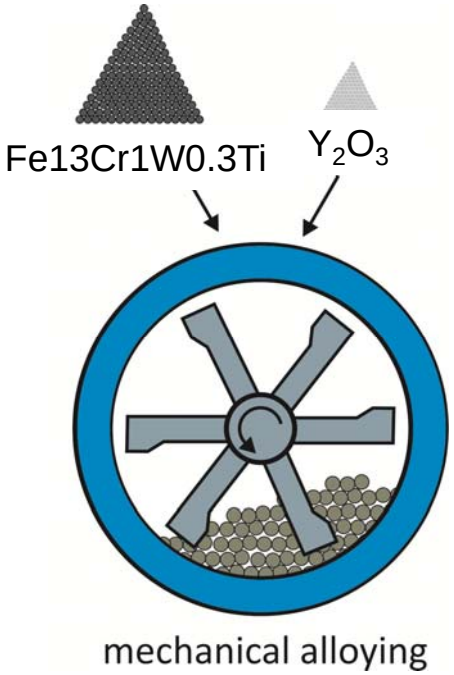
**Compacting of the powders containing the different oxides:**

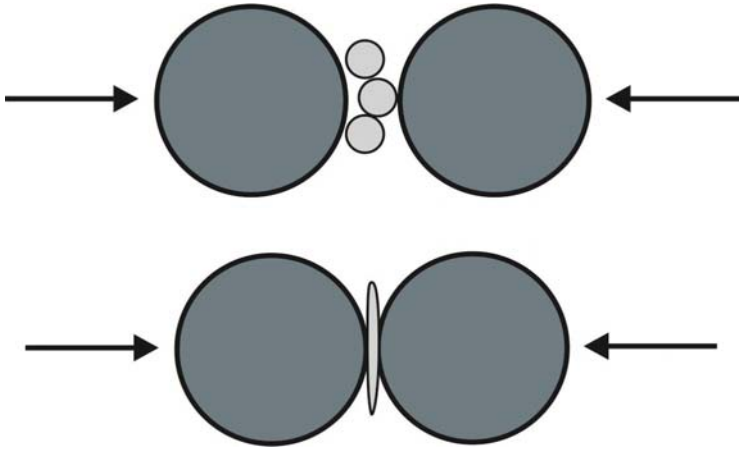


- HIP at 1100°C / 100 MPa for 2 hours
- Hot-rolling at 1100°C
- Reduction from 45 mm diameter to 6 mm thickness
- 5 passes needed for final shape, with reheating after each pass

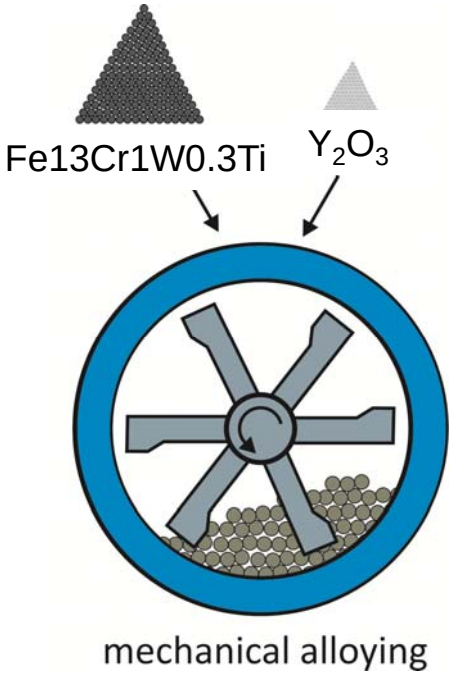
*TU Clausthal*

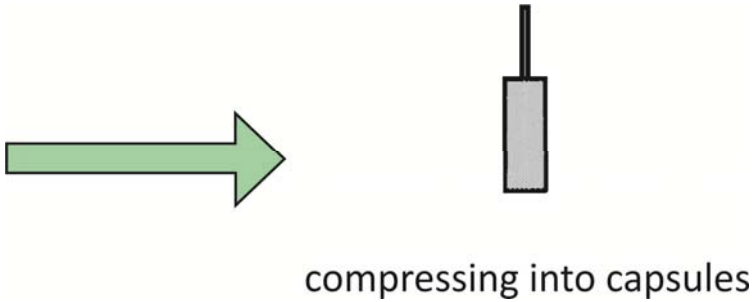
# Production of ODS alloys



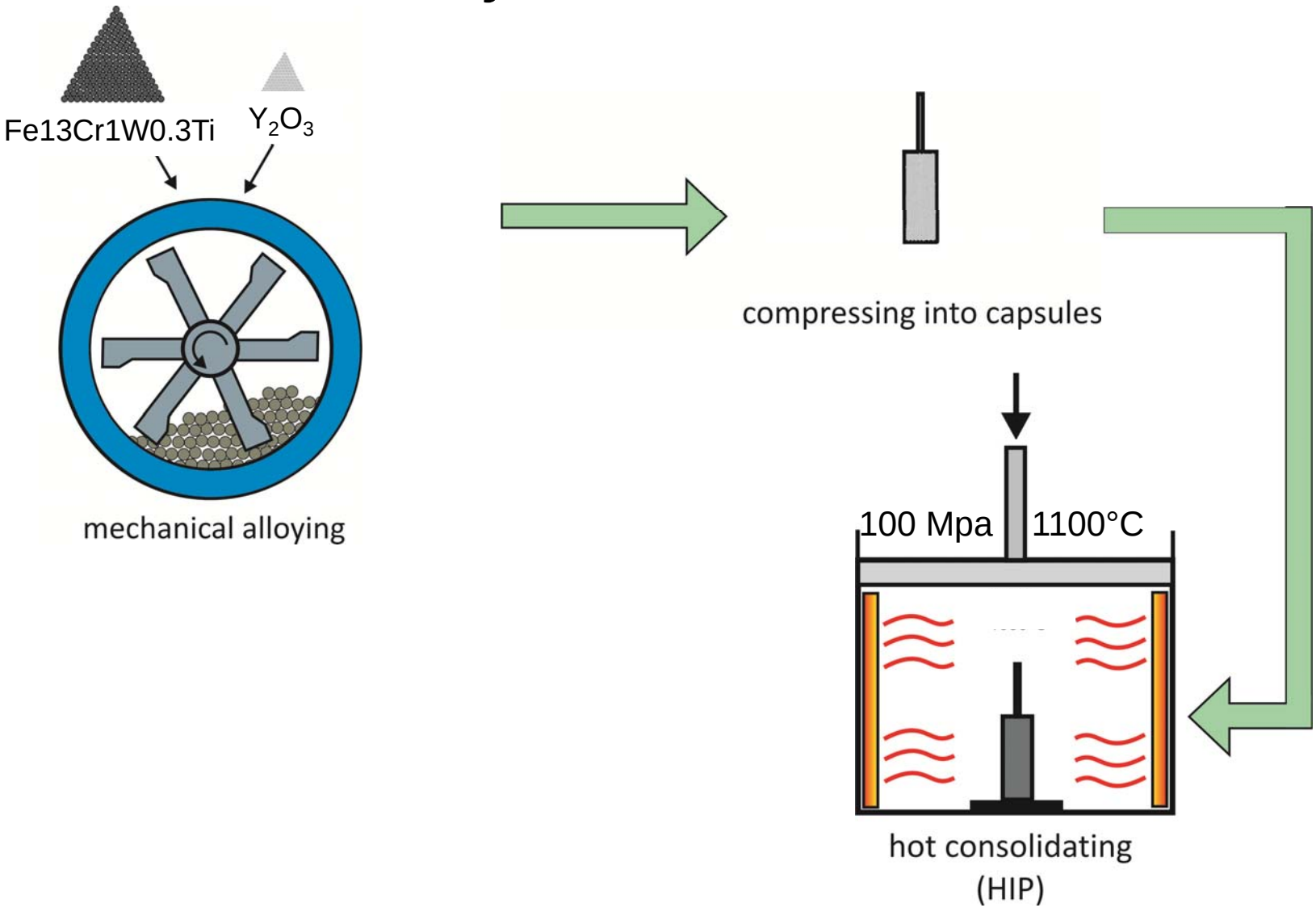



# Production of ODS alloys

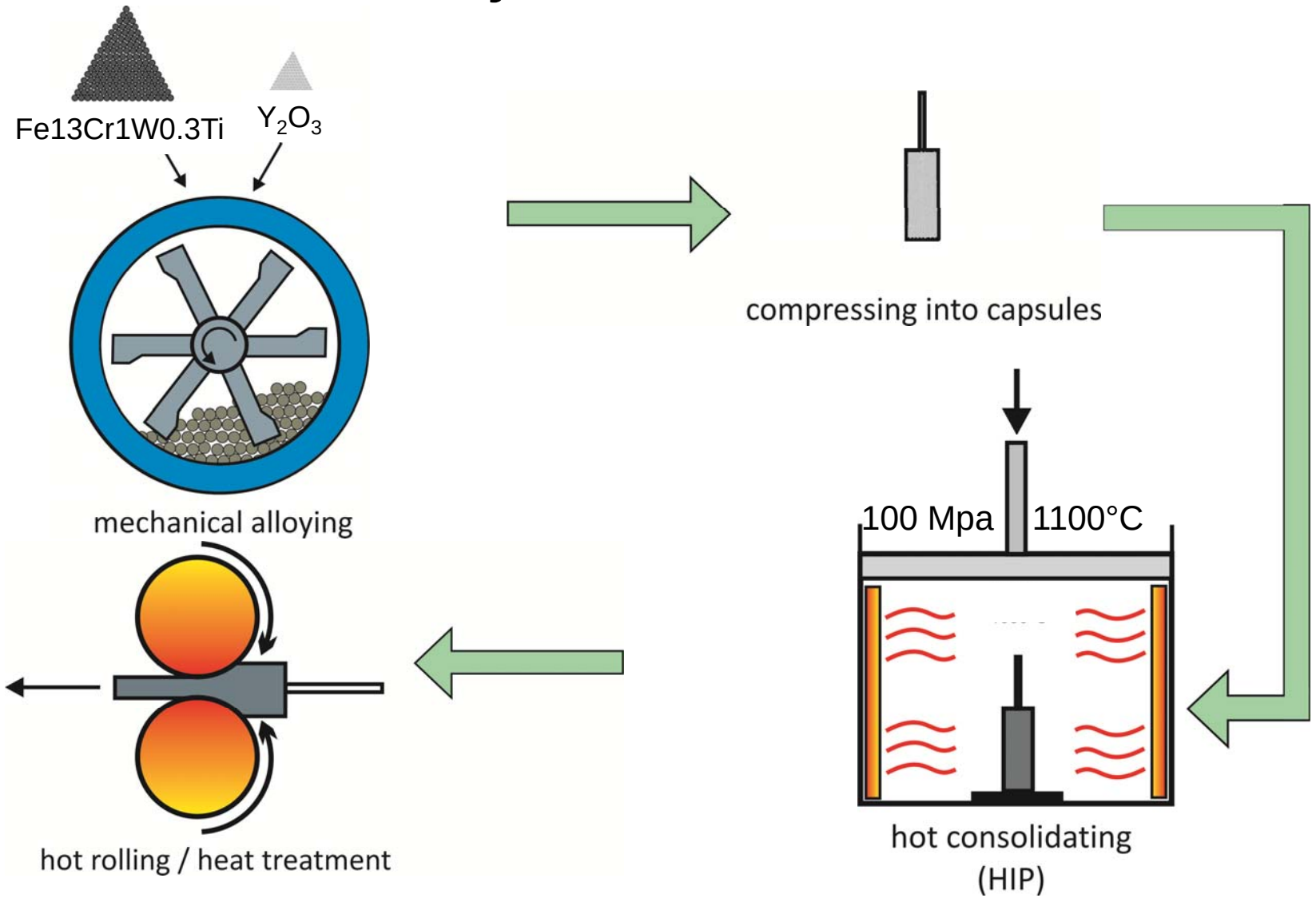


# Production of ODS alloys



# Production of ODS alloys



# Alternative ODS particles

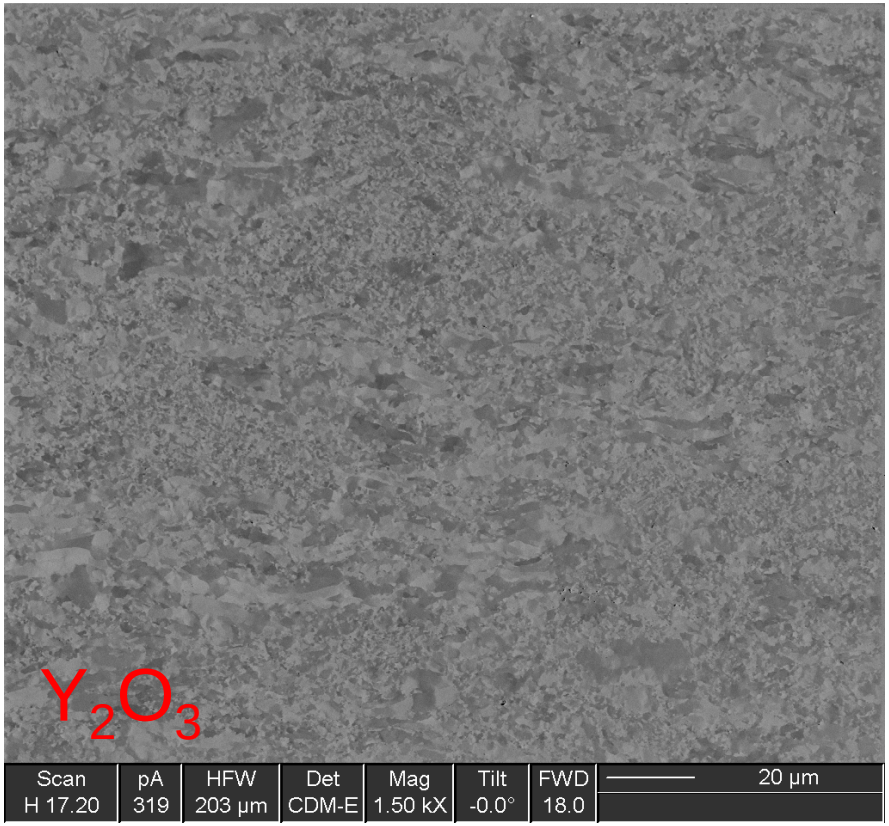
Pre-alloyed powder:

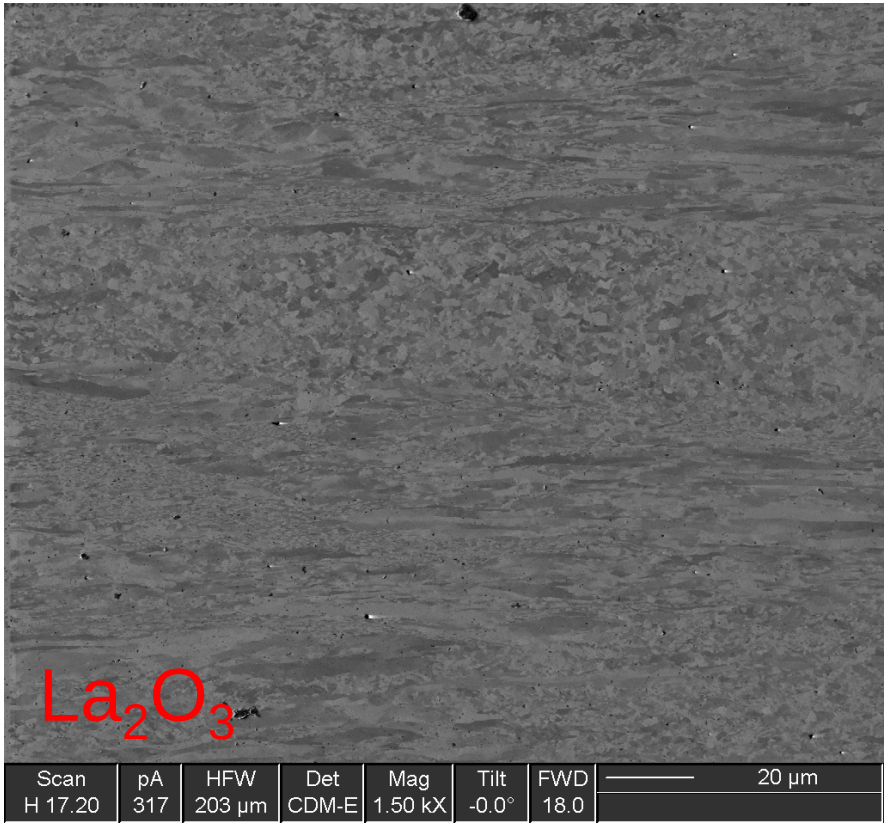
## Fe13Cr1W0.3 + 0.3 wt.% *oxide*

| 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

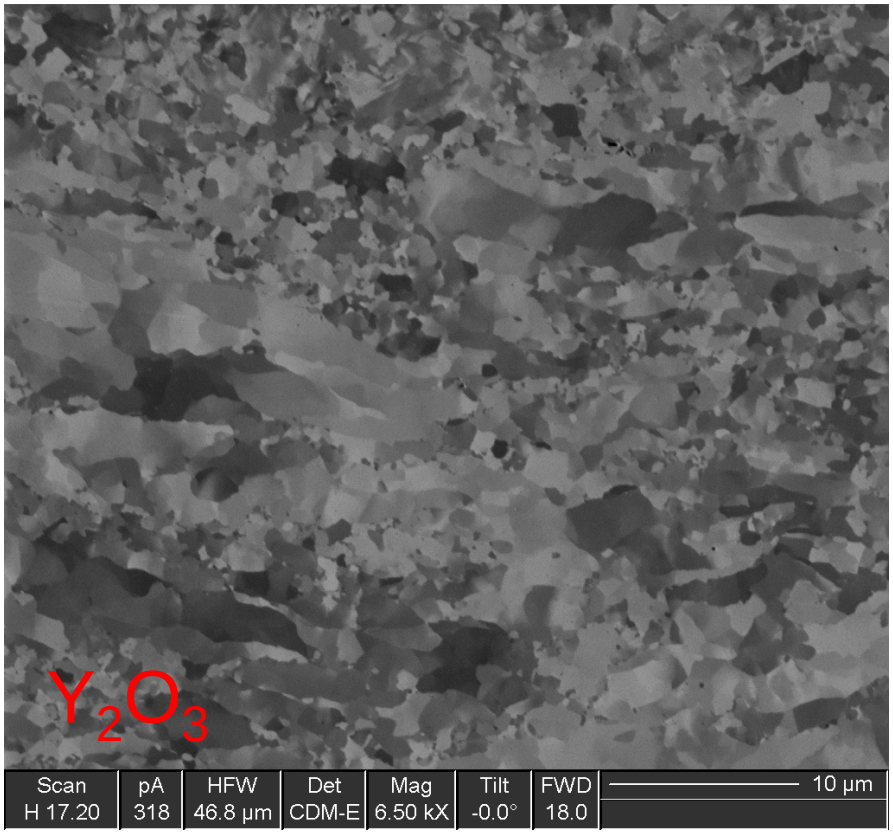
# Alternative ODS particles - FIB

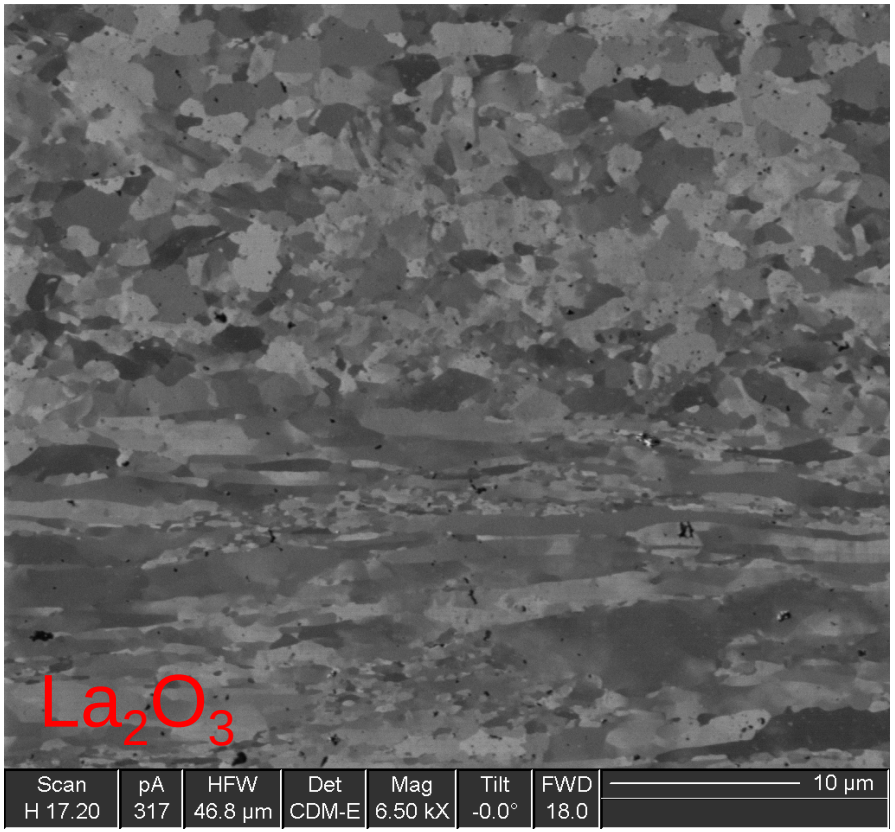



- bi-modal microstructure
- elongated + equiaxed grains

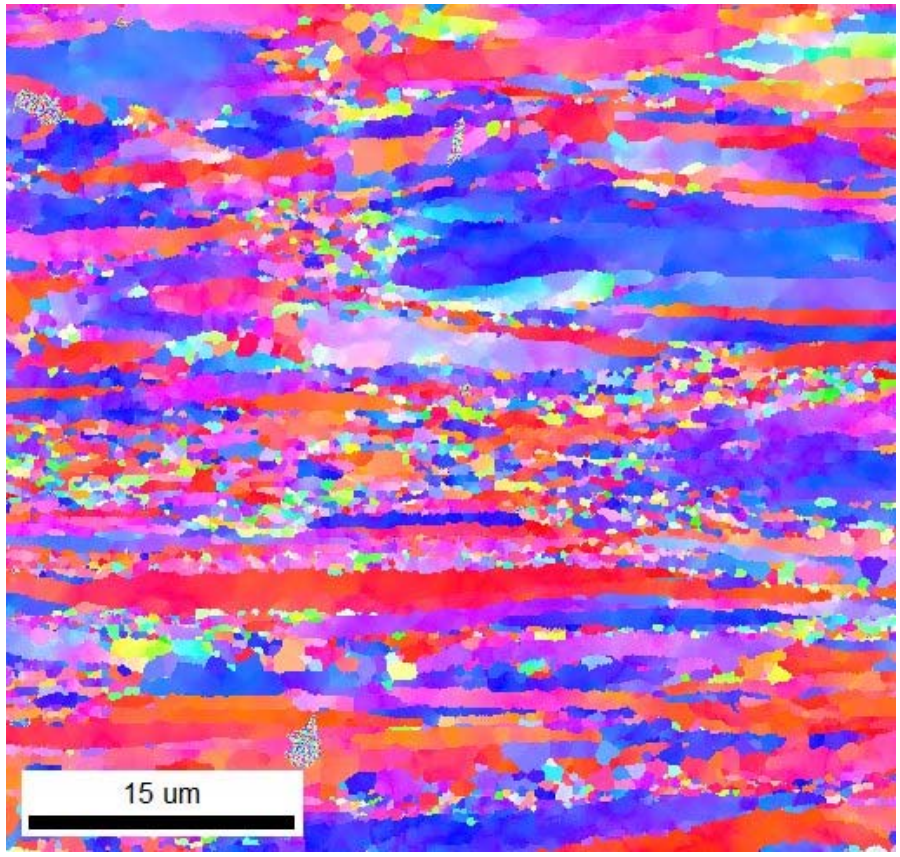
# Alternative ODS particles - FIB



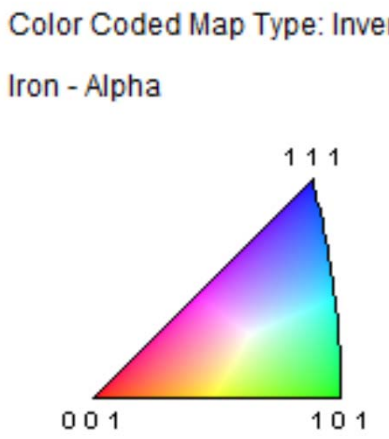




- recristallized grains surrounding elongated, unrecrystallized grains

# Alternative ODS particles

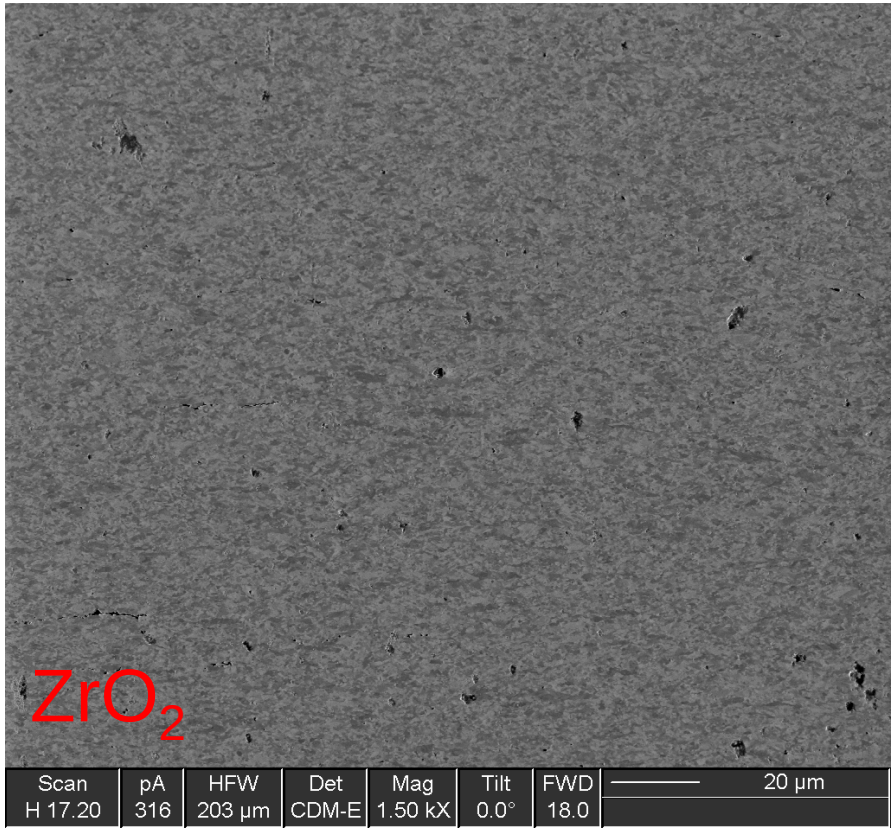


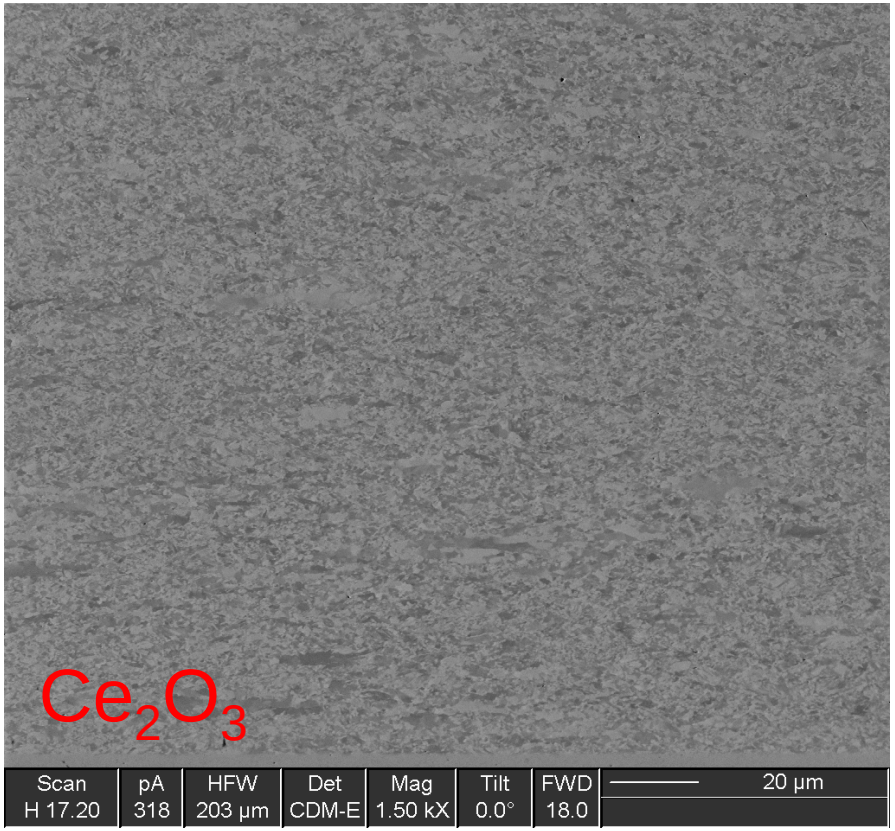

Fe13Cr1W0.3Ti + $La_2O_3$



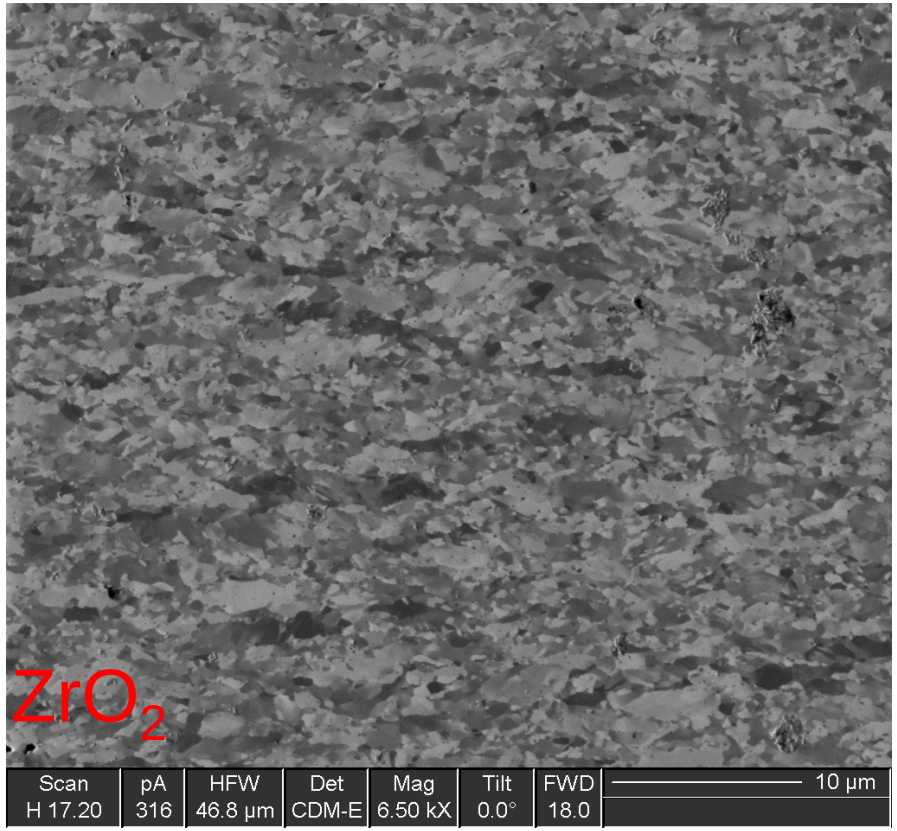

RD

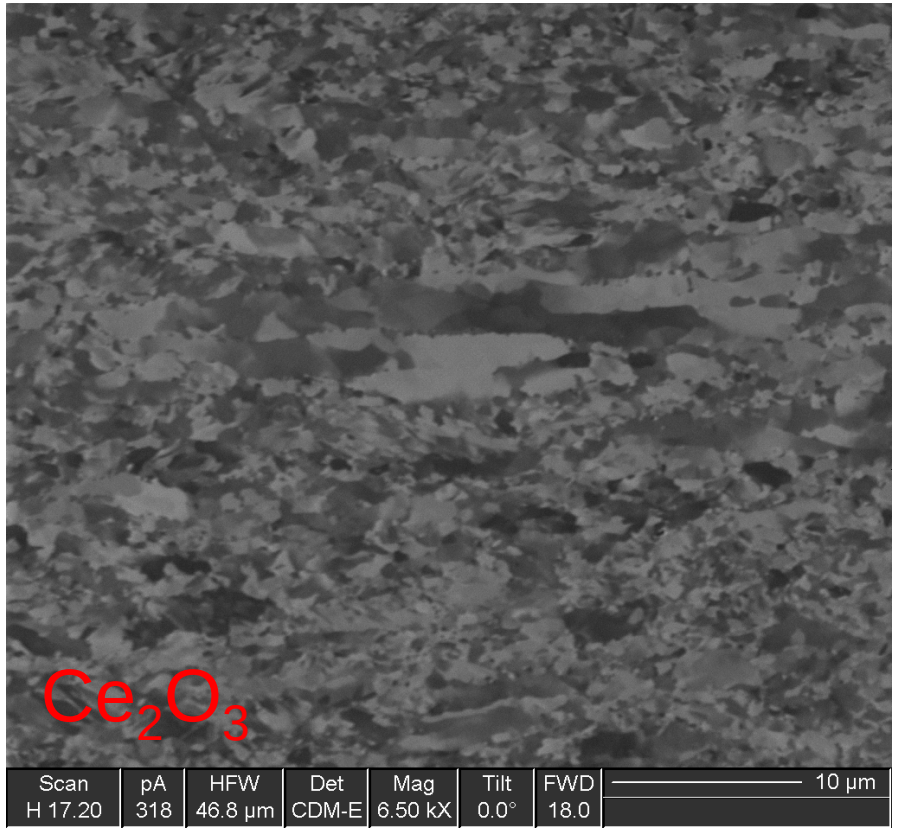
# Alternative ODS particles - FIB



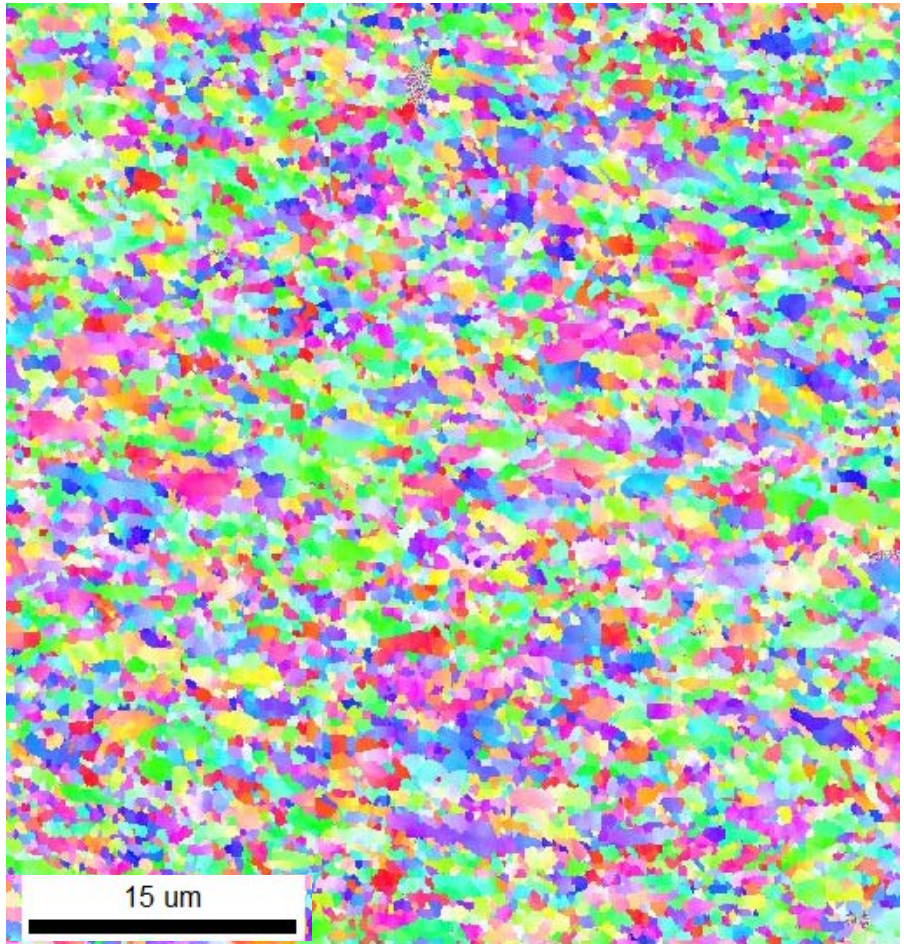
# Alternative ODS particles



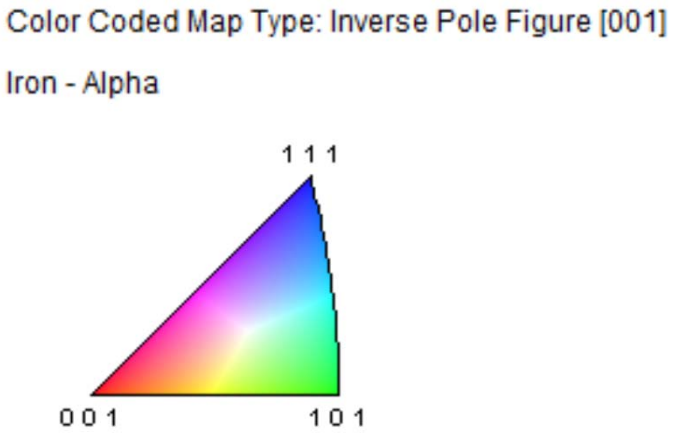




- (nearly) fully recrystallized structure
- only very little elongation visible

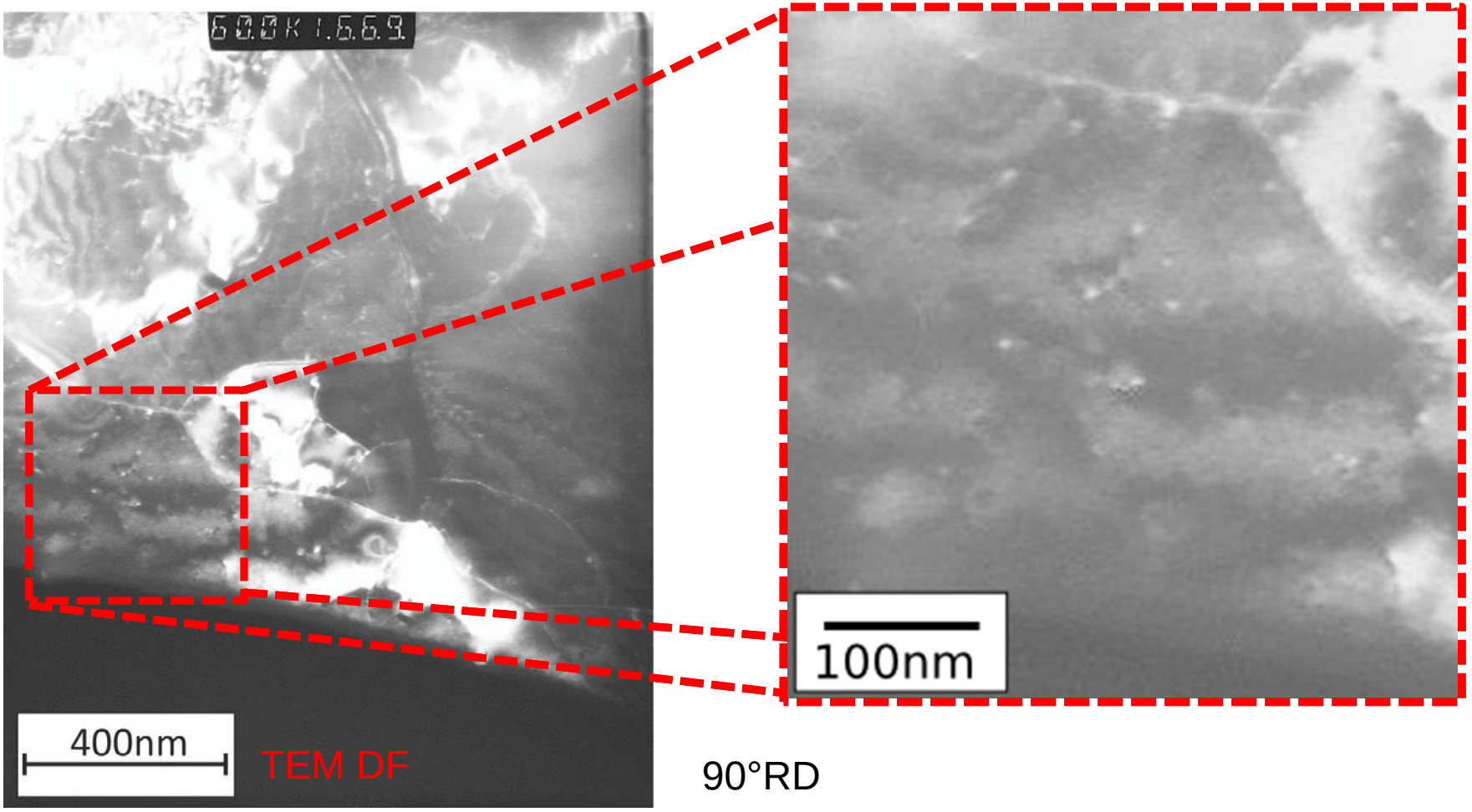
# Alternative ODS particles - EBSD




Fe13Cr1W0.3Ti + $ZrO_2$

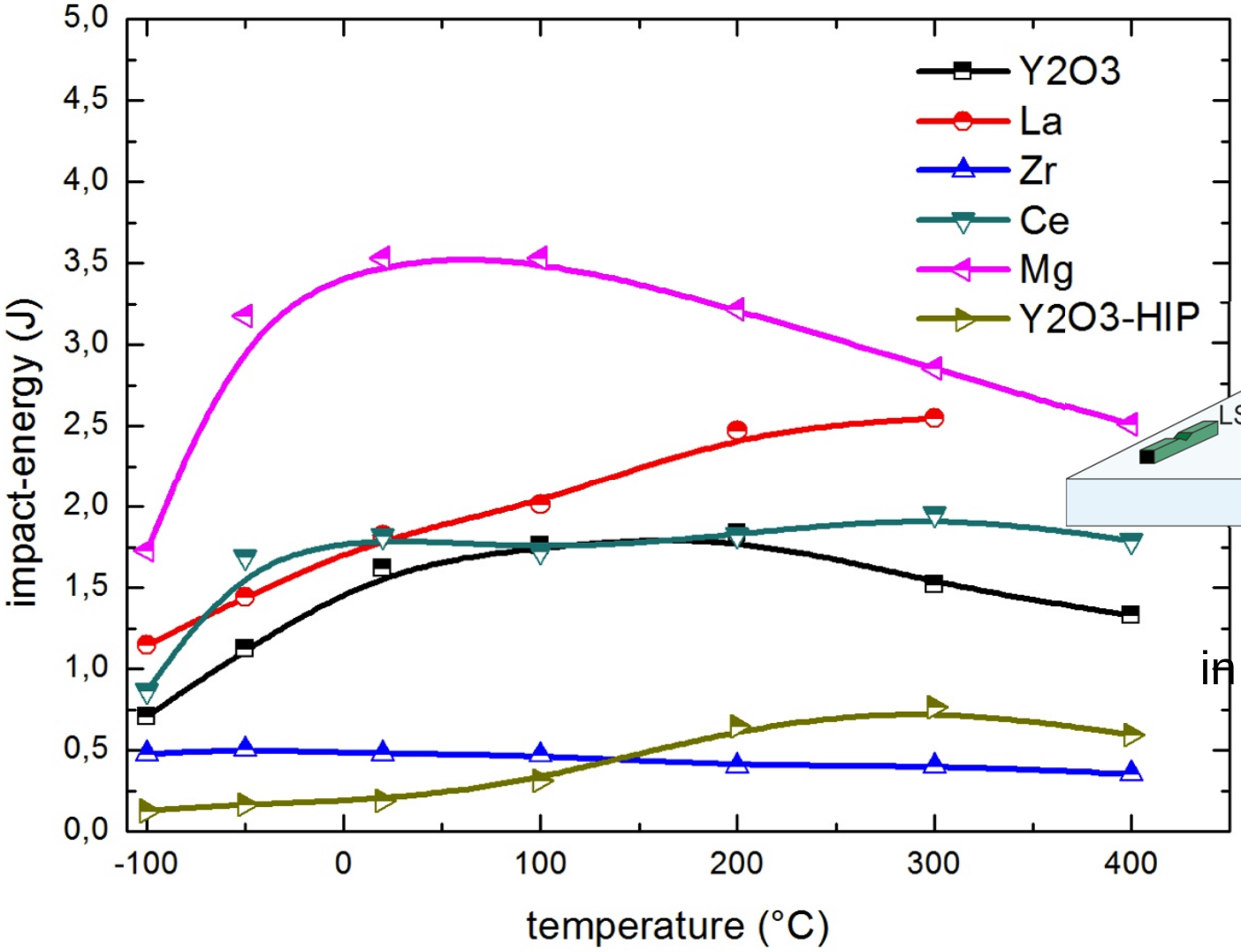


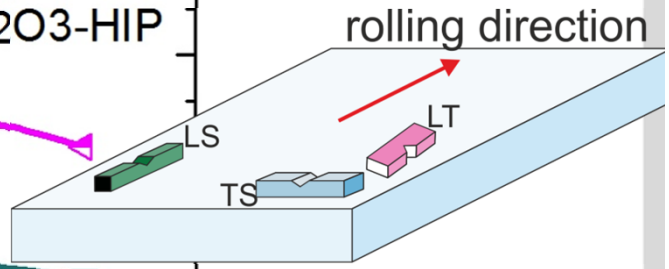
# Alternative ODS particles - TEM




- formation of ODS particles with $La_2O_3$
- fine distribution of the oxides (inside grains[1] and on GB[2])

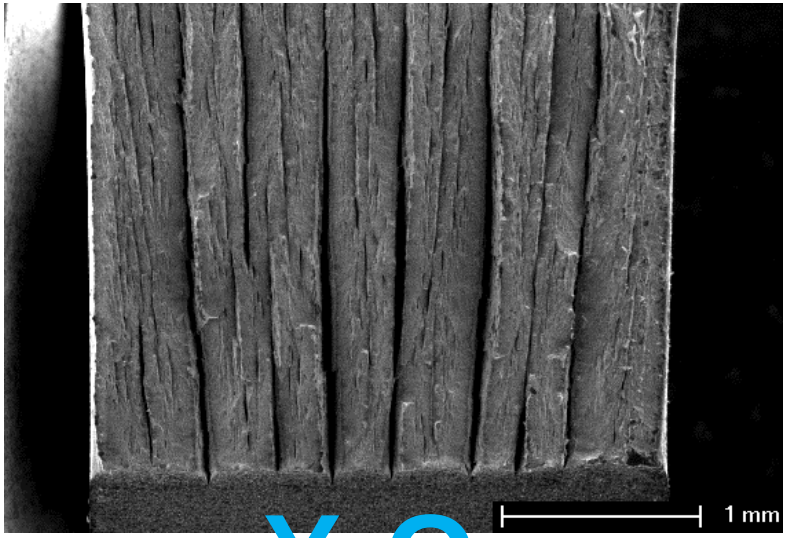
# Mechanical tests (charpy-impact test)



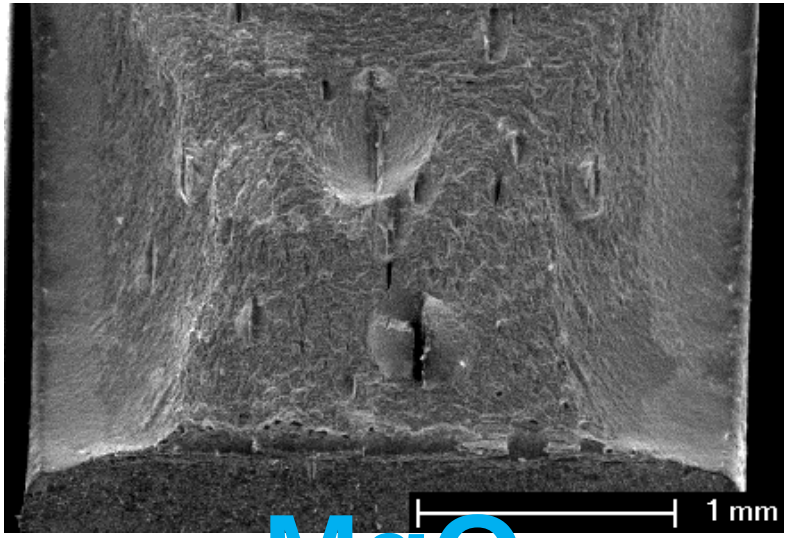

All specimens
in LT- orientation

# Mechanical tests (charpy-impact test)



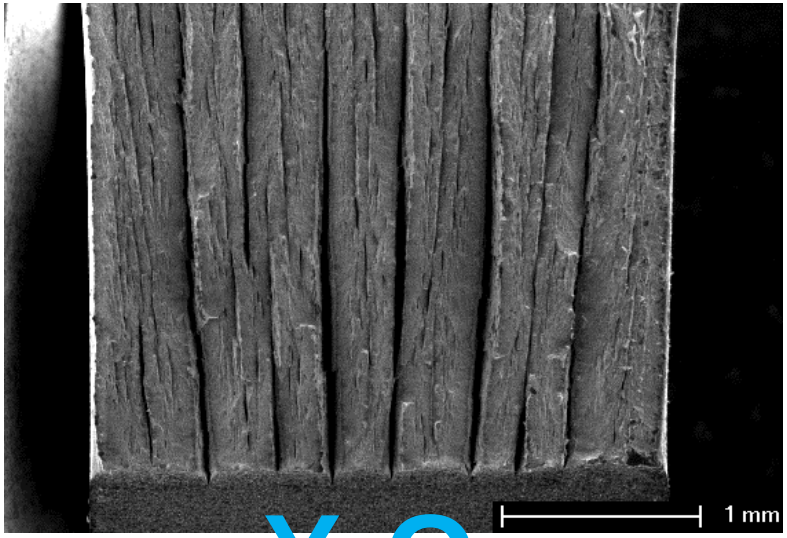

$Y_2O_3$

RT

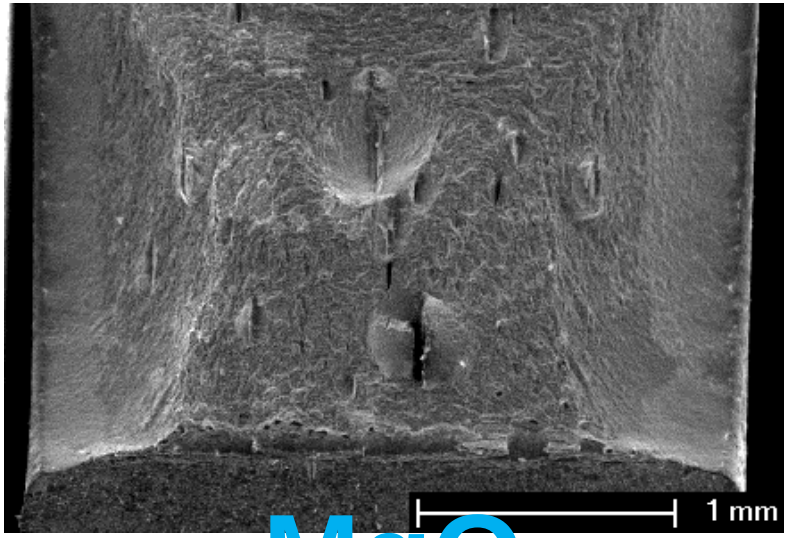



MgO

# Mechanical tests (charpy-impact test)

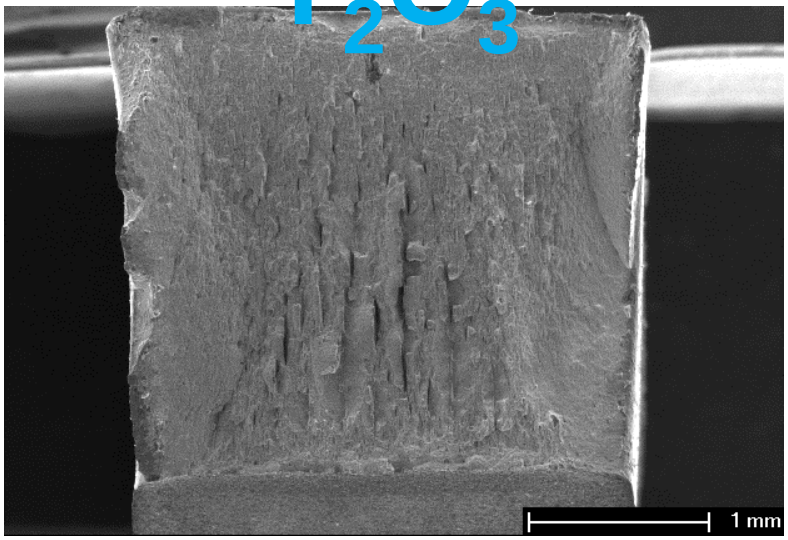



RT

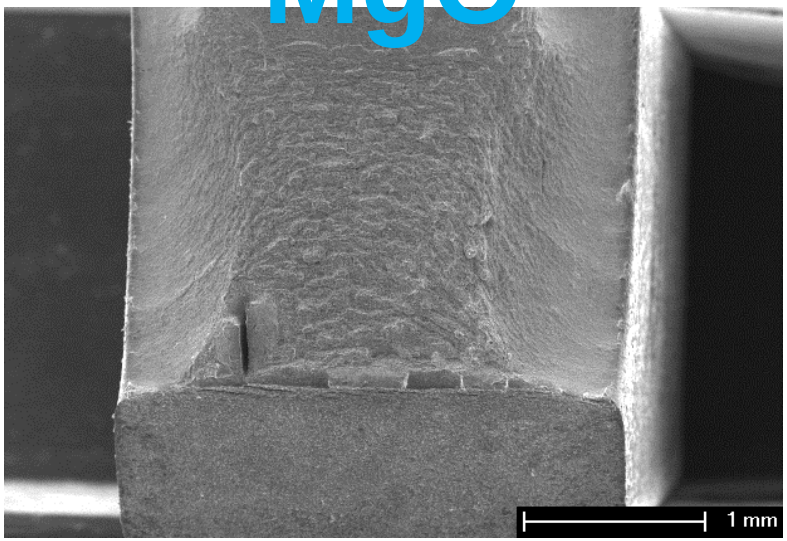



$Y_2O_3$

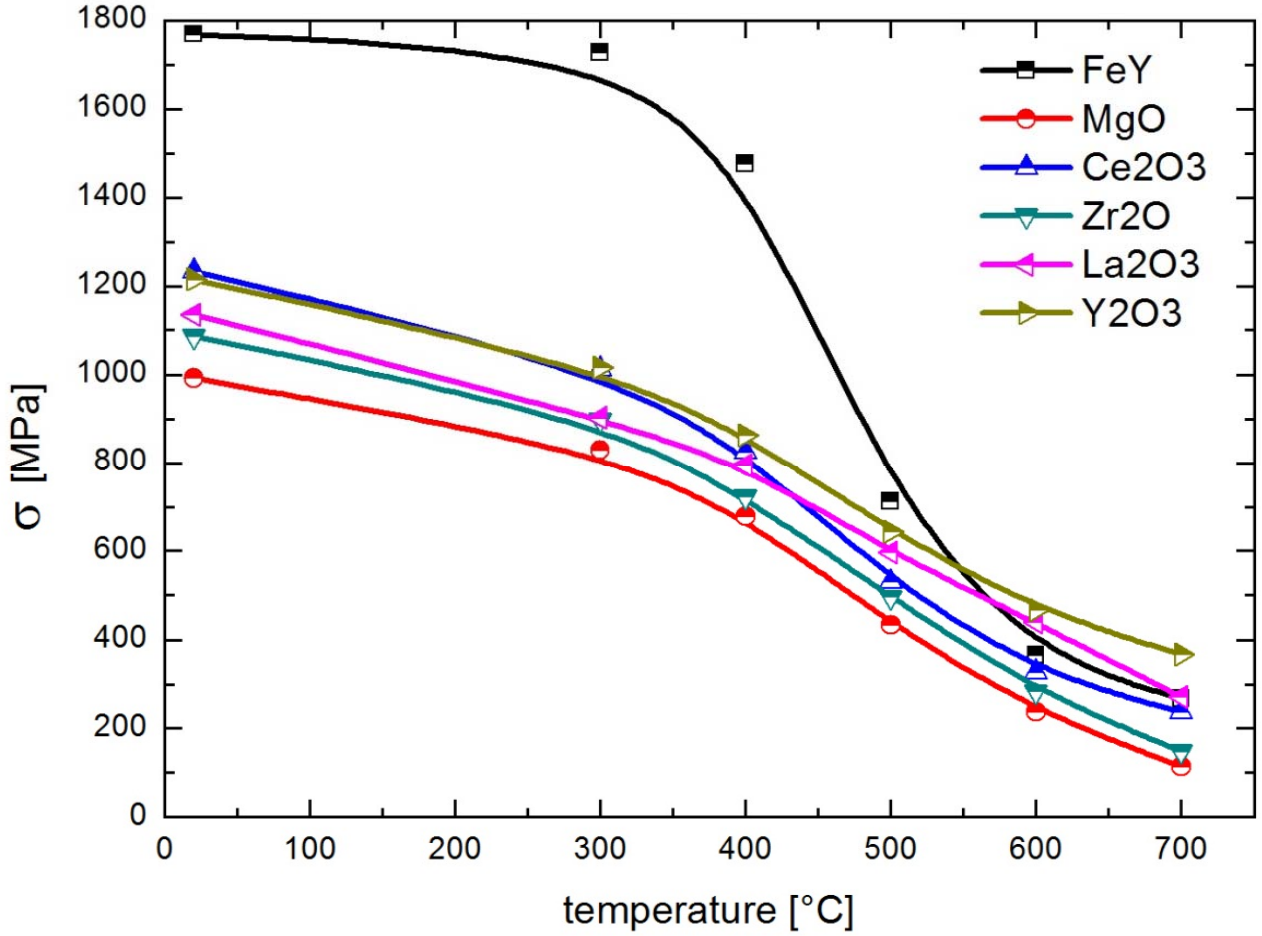
MgO




300°C

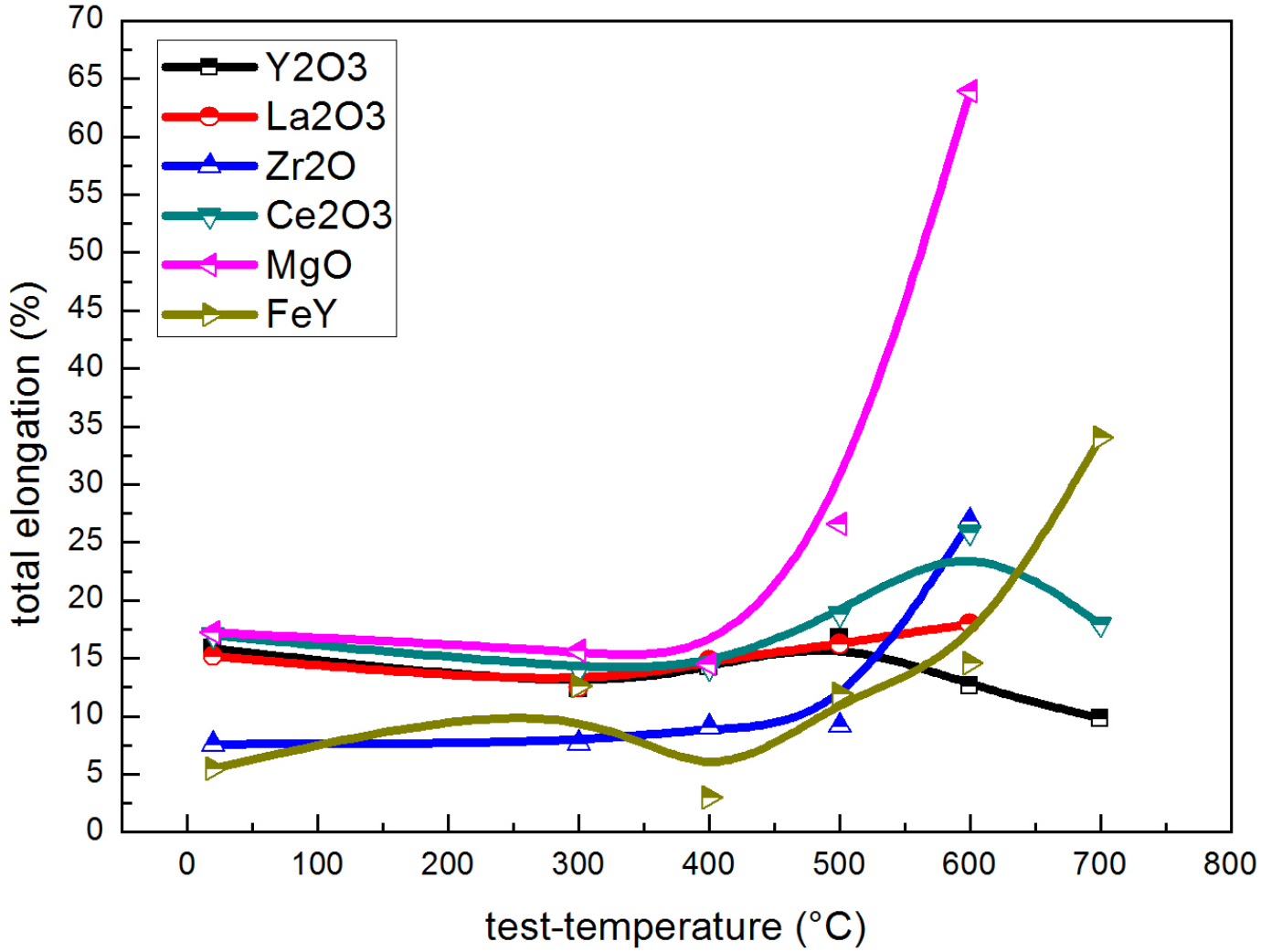


# Mechanical tests (tensile tests – yield strength)

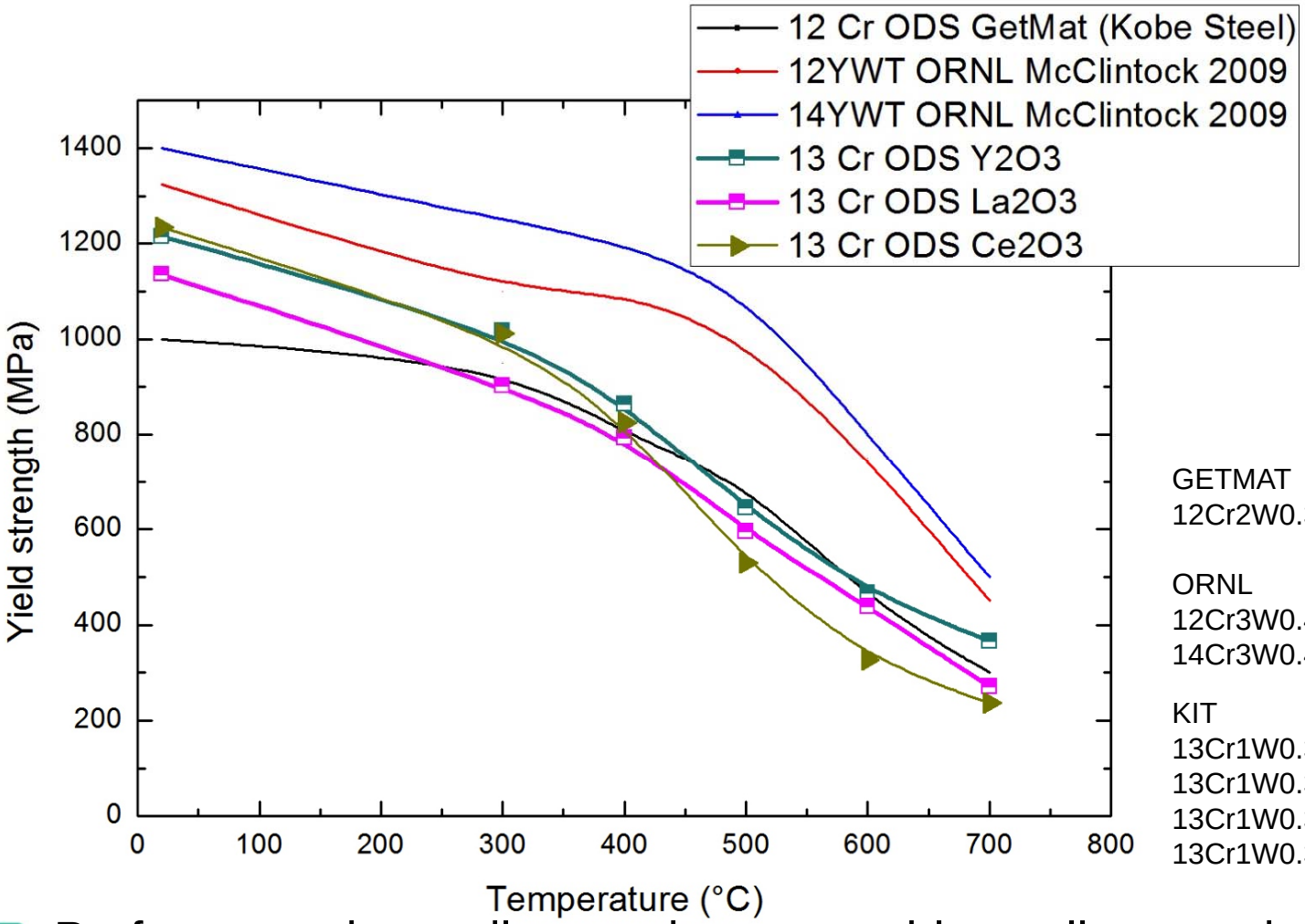



- Y-containing alloys show the best results
- Most alloys perform in a similar way

# Mechanical tests (tensile tests – total elongation)



# 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

# Conclusion

## Alternative oxides for ODS steels

- Formation of nano-oxides is possible with alternative oxides
- Two major types of microstructures evolved (Elongated bi-modal / Recrystallized)
- Tensile properties of different oxides are comparable to yttrium-alloys
- Improved charpy-impact properties for $Ce_2O_3$ and MgO

***Thank you for your attention!***