Investigation on different oxides as candidates for nano-sized ODS particles in reduced-activation ferritic (RAF) steels

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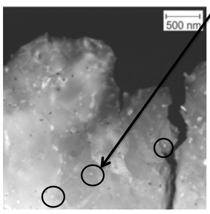
Contents

Introduction

- What are ODS alloys?

Oxide **D**isperions-**S**trengthened alloys

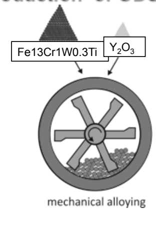


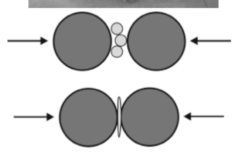
Nano-sized oxide-particles 10-20nm

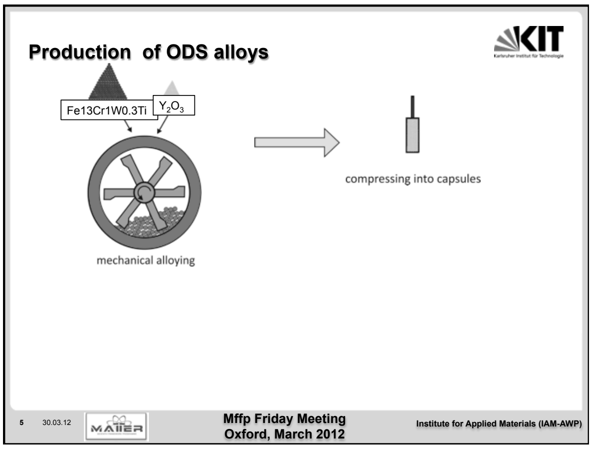
+ good corrosion-resistance
+ excellent high-temperature properties
++ improved creep-strength
- material tends to be brittle
- high production costs

(TEM High-Angle-Annular-Dark-Field Image)

Production of ODS alloys






Production of ODS alloys
Fe13Cr1W0.3Ti
Y_2O_3
mechanical alloying
compressing into capsules
5
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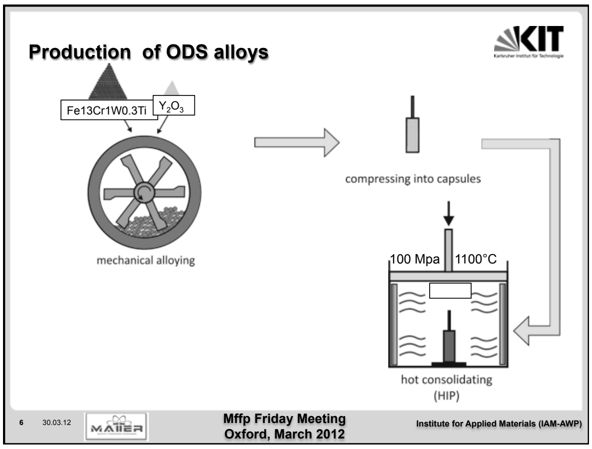
Production of ODS alloys
Fe13Cr1W0.3Ti
Y_2O_3
mechanical alloying
compressing into capsules
100 Mpa
1100°C
hot consolidating
(HIP)
6
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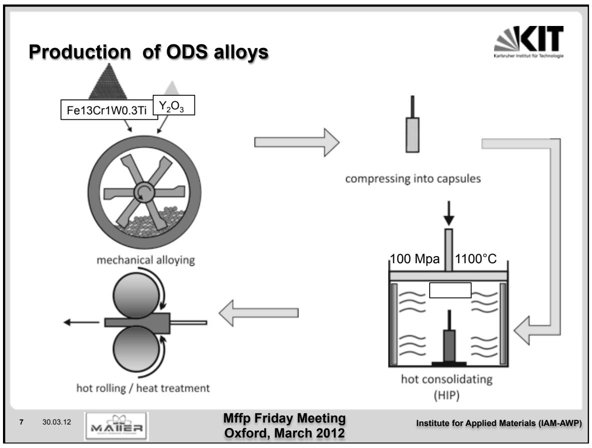
Production of ODS alloys
Fe13Cr1W0.3Ti
Y_2O_3
mechanical alloying
compressing into capsules
100 Mpa
1100°C
hot consolidating
(HIP)
hot rolling / heat treatment
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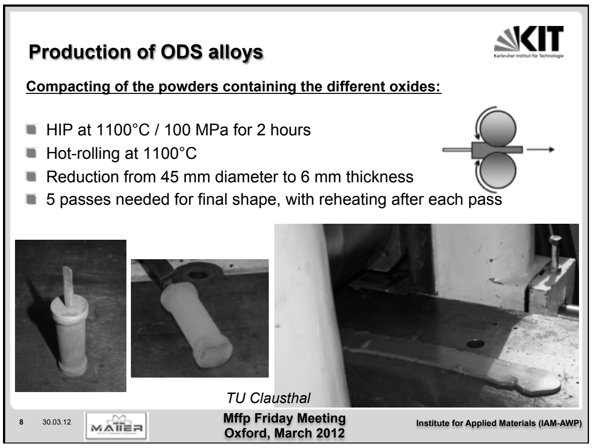
Production of ODS alloys
Compacting of the powders containing the different oxides:
HIP at 1100°C / 100 MPa for 2 hours
Hot-rolling at 1100°C
Reduction from 45 mm diameter to 6 mm thickness
5 passes needed for final shape, with reheating after each pass
TU Clausthal
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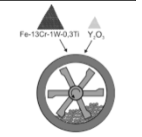
Production of ODS alloys

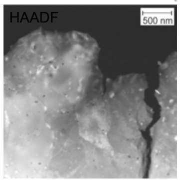
Production-parameters:

No.	composition	milling-speed	milling-time
1	Fe13Cr1W0.3Ti + La_2O_3	1200 / 800	80h
2	Fe13Cr1W0.3Ti + Ce_2O_3	1200 / 800	80h
3	Fe13Cr1W0.3Ti + MgO	1200 / 800	80h
4	Fe13Cr1W0.3Ti + ZrO_2	1200 / 800	80h
5	Fe13Cr1W0.3Ti + Fe_2Y	1200 / 800	80h
Ref.	Fe13Cr1W0.3Ti + Y_2O_3	1200 / 800	80h

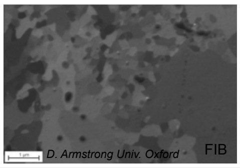
- milling in argon-atmosphere
- ball to powder ration 10:1 (2000g : 200g)
- complete produktion in argon (glove-box)

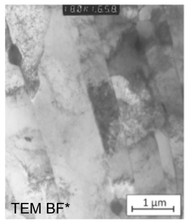


Characterization (FIB/TEM)



Fe13Cr1W0.3Ti + **Y_2O_3**

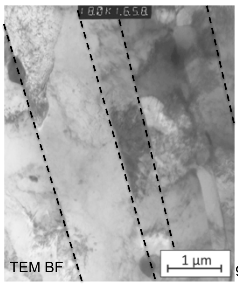




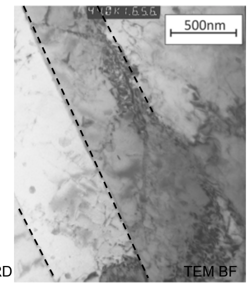
Fe13Cr1W0.3Ti + **La_2O_3** rolled

*GRC - Physical Metallurgy 2011, August 3., Boston, USA

Characterization (microstructure)

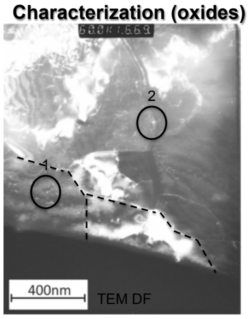


90°RD

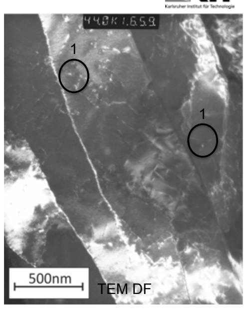


- clearly visible rolling texture
- grain size approx. 400 to 800 nm width, but micrometer-sized length

Characterization (oxides)

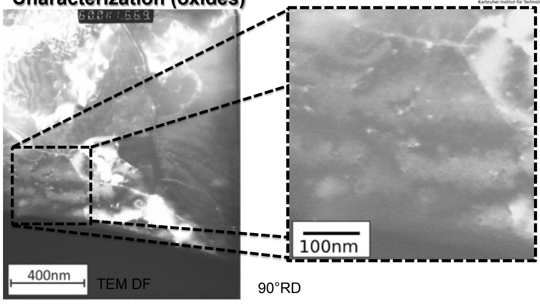


90°RD



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

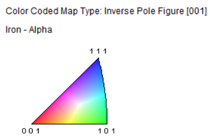
Characterization (oxides)



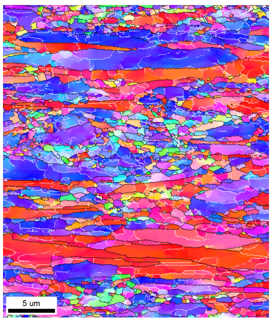
- formatation of ODS particles with La_2O_3
- fine distribution of the oxides (inside grains[1] and on GB[2])

EBSD Measurements

Fe13Cr1W0.3Ti + Y_2O_3



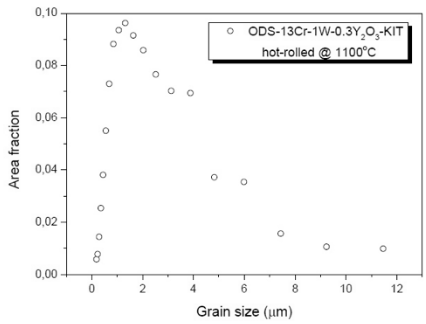
EBSD Measurements

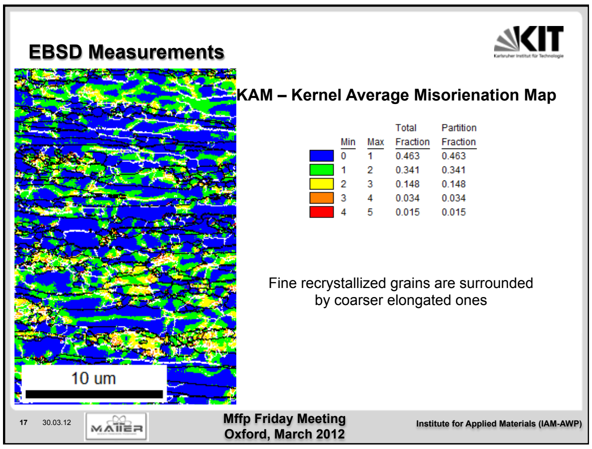


Results from EBSD Measurements

- A bimodal grain size distribution is visible
- Grains with <110> parallel to the rolling direction
- Predominance of {001} <110> rotated cube (α-fiber) (typical texture in bcc metals)

EBSD Measurements




EBSD Measurements
KAM – Kernel Average Misorienation Map
Min Max Total Fraction Partition Fraction
0 1 0.463 0.463
1 2 0.341 0.341
2 3 0.148 0.148
3 4 0.034 0.034
4 5 0.015 0.015
Fine recrystallized grains are surrounded by coarser elongated ones
10 um
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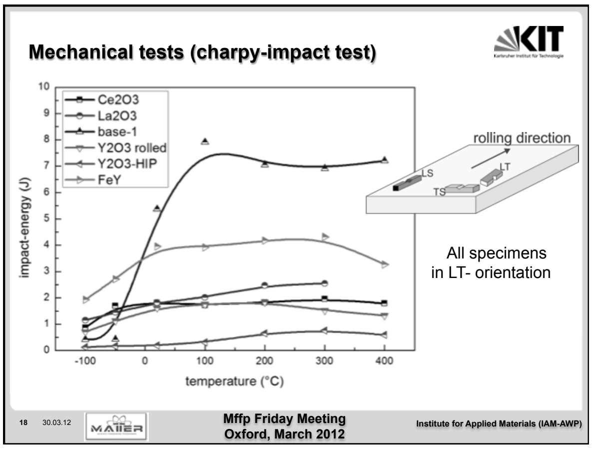
Mechanical tests (charpy-impact test)
Ce2O3
La2O3
base-1
Y2O3 rolled
Y2O3-HIP
FeY
impact-energy (J)
temperature (°C)
rolling direction
LS
LT
TS
All specimens in LT- orientation
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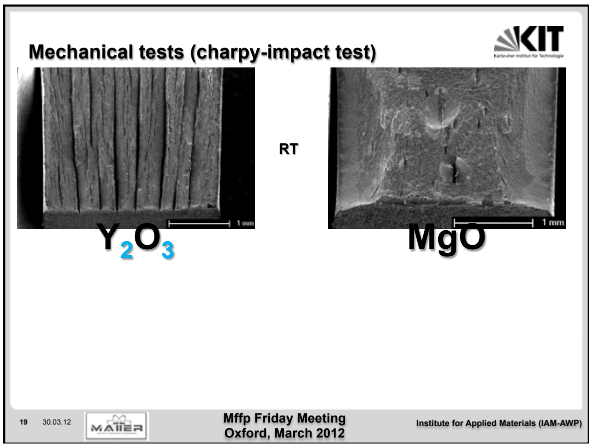
Mechanical tests (charpy-impact test)
RT
Y_2O_3
MgO
1 mm
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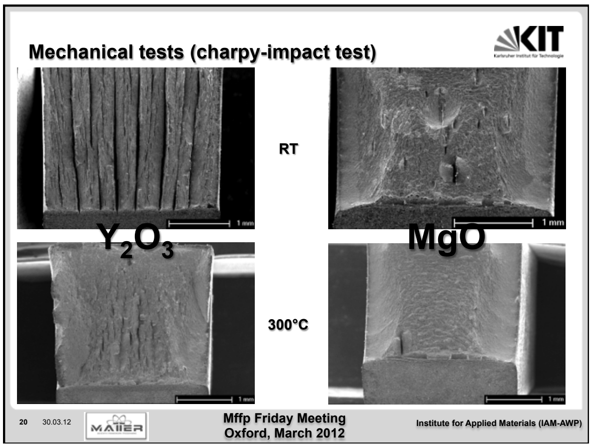
Mechanical tests (charpy-impact test)
RT
Y_2O_3
MgO
300°C
1 mm
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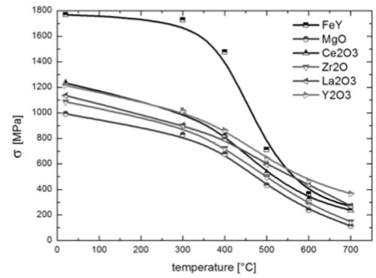
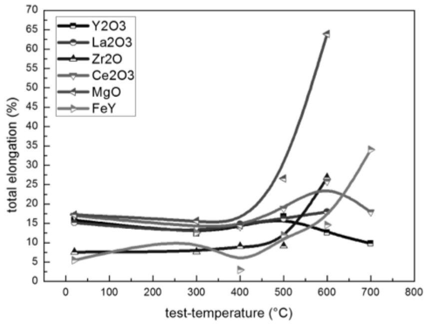
Mechanical tests (tensile tests – yield strength)

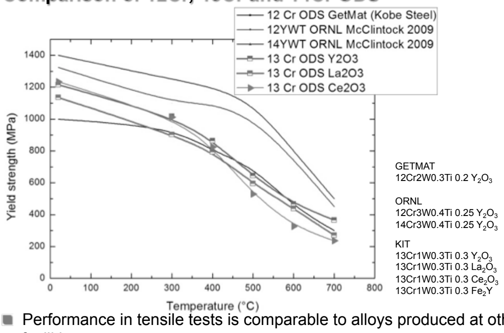


- Y-containing alloys show the best results
- Most alloys perform in a similar way

Mechanical tests (tensile tests – total elongation)



Comparison of 12Cr, 13Cr and 14Cr ODS



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

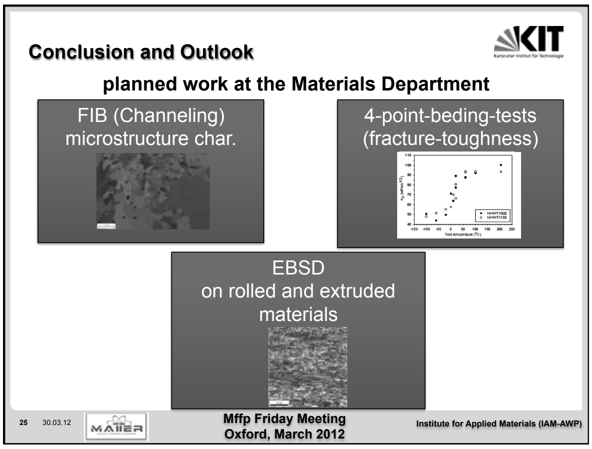
Conclusion and Outlook

Alternative oxides for ODS steels

- Formation of nano-oxides is possible with alternative oxides
- Tensile properties of different oxides are comparable to yttrium-alloys
- Improved charpy-impact properties for Ce_2O_3 and MgO

Outlook

- Detailed TEM Characterization of nano-oxides is still in progress
- EBSD mappings of selected oxides (other than Y_2O_3)


Conclusion and Outlook
planned work at the Materials Department
FIB (Channeling)
microstructure char.
4-point-beding-tests
(fracture-toughness)
EBSD
on rolled and extruded
materials
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Thank you for your
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