Karlsruher Institut für Technologie

Characterization and optimization of a nanoscale ferritic oxide-dispersion-strengthened (ODS) alloy

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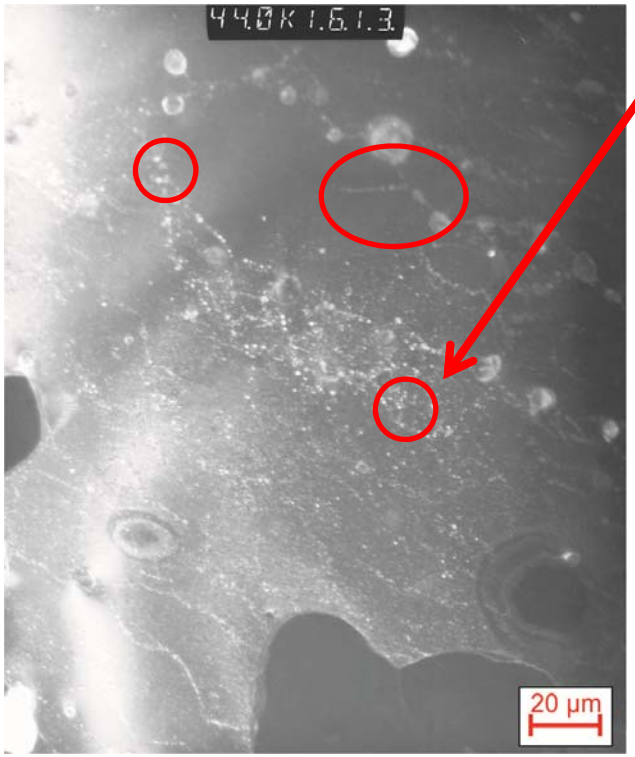
- Introduction to ODS alloys
- Powder characterization
- Thermo-mechanical treatment
- Outlook

Introduction

- What are ODS alloys?

Oxide **D**isperions-Strengthened alloys



(TEM Dark-Field Image)

nanoscale oxide particles10-20nm

+ good corrosion resistance

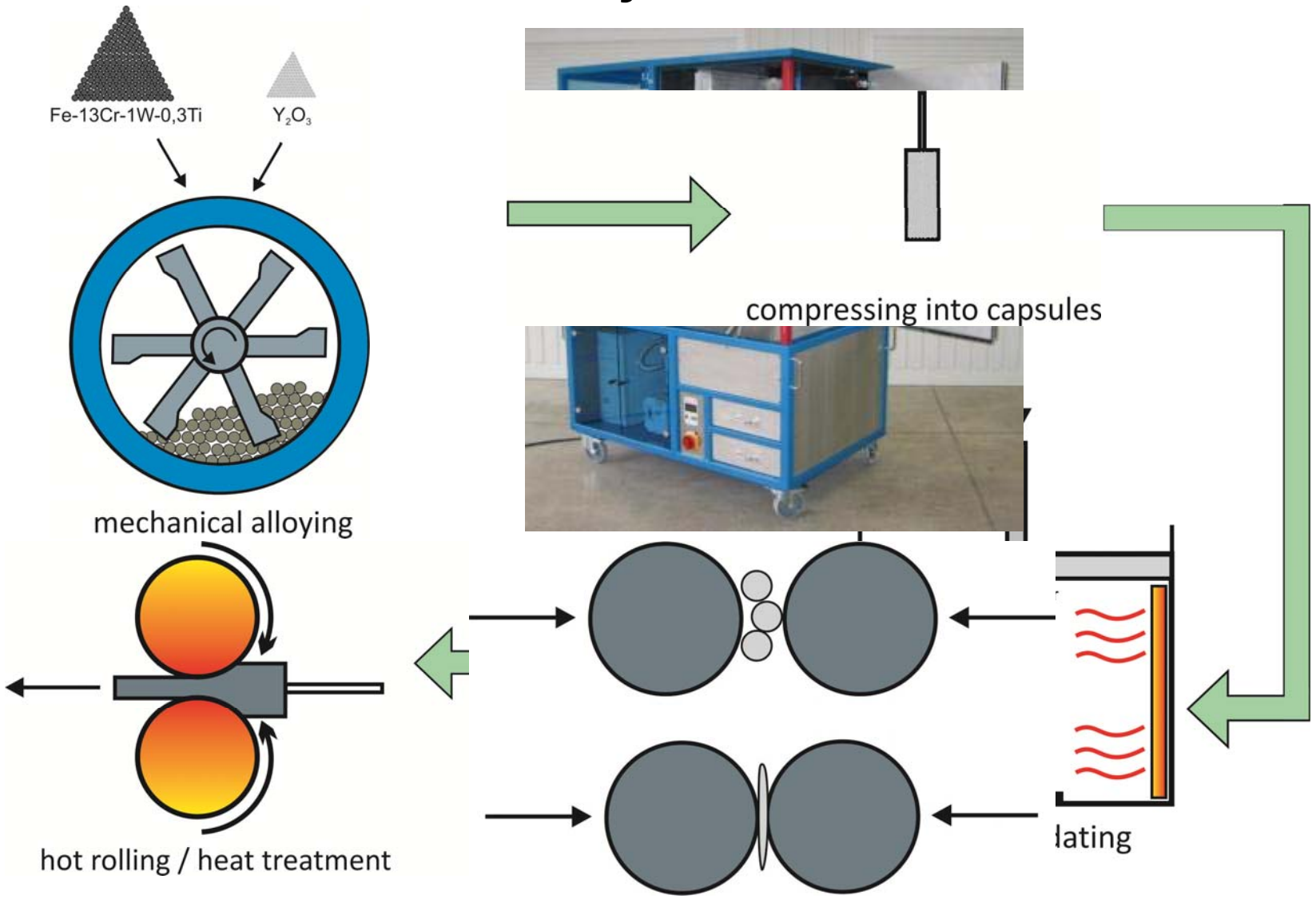
+ excellent high-temperature-properties

++ improved creep strength

- Material tends to be brittle

- High manufacturing costs

Production-route of ODS alloys

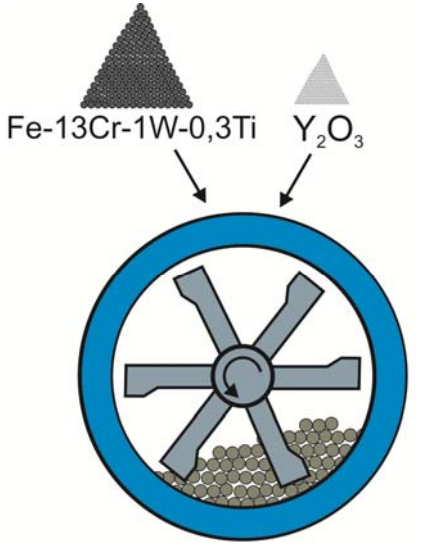


Production of a ferritic ODS alloy

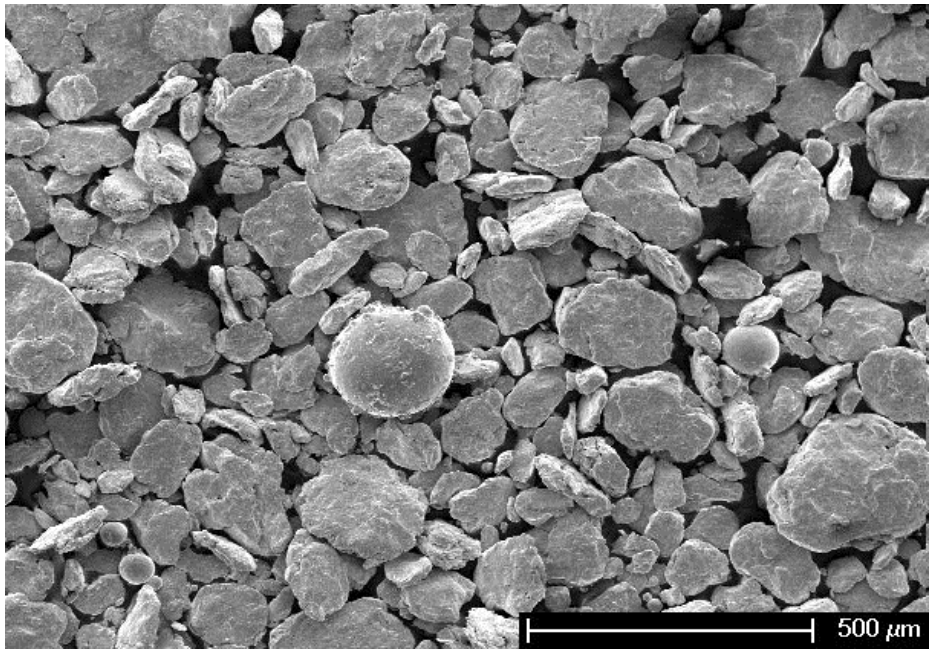
Production-parameters:

No.	composition	milling-speed	milling-time
1	Fe13Cr1W0.3Ti + Y_2O_3	1200 / 800	24h
2	Fe13Cr1W0.3Ti + Y_2O_3	1200 / 800	48h
3	Fe13Cr1W0.3Ti + Y_2O_3	1200 / 800	80h

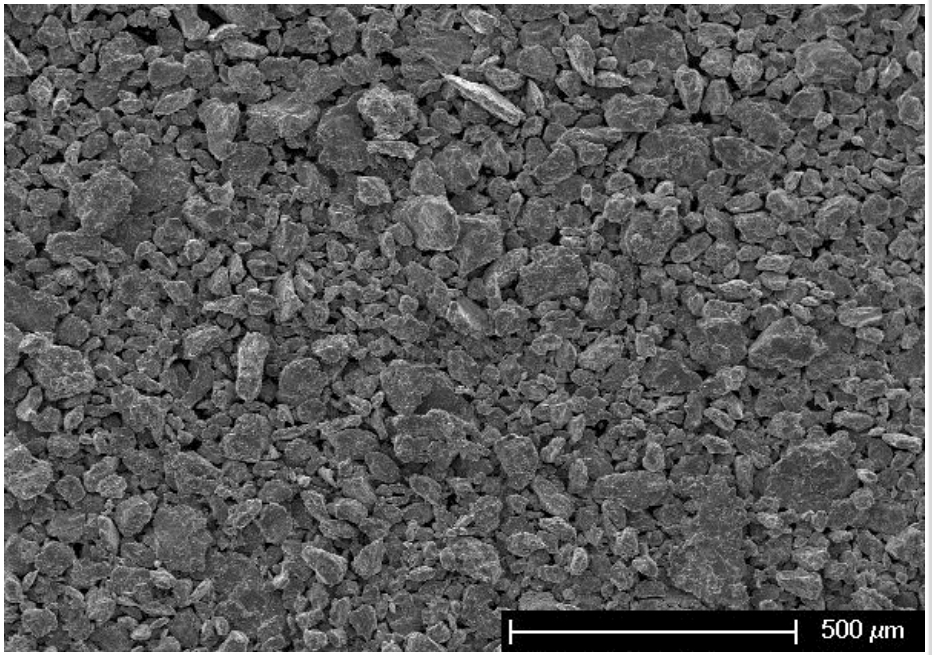
- Milling in Argon-atmosphere
- Ball to powder ratio 10:1 (2000g : 200g)
- Complete production under excess of oxygen (handling in glove-box)



Powders after 24 and 80 hours milling

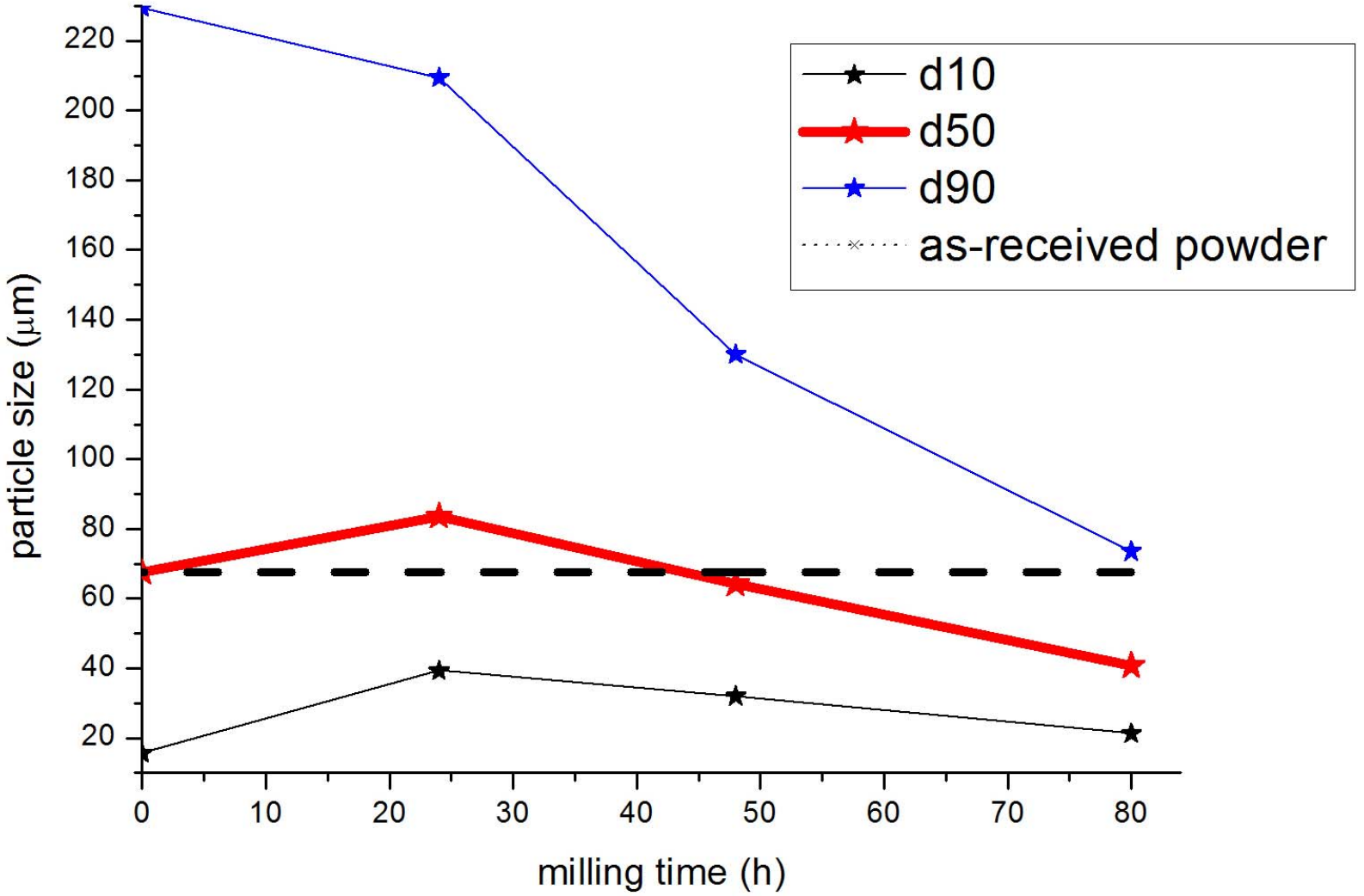


After 24 hours



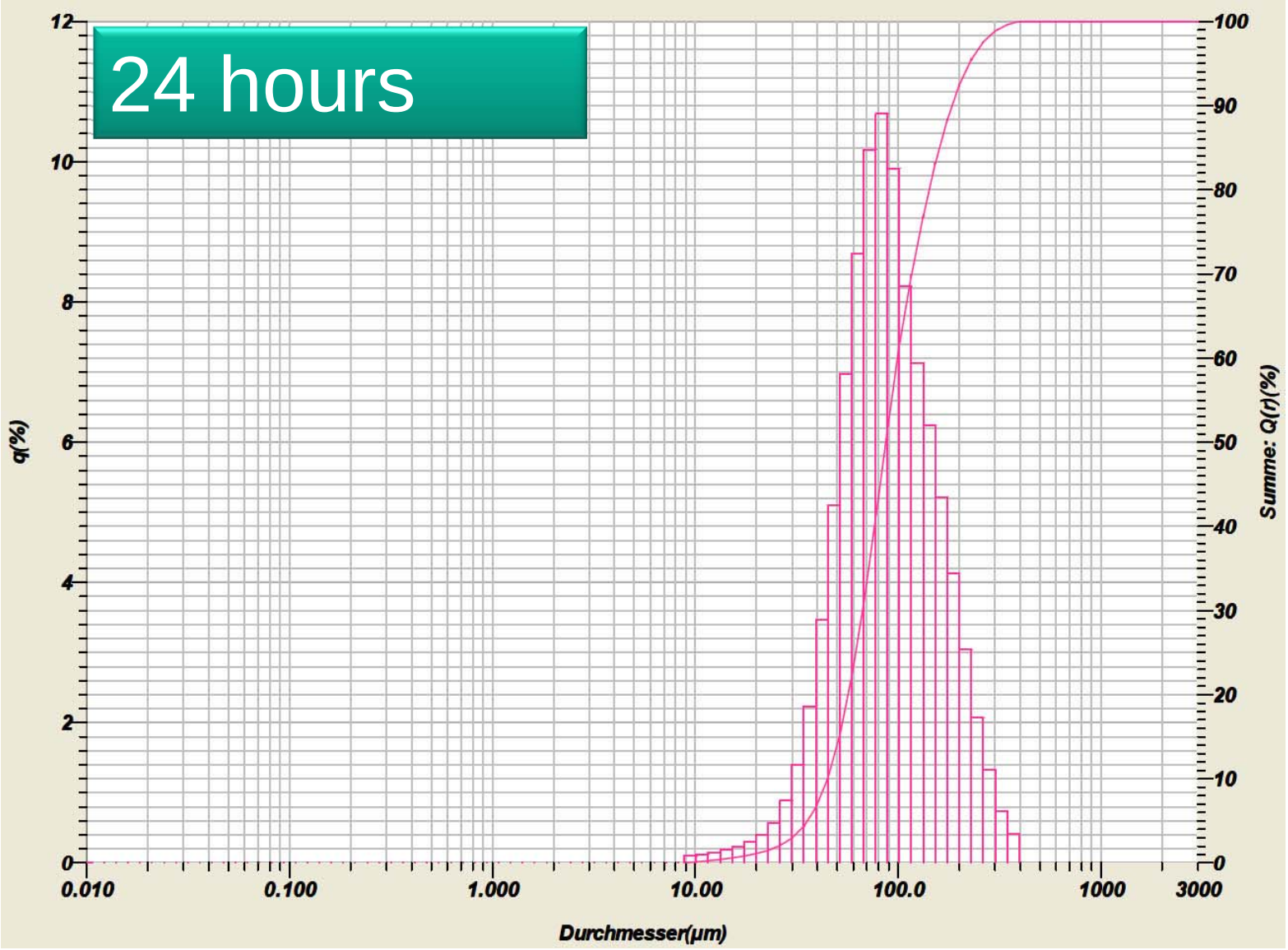
After 80 hours

Particle size after different milling times

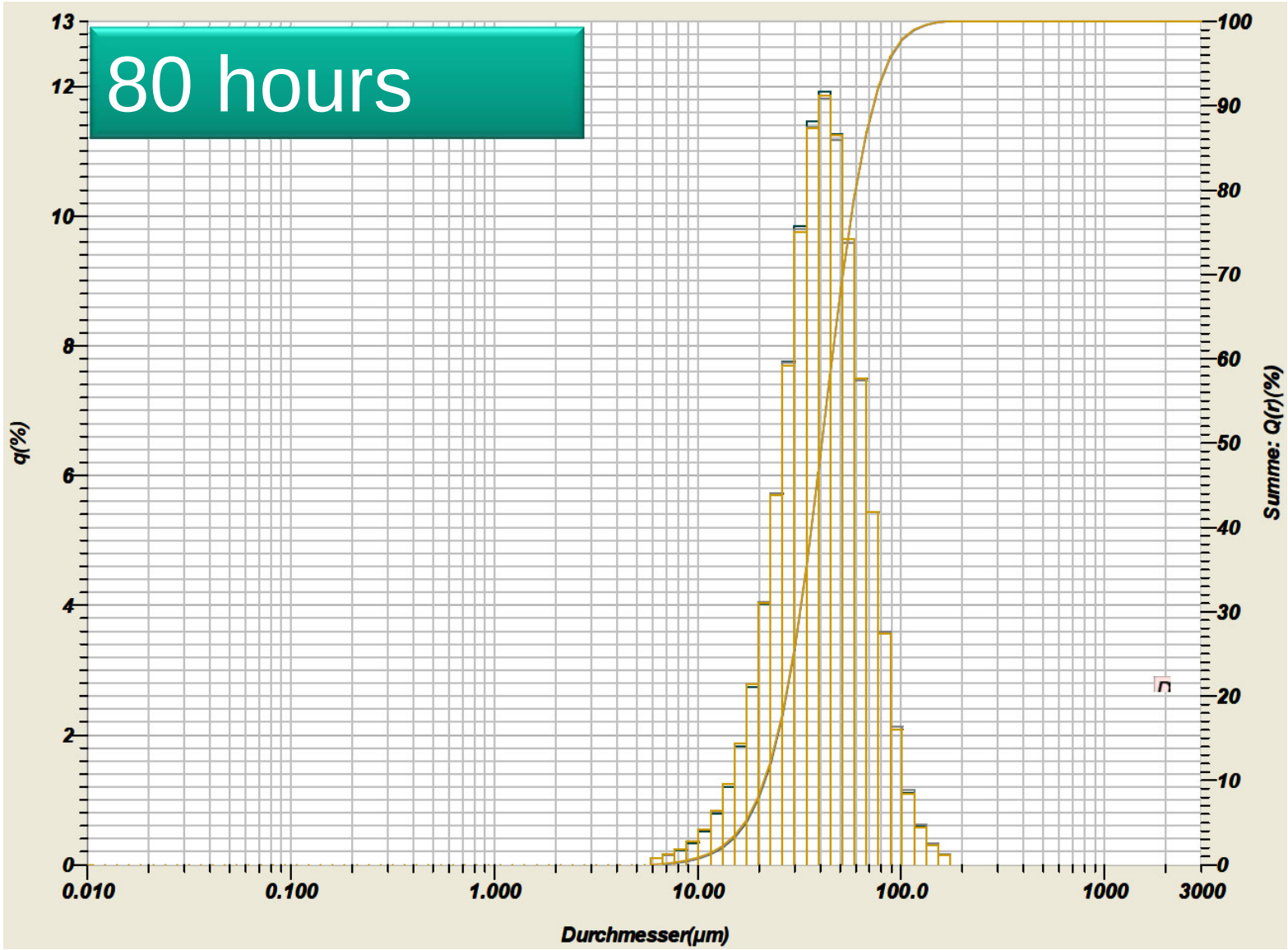


After 80 hours, a more homogeneous particle-size-distribution could be achieved.

Particle size after different milling times

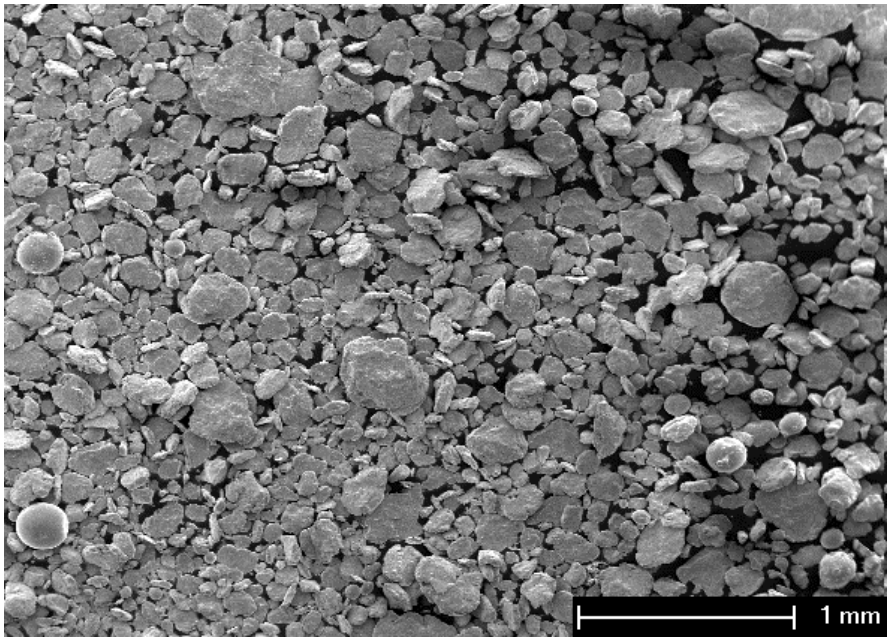


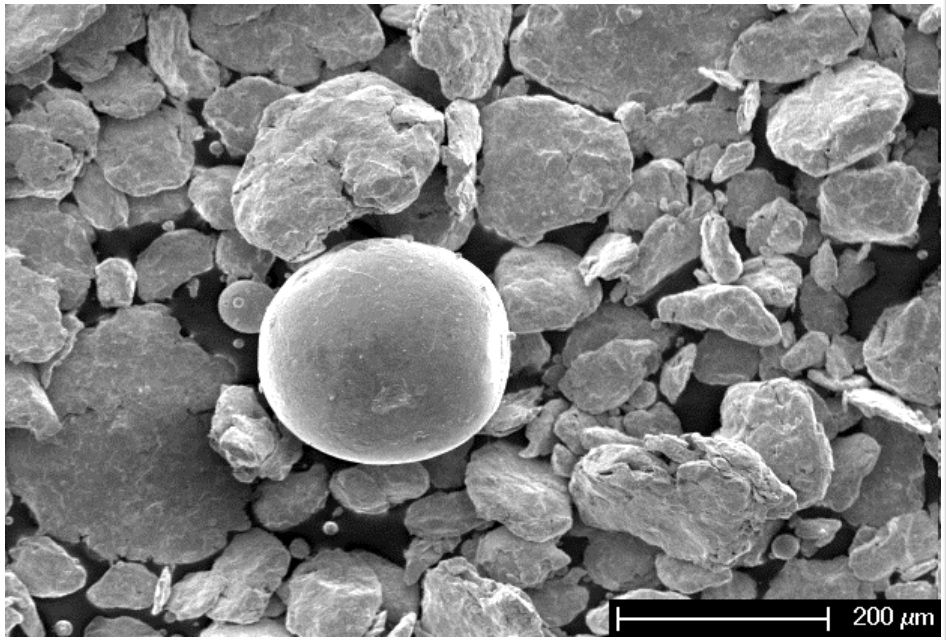
Particles size after different milling times



SEM-images of the milled powders

Fe13Cr1W0,3Ti+0,3Y_2O_3 after 24h milling with 1200 / 800 U/min





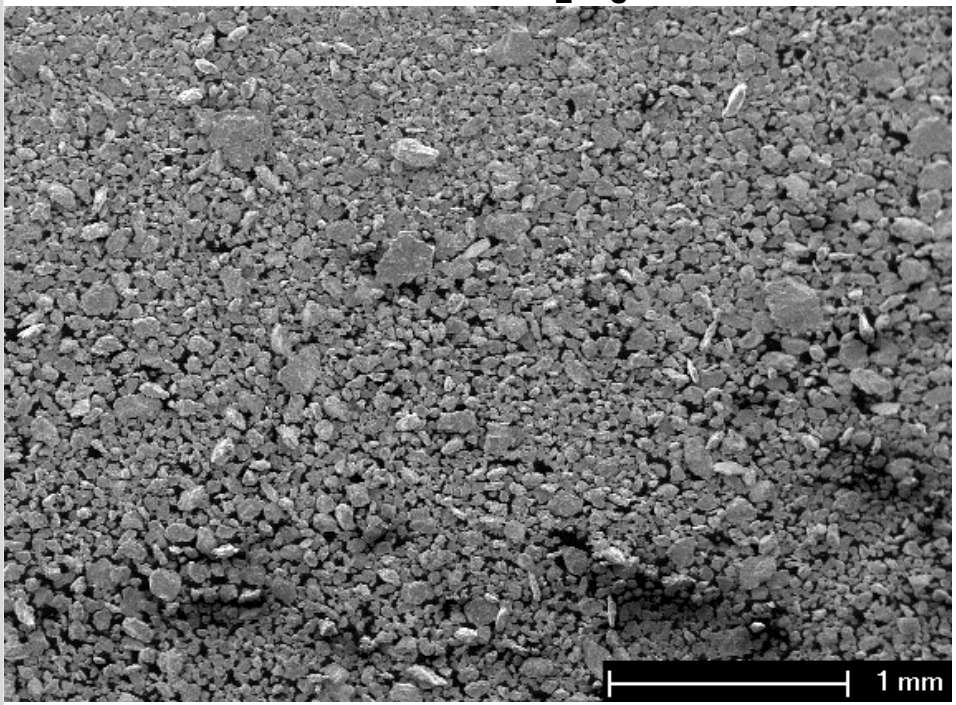
- Perfectly spherical particles could be found.
- These are remaining particles of the as-received powders, which survived the mechanical alloying process.

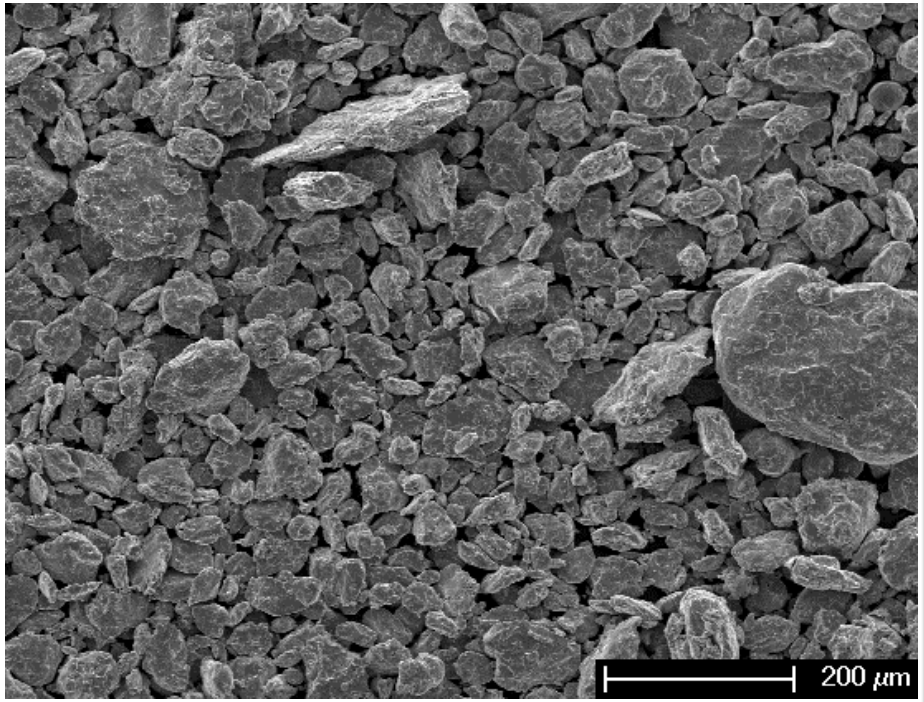
Conclusion: milling-time and –energy were not sufficent!

- Coarsening of the powders (compared to the as-received condition)could be observed.

SEM-images of the milled powders

Fe13Cr1W0,3Ti+0,3Y_2O_3 after 80h milling-time at 1200 / 800 rpm





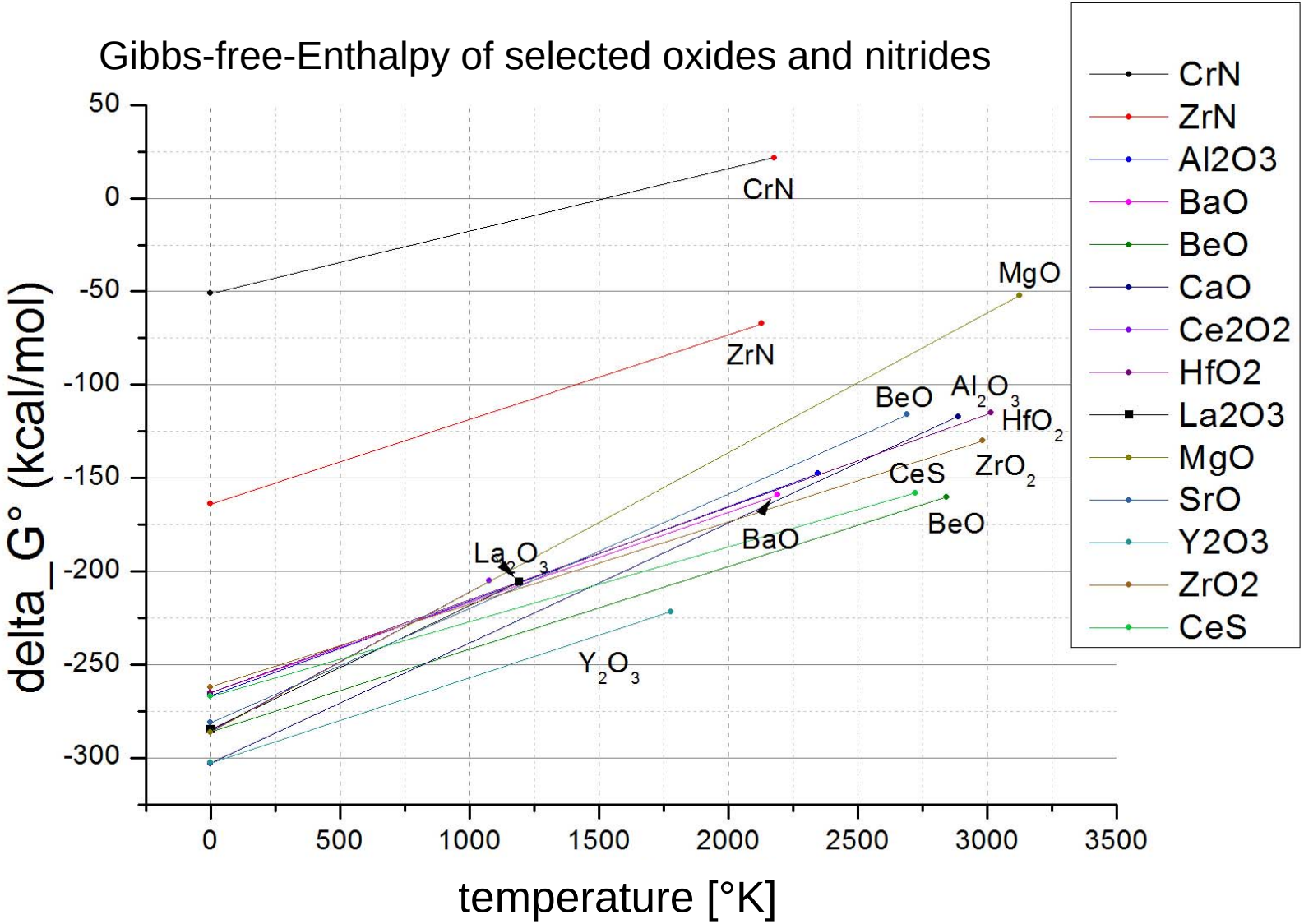
- All powder particles were deformed, no spherical particles detected
- Powder is more fine grained, particle size smaller than in as-received condition (d_{50}=40,8µm)

Results of the investigations of milling-time

By comparing the MA-powders after the different milling-times the follwoing aspects could be observed:

- 24 hours milling-time is not enough for the given material
- Milling for longer times leads to:
  - Homogenization of the particle-sizes
  - Refinement of the particles (smaller than the as-received condition)

Alternative ODS particles



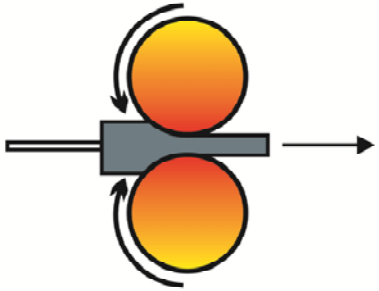
Oxide Screening

- According to the Gibbs-Free-Enthalpy, the most promising oxides were:
  - Hafnium-Oxide (HfC)
  - Lanthan-Oxide (La_2O_3)
  - Magnesium-Oxide (MgO)
  - Zirkonia-Oxide (ZrO)
  - Cerum-Oxide (Ce_2O_3)
- Mechanical Alloying with Fe13Cr1W0,3Ti-Powder + 0,3 oxide were carried out a Zoz Simoloyer Attritor Ball-Mill
- The milling was done for 80 hours at 1000 / 700 rpm

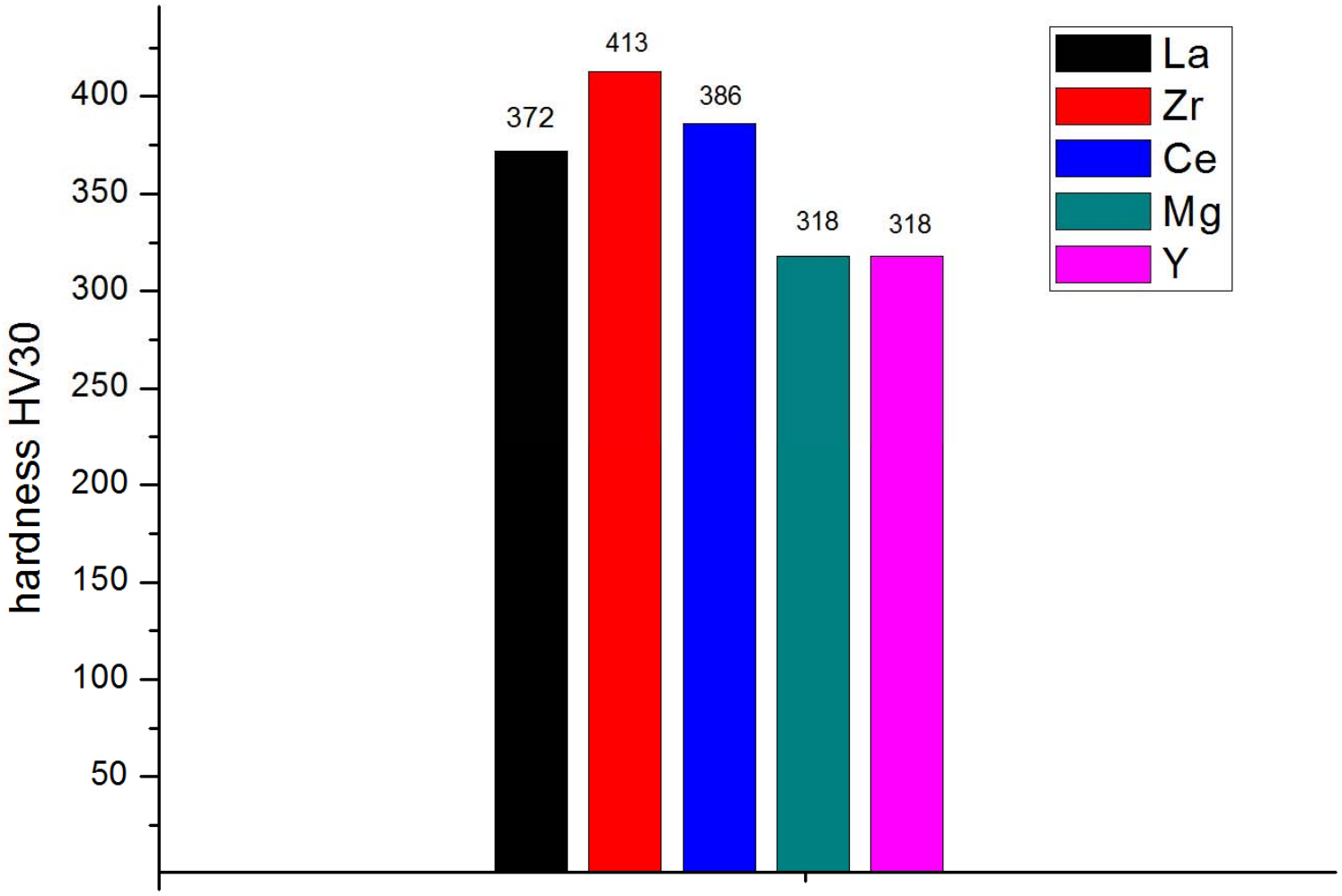
Thermo-mechanical treatment

The produced batches (capsules) containing different oxides were hot-rolled:

- HIPing at 1100°C / 100 MPa for 2 hours
- Rolling at 1100°C
- Reduction of the thickness from 45 to 6 mm
- 5 passes with reheating to process temperature needed for the reduction



Mechanical properties (Vickers-hardness)



Outlook

<u>Outlook of the ongoing and planned tasks</u>:

- Mechanical testing of the rolled alloys (charpy-impact, tensile and creep-strength)
- Fabrication of new batch of alloys with a possible variation of the chemical composition (depending on the results of the mechanical tests)

Thank you for your attention!