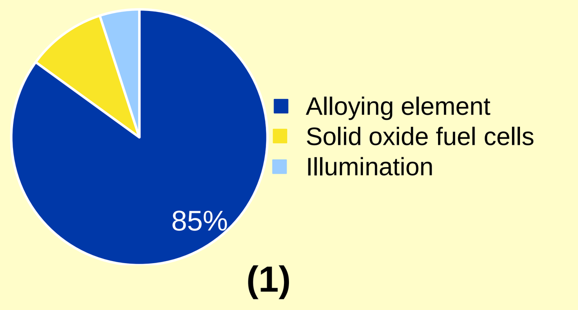
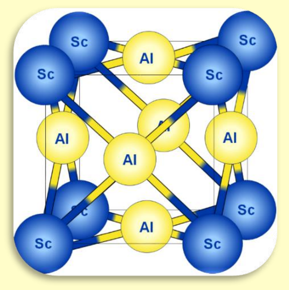
New Metallothermic Reduction Methods for Sc and Al-Sc master alloys

F. Brinkmann[1], B. Friedrich[1],
[1]IME Process Metallurgy and Metal Recycling - RWTH Aachen University

OBJECTIVES



(1)



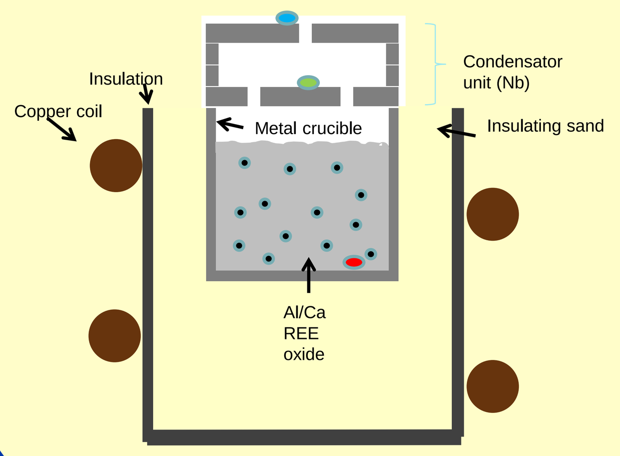
(2)

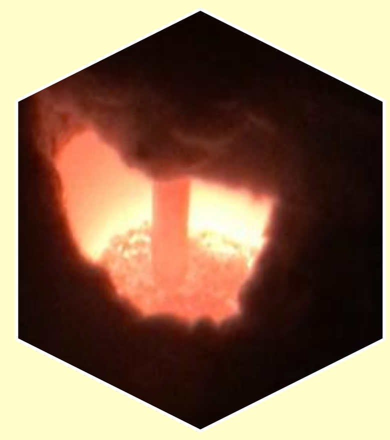
- Sc and Sc-bearing alloys synthesis from Sc precursors
- Understanding the fundamental reactions governing the metallothermic reduction
- Detailed thermochemical description of the systems

EXPERIMENTAL METHODS

Synthesis

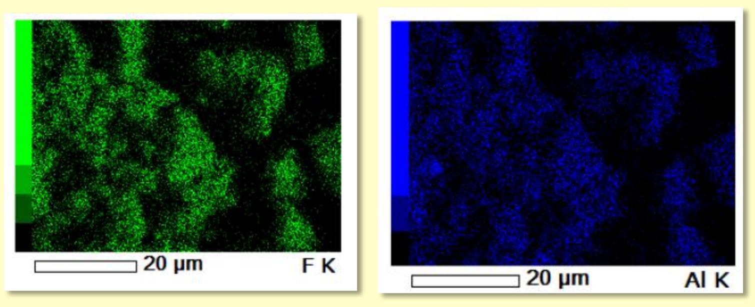
Vacuum Induction Melting (VIM)



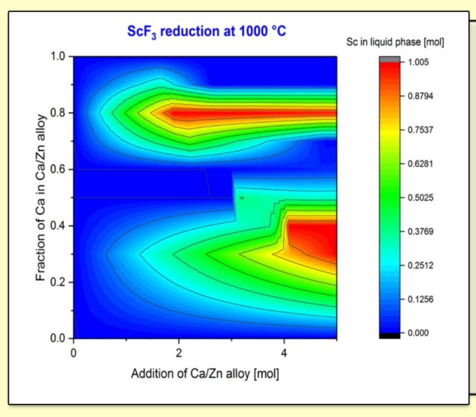


Characterization

- **ICP:** Product composition
- **XRD:** Analysis of phases
- **EDS:** Elemental distribution

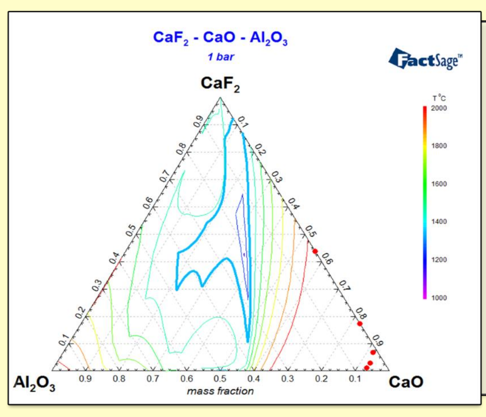


THERMOCHEMICAL MODELING WITH FactSage®

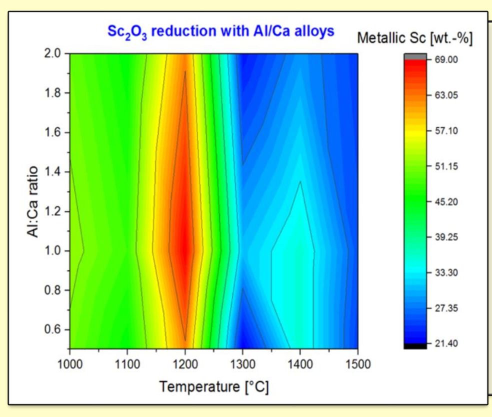


ScF_3 reduction with Ca: Zn as alloying element

Lowering T_{liq}



Slag design for co-reduction: liquid slag with additions of CaF_2 and Al_2O_3

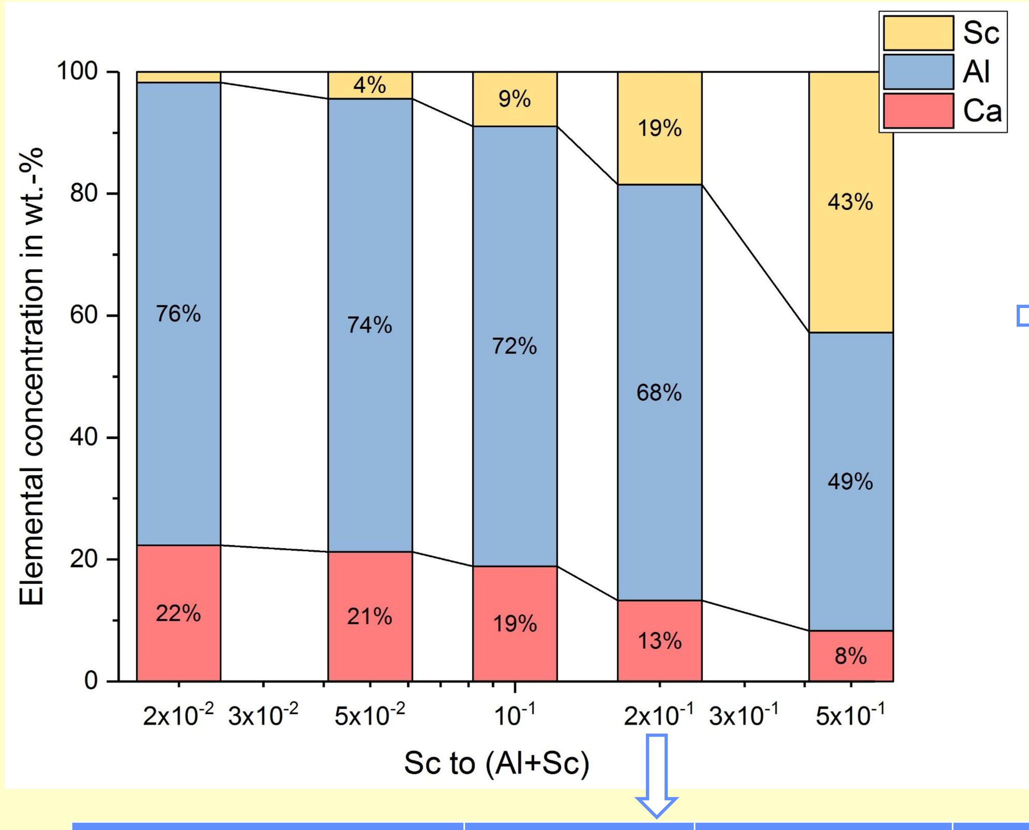


Sc_2O_3 reduction possible with Al or Zn as collector metal: surpassing fluorination

Optimized thermochemical system that ensures

- 100 % Sc yield
- All-liquid slag
- Sc/Ca ratio > 1

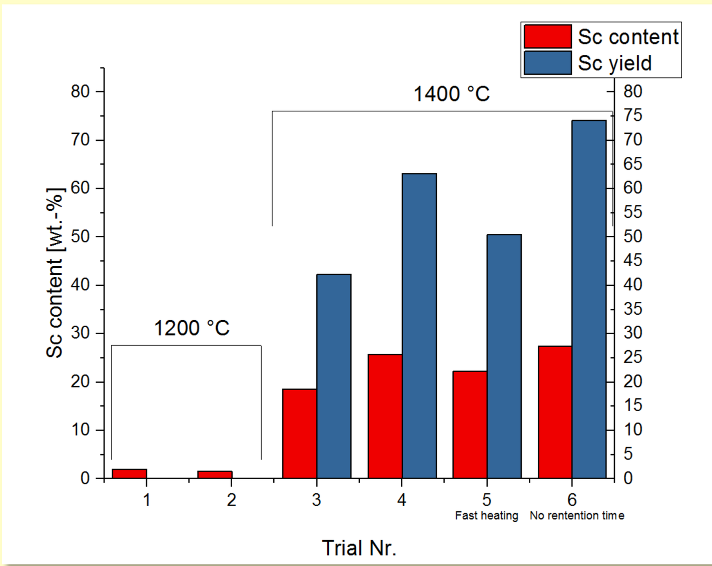
Calculation of heat density, viscosity and influence of fluxes on component activity



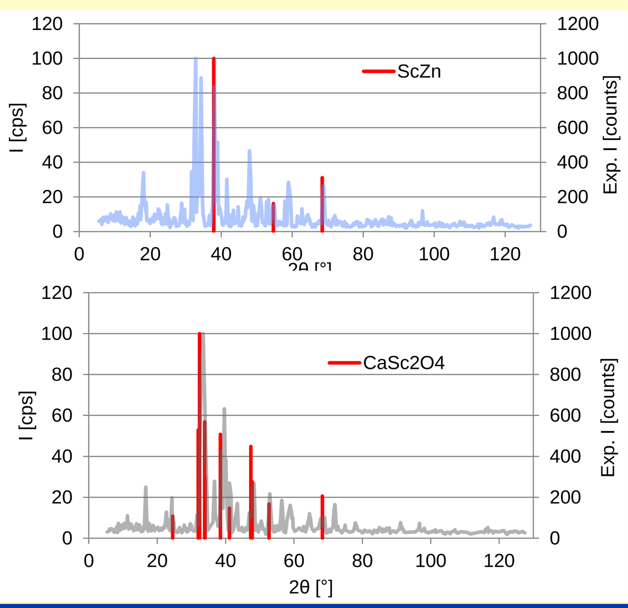
Compound	ScF_3	Al_2O_3	Ca	CaF_2
Wt.-%	5.3	33.2	24.8	36.7

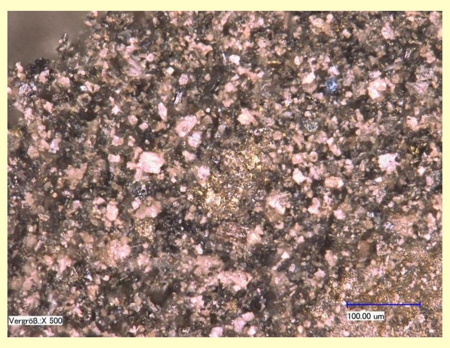
ScF_3 + Al / Sc_2O_3 + Ca/Zn

- Graphite crucible
- Al-Sc formed
- $AlF_{3,g}$ as side product



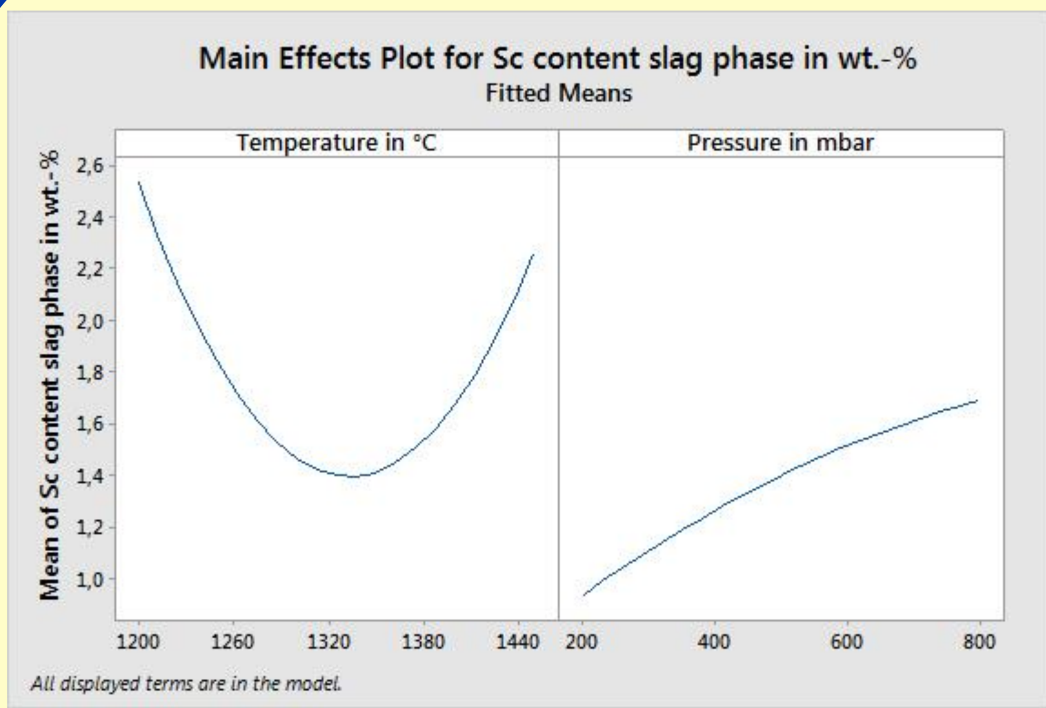
- Ta crucible
- ScZn and $CaSc_2O_4$ formation

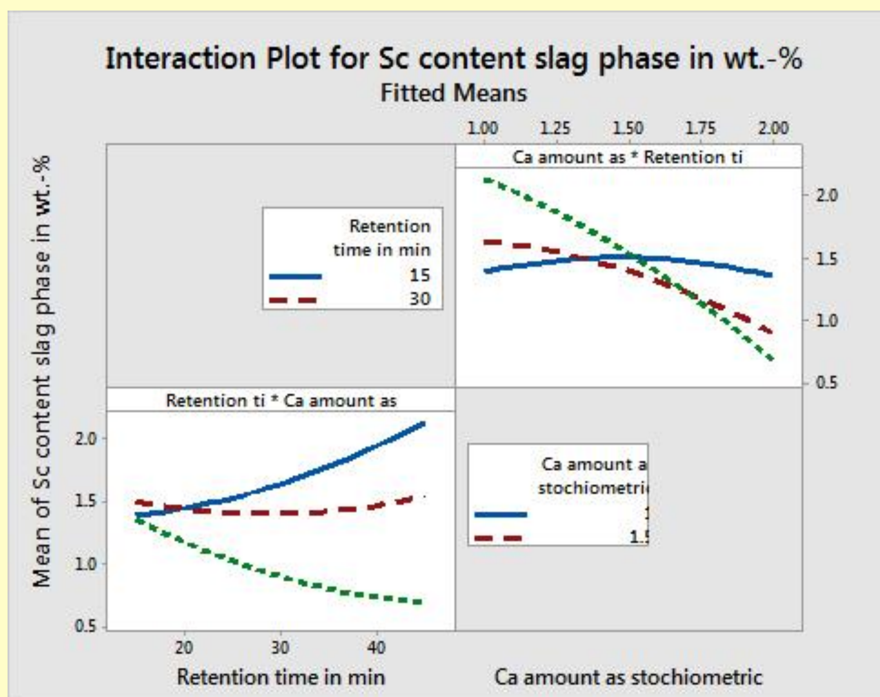




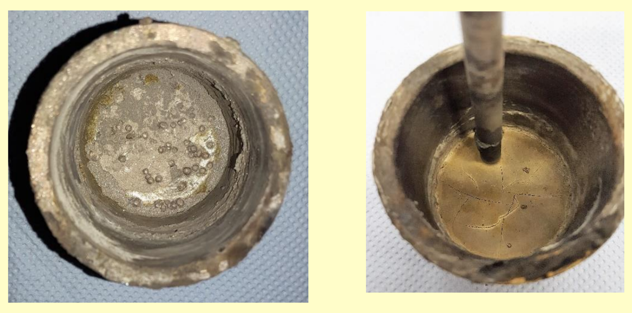
$CaSc_2O_4$ [wt.-%]	Sc_2O_3 [wt.-%]	ScZn [wt.-%]	$ScZn_{12}$ [wt.-%]
88.8	0.6	5.7	4.9

CO-REDUCTION ScF_3 / Al_2O_3 WITH Ca





- Slag Sc content as target: intermediate temperatures optimal, low pressures aid Sc reduction
- Ca surplus with bigger impact at longer retention times



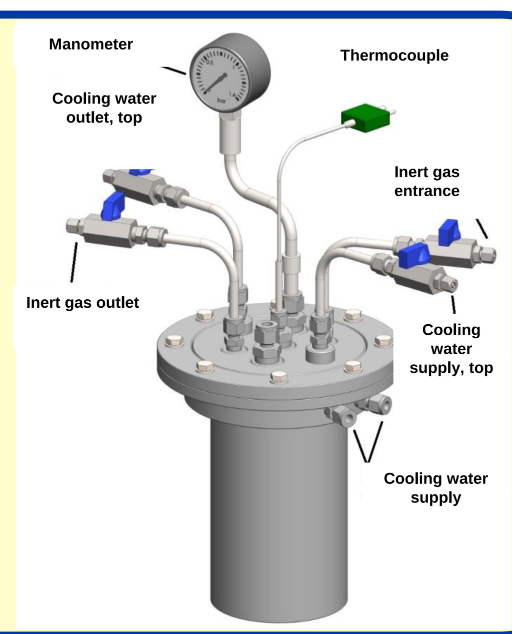
Phases left in crucible. Metal on the left, slag on the right

CONCLUSION

- Metallothermic reduction of ScF_3 feasable with various reducing elements – challenges remain with regards to crucible material and understanding the reaction mechanisms
- Sc_2O_3 reduction only possible at low yields with spinell formation

FUTURE WORK

- Scale-Up in Ta crucible (co-reduction)
- Investigating reaction mechanism by gas-solid cell



REFERENCES

(1) Marscheider-Weidemann, F.; Langkau, S.; Hummen, T.; Erdmann, L.; Espinoza, L. T.; Angerer, G.: Rohstoffe für Zukunftstechnologien 2016 – Raw materials for emerging technologies 2016, German Mineral Resources Agency DERA at the Federal Institute for Geosciences and Natural Resources BGR: Berlin, Germany Vol. 28 (2016), pp. 1-360
(2) Galav, K. L.; Joshi, K. B.: Ab initio investigations of structural and electronic properties of AlSc 3, International Journal of Computational Materials Science and Engineering Vol. 3 (2014) No. 04, p. 1450019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730105.

scale SCANDIUM ALUMINIUM EUROPE

IME DIE METALLURGEN

RWTH AACHEN UNIVERSITY