C4: Casting technology for ODS steels (HZDR, KIT, IPUL)

A candidate material for high-temperature applications:
Oxide dispersion strengthened (ODS) steels (high Cr-steels):
Homogeneously dispersed Yttria nanoparticles

Up to now: only powdermetallurgical production – very expensive!

Need: low-cost casting route

Mixing-in of small particles: strong stirring – can efficiently be made by em fields

weak continuous RMF + pulse of TMF
ceramic particles (2 g/cm^3) on GaInSn (6.5 g/cm^3)
almost all particles submerged

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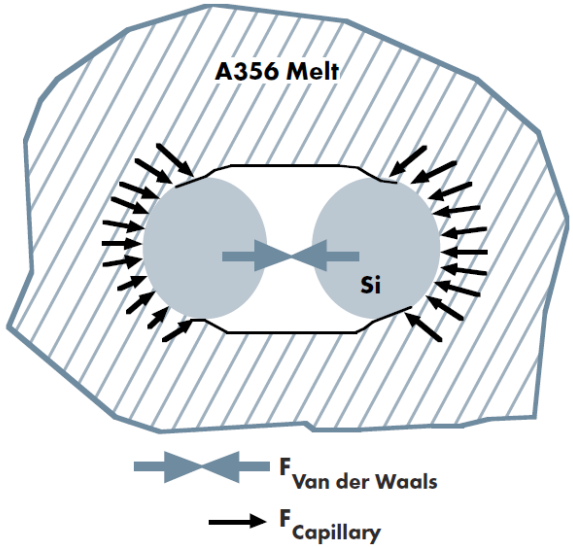
Fluiddynamic mixing of nano-particles:
agglomeration to micro-particles

Al and Mg-alloys: ultrasonic excitation
efficient for nano-particle distribution!
Induced cavitation produces excellent
nano-particle dispersion by
collapsing the residual gas bubbles.



Molten steel: application of ultrasound not possible due to temperature

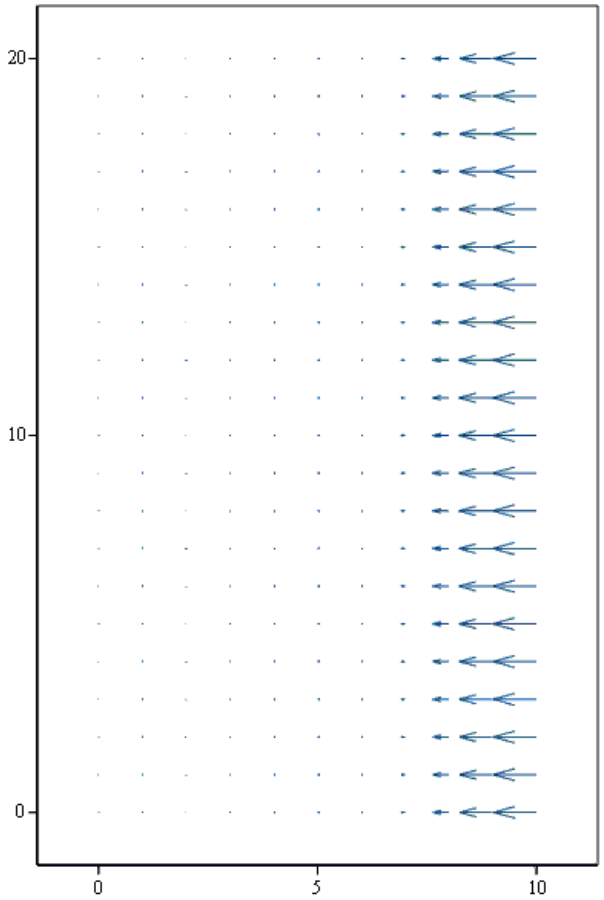
Solution: electromagnetic excitation of sound waves
Superposition of AC and DC magnetic fields

Project tasks:
- Theory of em waves
- model experiments: em induced pressure oscillations measured
- copper samples processed at IPUL
- design and installation of vacuum furnace with em fields for steel processing
- thermodynamic and kinetic calculations of the ODS case at KIT
- ODS samples to be characterized at KIT and HZDR

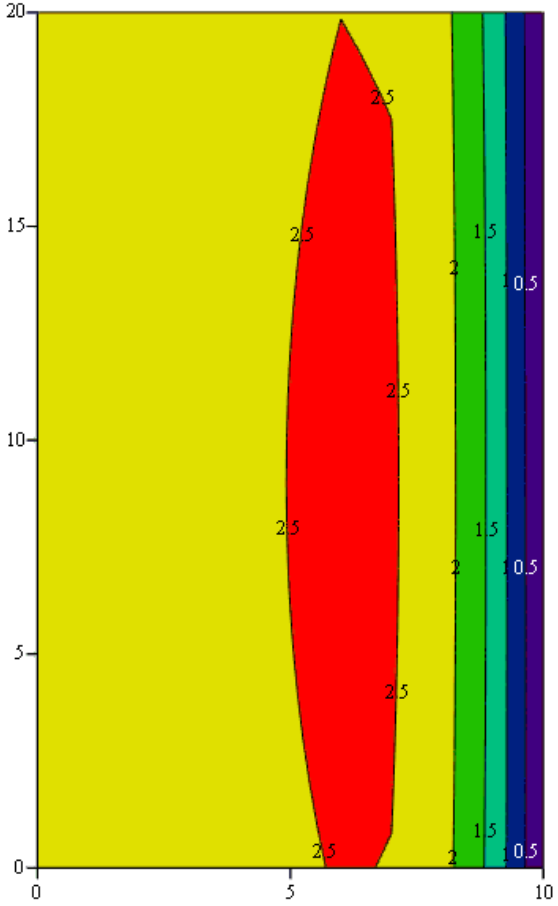
Links: A4, A5, C1, C3

C4: Casting technology for ODS steels

Proposed contactless EM-excitation by superimposed AC/DC fields in liquid steel



Alternating EM-force at B_{AC} = 0.09 T and B_{DC} = 2.4 T , f = 20 kHz



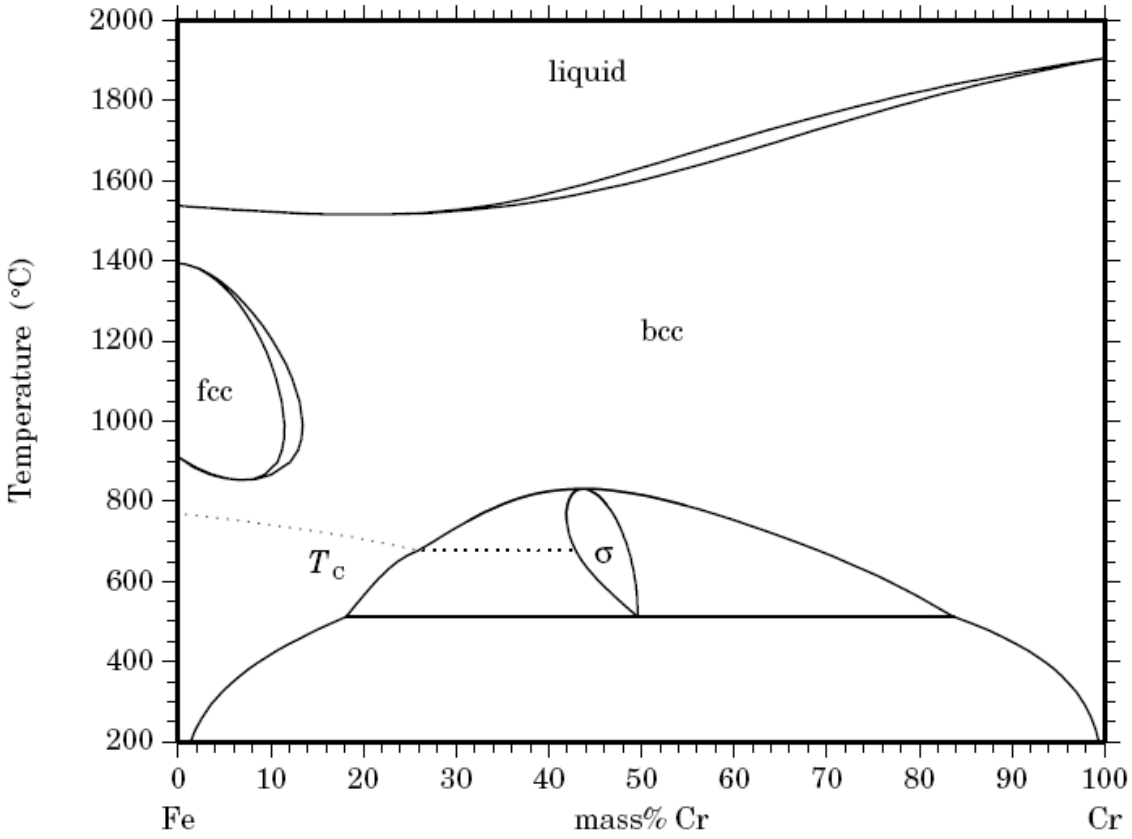
Alternating pressure with 2 bar amplitude

C4-WP6: Thermodynamic and Kinetic Calculations for ODS Steels

P. Franke, H.J. Seifert, A. Möslang, KIT, IAM-AWP

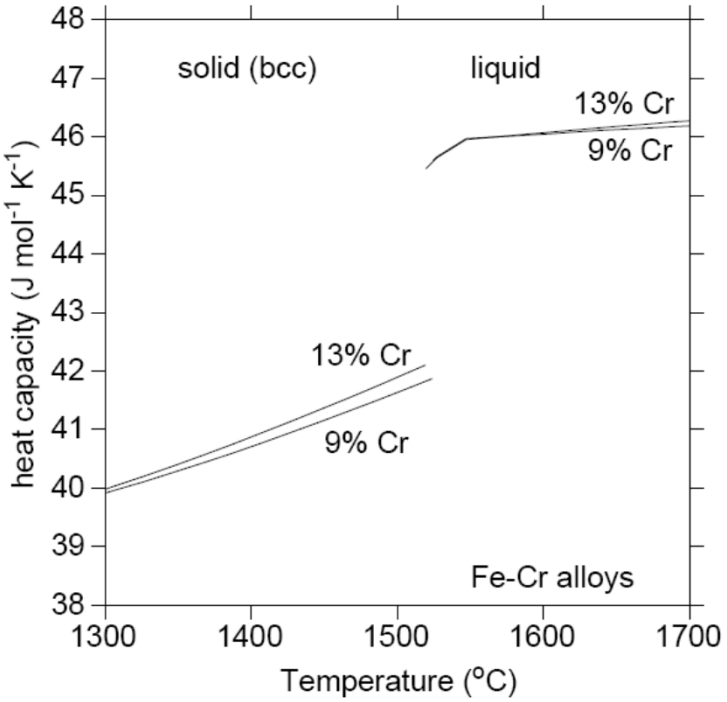
Previous work

- dataset Fe-Cr-O available
- phase diagrams
- property diagrams

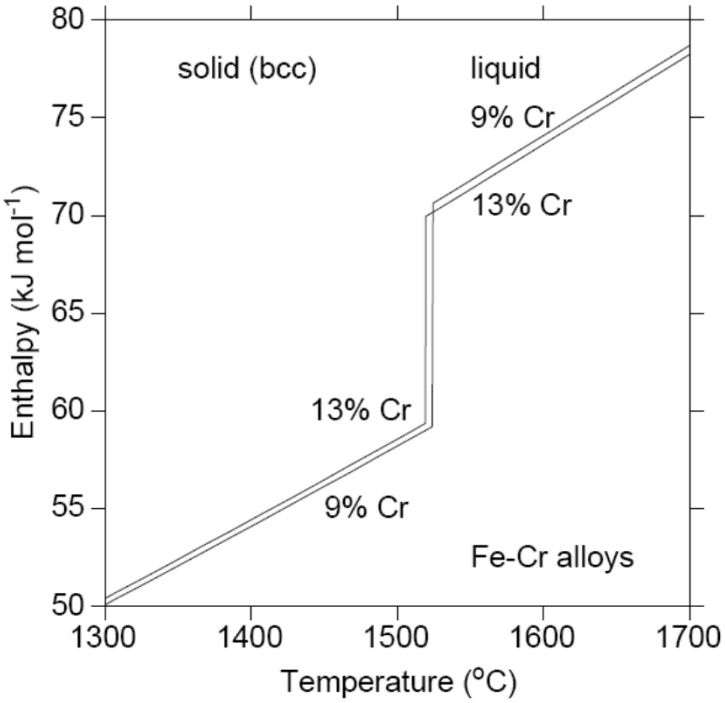


calculated phase diagram of Fe-Cr

Property diagrams for Fe-Cr alloys



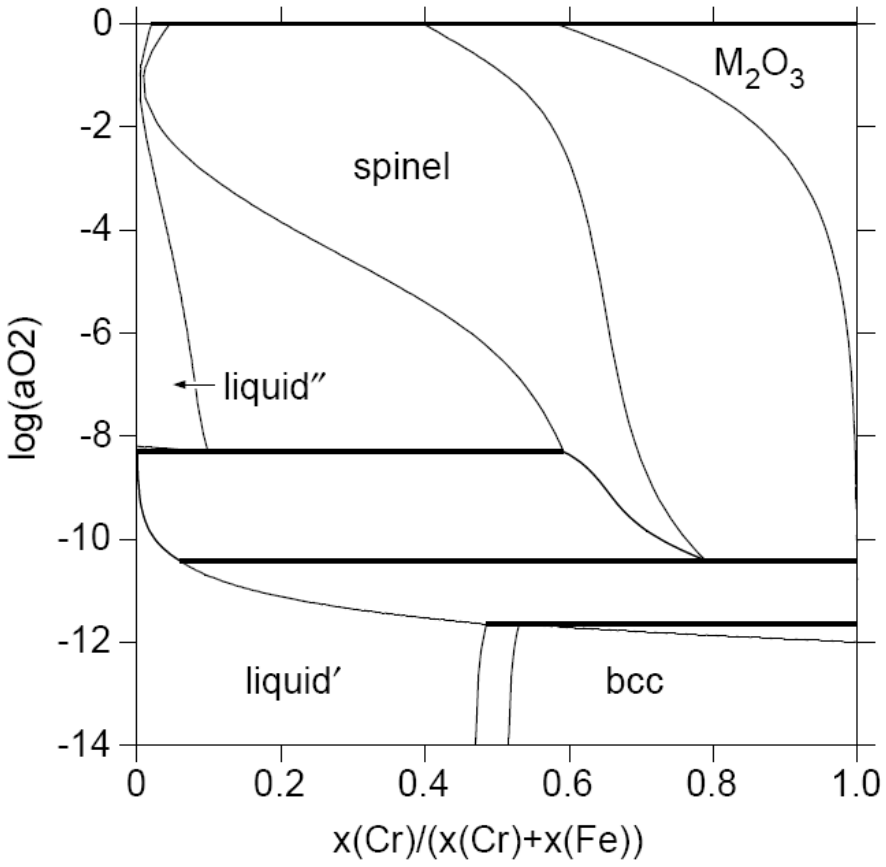
heat capacity of Fe-Cr alloys



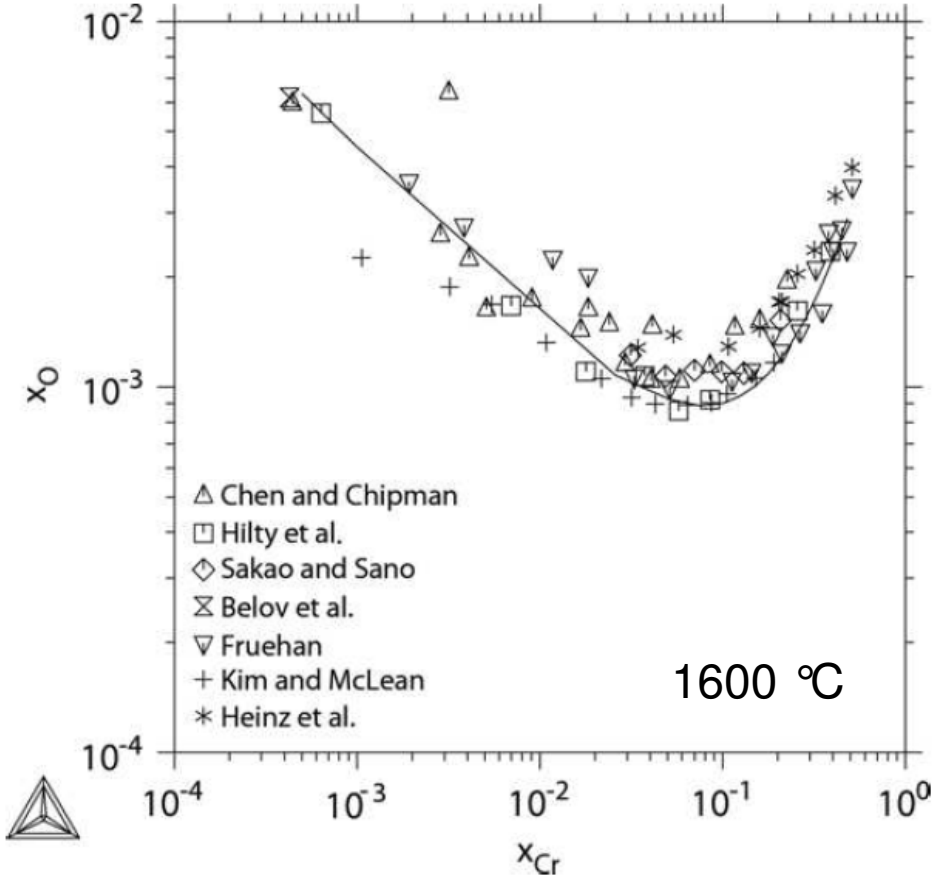
enthalpy of Fe-Cr alloys

	9% Cr	13% Cr
solidus	1523.7 °C	1519.1 °C
liquidus	1524.3 °C	1519.6 °C
melting enhalpy	11.4 kJ/mol	10.4 kJ/mol

The system Fe-Cr-O



Phase diagram of Fe-Cr-O at 1600 °C



Oxygen solubility in Fe-Cr alloys

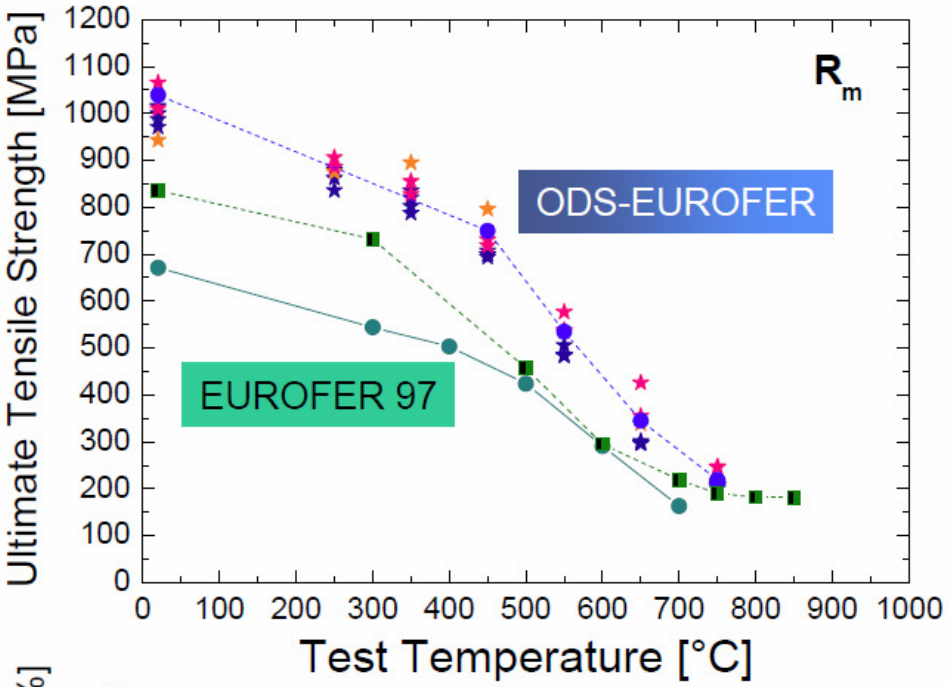
Planned work in C4-WP6

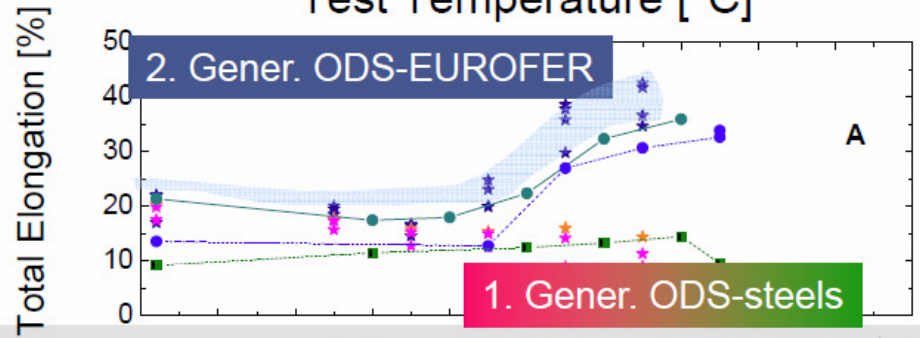
- thermodynamic assessment of the quarternary system Fe-Cr-Y-O
- solubility of Y and of Y_2O_3 in Fe-Cr alloys
- calculation of heat capacity, heat contents and transformation temperatures
- calculation of solidification under equilibrium and non-equilibrium conditions
- investigation of solidified ODS steel samples by SEM, TEM, EDX, WDX

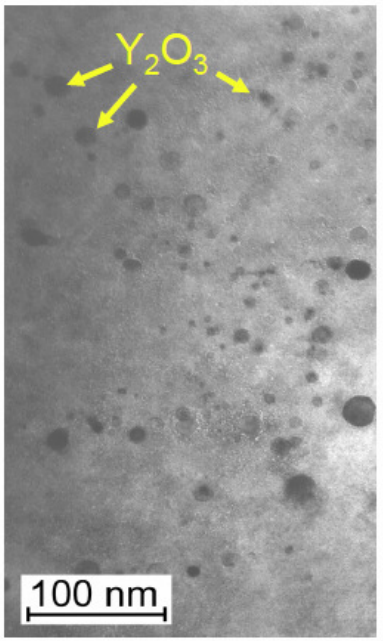
Reserve

Casting of ODS-Steel

Oxide dispersion strengthened FM Steels
- Tensile Strength and Ductility -

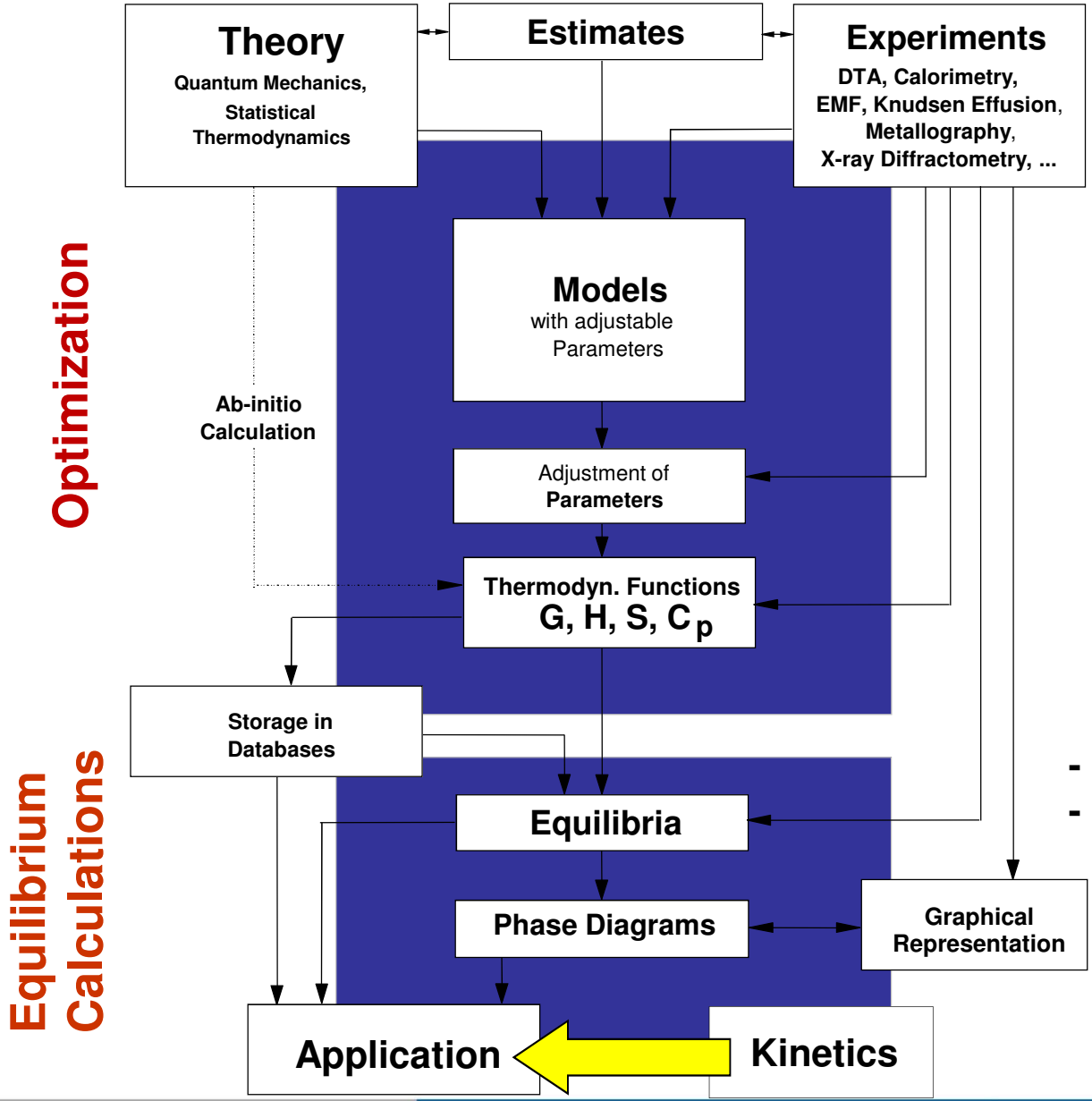






ODS EUROFER:
Superior Ductility in the entire temperature range (RT – 700 °C)

Computational Thermodynamics



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CALculation of PHAse Diagrams

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- Sharp interface methods
- Phase field methods