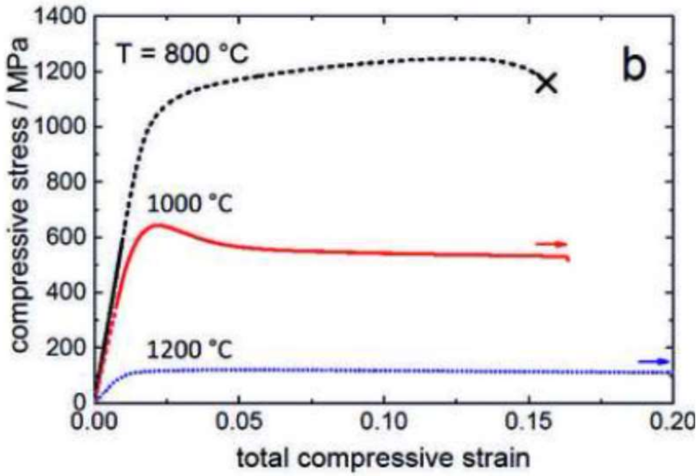
Project: Development of refractory metal-based CCAs with improved mechanical properties

I. Motivation and preliminary work (in the framework of the on-going DFG-project)

Refractory metal-based alloys, in particular, HEA Nb-Mo-Cr-Ti-Al and CCA Ta-Mo-Cr-Ti-Al can be considered as promising high temperature structural materials because:

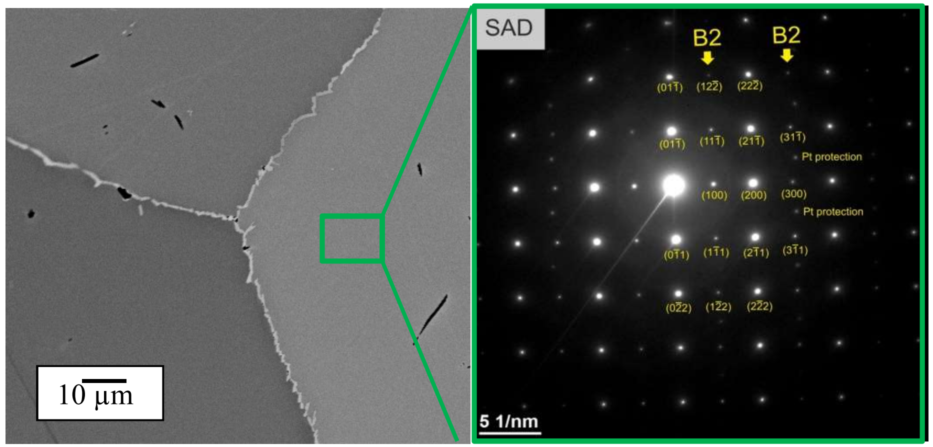
a) Already good strength at high temperatures in the nearly single phase HEA condition

HEA Nb-Mo-Cr-Ti-Al
(heat-treatment 1300°C, 20h)



b) Widely adjustable microstructure in the CCA condition that can further improve high-temperature strengh

CCA Ta-Mo-Cr-Ti-Al (BCC/B2, Laves)
(heat-treatment 1500°C, 20h)



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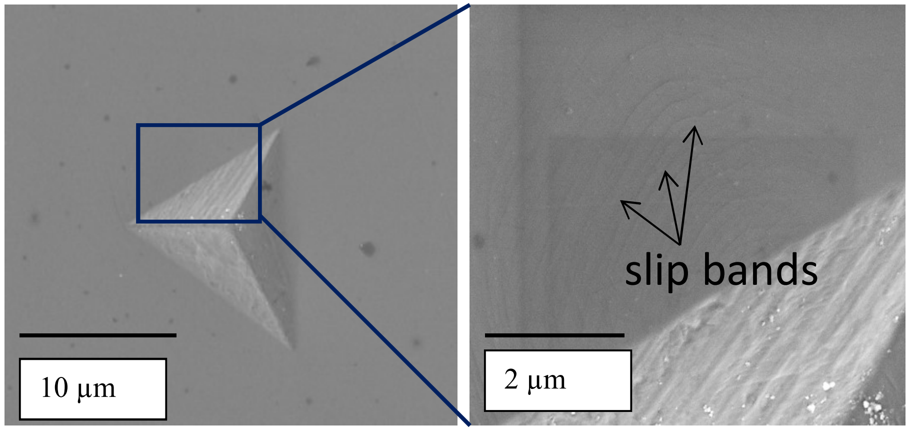
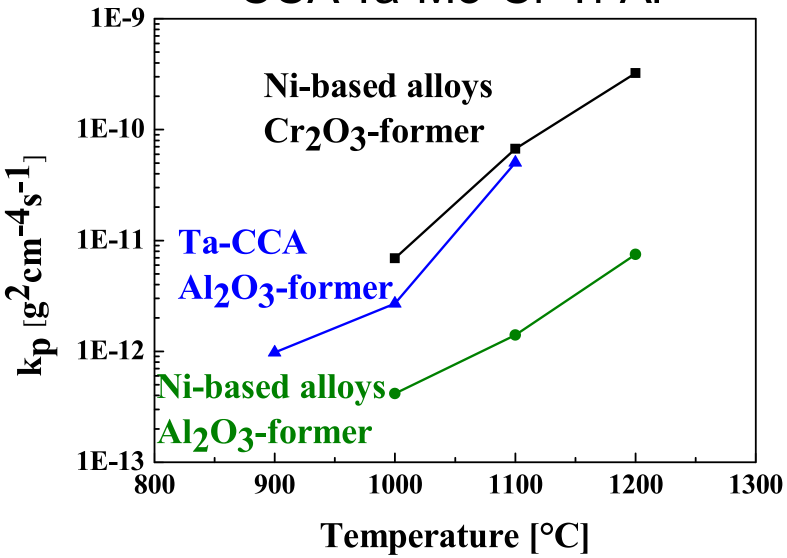
c) Plastically deformable matrix (BCC) at ambient temperatures

HEA Nb-Mo-Cr-Ti-Al



d) high oxidation resistance

CCA Ta-Mo-Cr-Ti-Al



Main drawback: low ductility of HEA/CCA at RT (if Laves phase is present)

II. Objectives: establishment of a favorable property combination guided by physical metallurgy design principles

- high temperature strength
- ductility at low temperatures
- oxidation resistance

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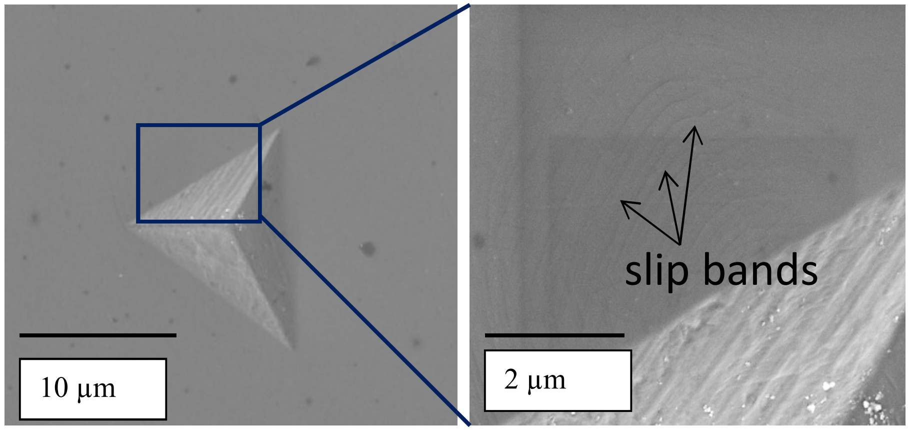
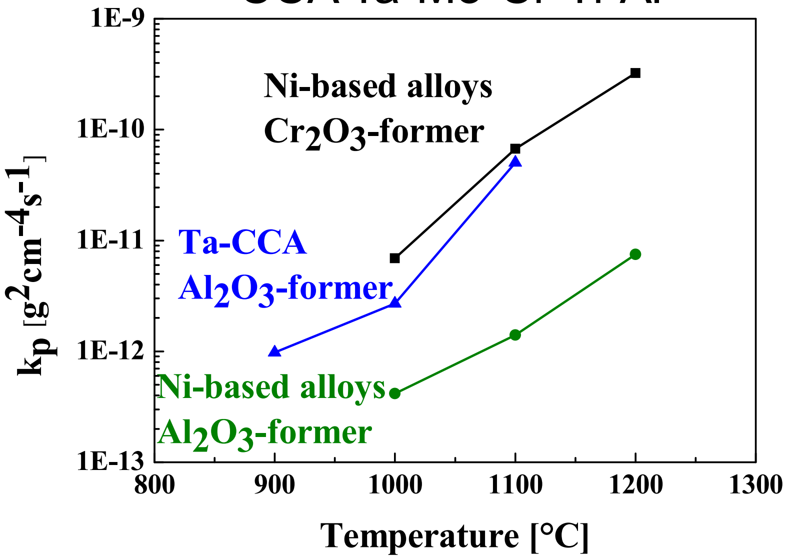
c) Plastically deformable matrix (BCC) at ambient temperatures

HEA Nb-Mo-Cr-Ti-Al



d) high oxidation resistance

CCA Ta-Mo-Cr-Ti-Al



Main drawback: low ductility of HEA/CCA at RT (if Laves phase is present)

II. Objectives: establishment of a favorable property combination guided by physical metallurgy design principles

- high temperature strength
- ductility at low temperatures
- oxidation resistance

} primary objectives (high temperature strength, ductility at low temperatures)

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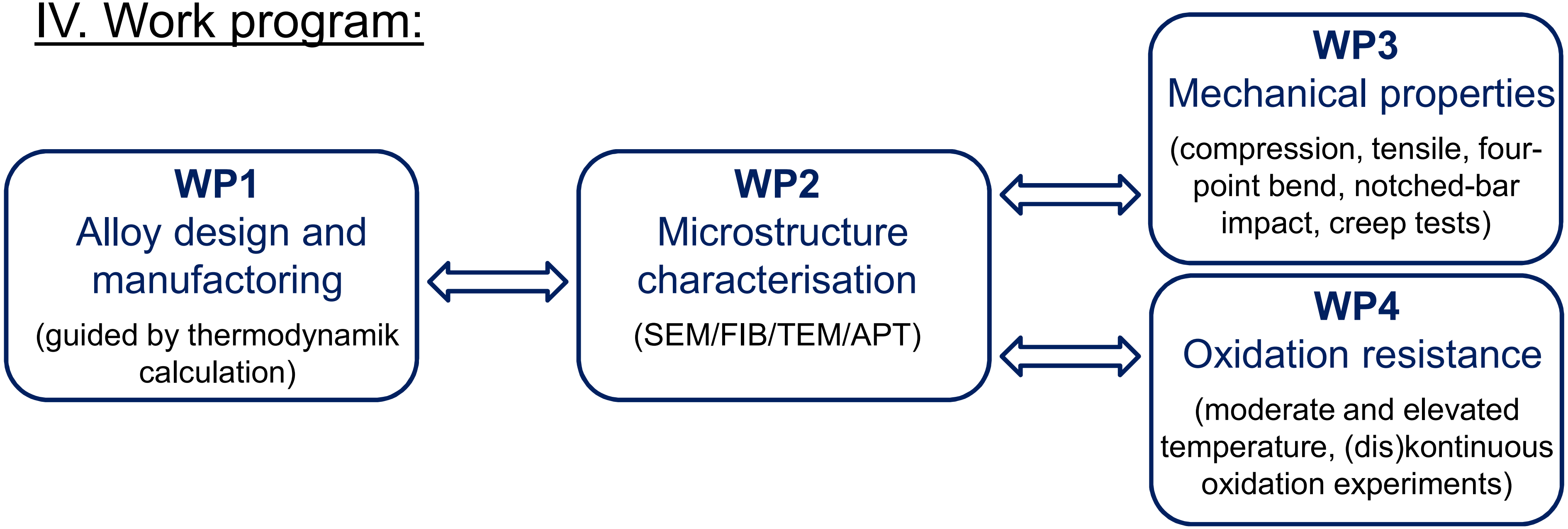
III. Strategies to achieve objectives:

- Suppression of the inherently brittle Laves phases Cr_2Nb/Cr_2Ta by lowering the Cr content in the CCAs Nb-Mo-Cr-Ti-Al & Ta-Mo-Cr-Ti-Al
- Establishment of a two-phase microstructure (BCC/B2) with a substantial amount of the second strengthening B2 phase by varying the Nb/Ta-ratio in the new 6-component Nb-Ta-Mo-Cr-Ti-Al alloys
- Ductilizing the alloy matrix at ambient temperature by additions of Re

IV. Work program:



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V. Contribution to the objectives of the priority program SPP 2006/1:

- chemical composition of the refractory CCAs with improved mechanical properties for high temperature applications will be identified
- mechanical behavior of the HEAs/CCAs at room and elevated temperatures will be extensively characterized; underlying deformation mechanisms will be determined
- oxidation resistance of novel refractory CCAs will be investigated and oxidation mechanisms/roles of each element clarified

⇨ Profound knowledge of mechanismen-based material behavior pave the way for successive application-related alloy development

VI. Cooperation with other researches:

- Prof. Hans-Jürgen Seifert and Dr. Michael Stüber (KIT, Institute for Applied Materials, IAM-AWP): mutual support in providing thermochemical data for thermodynamic calculations
- Dr. Ruth Schwaiger (KIT, Institute for Applied Materials, IAM-WBM): analyzes on dislocation mediated plasticity, providing material
- Dr. Mathias Galetz (Dechema Frankfurt) and Dmytro Naumenko (Research Center Jülich): discussion of the oxidation mechanisms of refractrory CCAs