Deformation Mechanisms in FCC and BCC High Entropy Alloys Under Various Conditions

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A contribution to the “HEA branch” of the SPP.

Institute for Applied Materials (IAM–WK) and Institute for Technical Physics (ITEP)
Motivation

The proposal aims at revealing deformation mechanisms and peculiarities of deformation in two HEA model systems, namely CoCrFeMnNi (FCC) and HfNbTaTiZr (BCC) under extreme conditions.

Specific problems:

- rare information on the interaction of dislocations and solute atoms in concentrated solid solutions
- lack of knowledge about contributions of dislocation cores and short range order to solid solution hardening
- contradictory prediction of stacking fault energy (DFT: 4 mJ/m² @ 4.2 K) and experimentally observed deformation mode in CoCrFeMnNi at 4.2 K
- not conclusively investigated twin systems in HfNbTaTiZr and their contribution to work-hardening and outstanding ductility

Huang et al. in Scripta Materialia 108 (2015) 44 - 47
Preliminary work

Peculiarities of deformation in CoCrFeMnNi and HfNbTaTiZr

- **CoCrFeMnNi:**
  - Serrated plastic flow at cryogenic temperatures as manifestation of dislocation-solute interaction
  - Complexity of the phenomenon needs detailed information about work-hardening, deformation twinning and physical properties at these temperatures

- **HfNbTaTiZr:**
  - Deformation twinning is active at room temperature
  - Twinning modes can only partially be attributed to the most common BCC twin system \((11\bar{1})\{11\bar{2}\)
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- experimental approach towards better understanding of dislocation-solute interactions
- revealing different deformation mechanisms specific to HEAs and their contributions to mechanical behavior of HEAs
- by means of:
  - manufacturing of high quality samples with specific composition and desired microstructure (IAM-WK, WP1)
  - mechanical testing of macroscopic HEA samples under extreme conditions, namely T down to 4.2 K and $\varepsilon$ up to $\sim 15 \text{ s}^{-1}$ (ITEP, WP2 & WP3)
  - determination of necessary physical properties, namely lattice parameter, shear modulus, thermal conductivity, heat capacity etc. (ITEP & IAM-WK, WP4)
  - scale-bridging, microstructural investigations, namely pseudo-ECCI, EBSD, TEM, APT (IAM-WK, WP5)
Collaborations

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Collaborations within the Priority Programme:

- Prof. Jens Freudenberger (IFW Dresden): cold- and hot-working of ingots
- Dr. Bronislava Gorr (University of Siegen): thermodynamic calculations within the Co-Cr-Fe-Mn-Ni system
- Dr. Michael Stüber (KIT, IAM-AWP): combinatorial film deposition within the Co-Cr-Fe-Mn-Ni for alloy screening
- Dr. Michael Feuerbacher (FZ Jülich) and Dr. Markus Heidelmann (University of Duisburg-Essen): oriented single crystals
- Dr. Ruth Schwaiger and Dr. Christian Brandl (KIT, IAM-WBM): micro-mechanical testing and atomistic simulation of deformation mechanisms

International collaborations:

- Prof. Sharvan Kumar (Brown University, USA): weak beam TEM studies on dissociated dislocations
- Prof. V. Subramanya Sarma (IIT Madras, India): cold- and hot-working simulation