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

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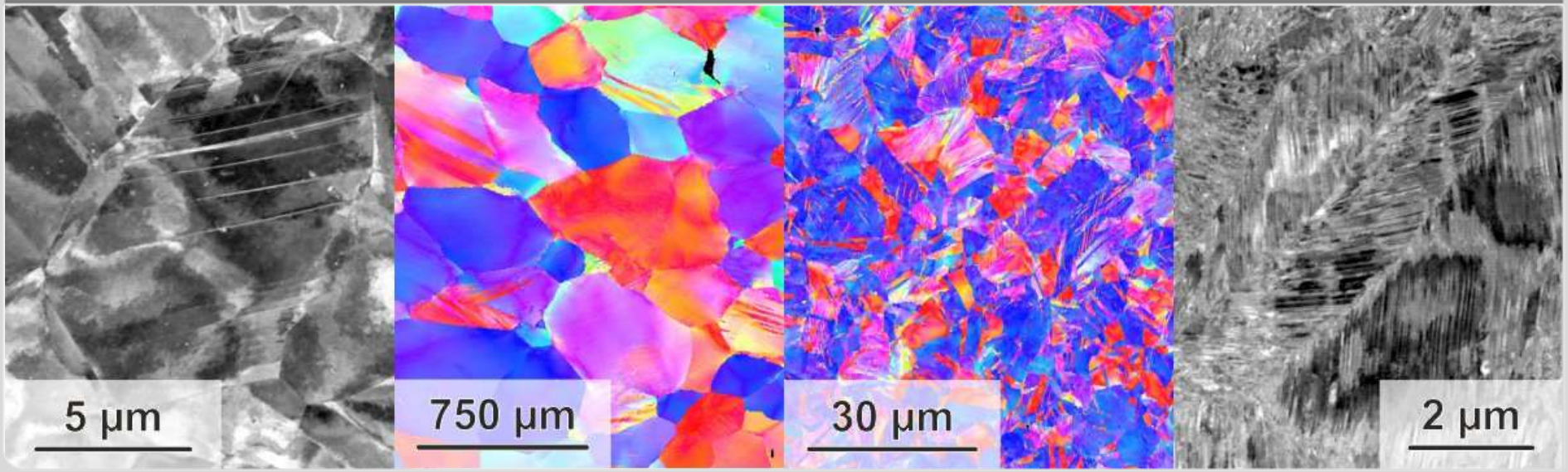
A contribution to the **"HEA branch"** of the SPP.

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



Motivation

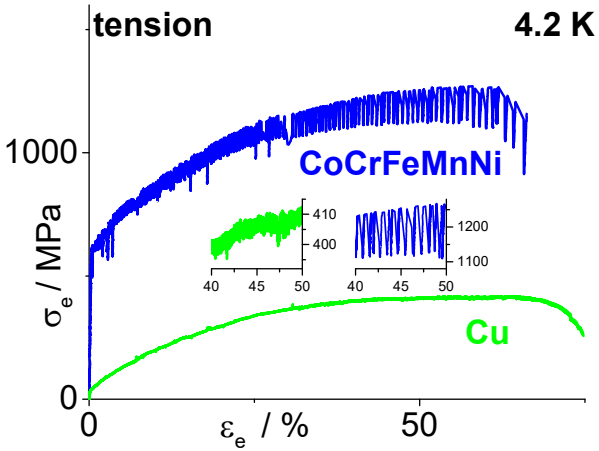
- The proposal aims at **revealing deformation mechanisms** and **peculiarities of deformation** in two HEA **model systems**, namely **CoCrFeMnNi (FCC)** and **HfNbTaTiZr (BCC)** under extreme conditions.
- Specific problems:
  - rare information on the **interaction of dislocations** and **solute atoms** 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**

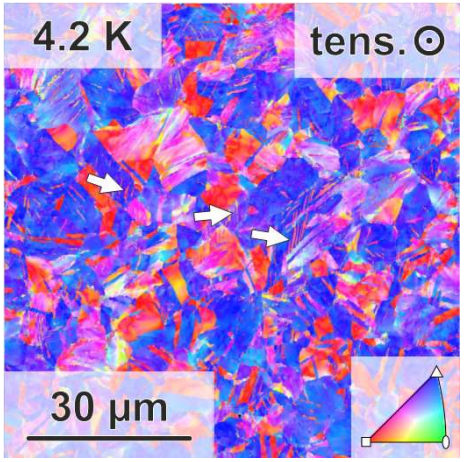
Huang et al. in Scripta Materialia 108 (2015) 44 - 47

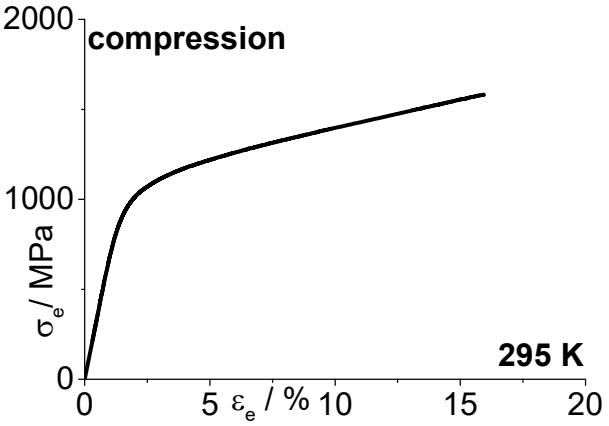
Preliminary work

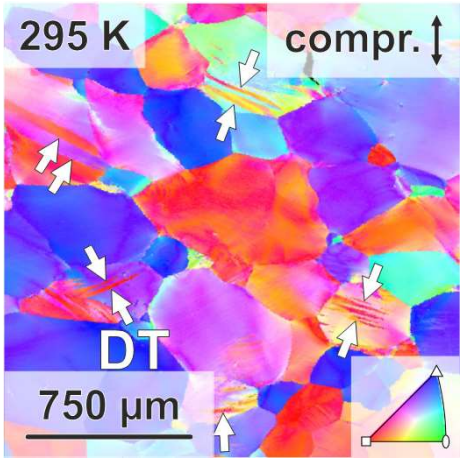
Peculiarities of deformation in CoCrFeMnNi and HfNbTaTiZr

- 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** $\langle 11\bar{1}\rangle\{112\}$









Contribution to the priority programme

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

- 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 $\dot{\varepsilon}$ up to ~15 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

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

- 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