Mechanisms of the simultaneous increase of strength and ductility in heavily cold rolled bcc metals

This presentation is about fundamental mechanisms of plastic deformation and fracture of bcc metals. In particular, the increase of strength and ductility after heavy cold rolling will be elucidated. We define 'ductility' as both

- the tensile ductility (i.e. uniform elongation) and
- the brittle-to-ductile transition (BDT).

Five tungsten (W) sheets have been rolled out from one and the same sintered ingot. The sheets differ in their degree of deformation. Electron microscopy as well as mechanical tests have been applied to identify deformation mechanisms. These are the main results:

1) Tensile tests show a change of deformation and hardening mechanisms after heavy cold rolling. A type of confined slip with only three active slip systems is suggested.
2) Strain-rate jump tests display an increase of the strain-rate sensitivity above the critical temperature. From this, a change in the dislocation-grain-boundary-interaction can be inferred.
3) The BDT decreases by more than 600 K down to -65 °C. The BDT temperature scales with the grain size (Fig. 1).
4) The activation energy of the BDT, \( \Delta H_{BDT} \), suggests that the BDT is still controlled by the glide of screw dislocations.

The presentation ends with a discussion on the mechanisms responsible for the 'Sub-zero-°C-BDT-W'. We suggest that dislocation sources along the crack front play a major role (grain boundary ledges, cross slip).

Fig. 1: The BDT temperature decreases by more than 600 K down to -65°C by heavy cold rolling. The underlying mechanisms have not been identified yet [C. Bonnekoh et al, 2017].