Engineering Conferences International
ECI Digital Archives

Nanomechanical Testing in Materials Research and Development V

Proceedings

Fall 10-4-2015

Orientation dependence of dislocation transmission through twin-boundaries studied by in situ µLaue diffraction

Nataliya Malyar
Max-Planck-Institut, malyar@mpie.de

Nagami Jaya
Max-Planck-Institut

Gerhard Dehm
Max-Planck-Institut

Christoph Kirchlechner
Max-Planck-Institute on Research of Collective Goods

Jean Sebastuen Micha
Grenoble University

Recommended Citation

Clarck W.A.T., Wagoner, R.H., Shen, Z.Y. (1992): On the criteria for slip transmission across interfaces in polycrystals – In: Scripta Metallurgica et Materialia, 26, 203-206. Imrich P.J, Motz C.,Dehm G., Kirchlechner C. (2014): Differences in deformation behavior of bicrystalline Cu micropillars containing a twin boundary or a large-angle grain boundary – In: Acta Materialia, 73, 240-250. Jin Z.-H.,Gumbsch P., Ma E., Albe K., Lu K., Hahn H., Gleiter H.(2006): The interaction mechanism of screw dislocations with coherent twin boundaries in different face-centered cubic metals – In: Scripta Materialia, 54, 1163-1168.

Structure and Nanomechanics
Prof. Dr. G. Dehm

Nano-/Micromechanics of Materials
Dr. C. Kirchlechner

Orientation dependence of dislocation transmission through twin-boundaries studied by in situ µLaue diffraction

Nataliya Malyar, Nagamani Jaya B, Jean-Sébastien Micha, Gerhard Dehm, Christoph Kirchlechner
*malyar@mpie.de

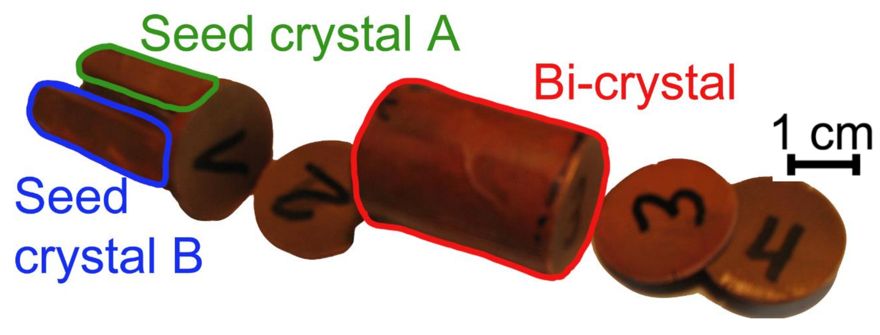
Max-Planck-Institut für Eisenforschung GmbH
Düsseldorf/Germany

Motivation

Dislocation-twin boundary interaction is not entirely understood but gains attention due to the outstanding mechanical performance of nano-twinned materials. Here, we show µLaue compression experiments on a coherent Σ3 ⟨111⟩ twin. The samples are all tested in different crystallographic loading direction with the twin boundary being parallel to the loading direction.

Sample production

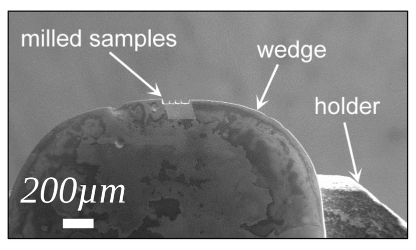
TB production in Bridgman furnace



- material: **copper**
- using graphite crucible
- growth rate 10 mm/hour

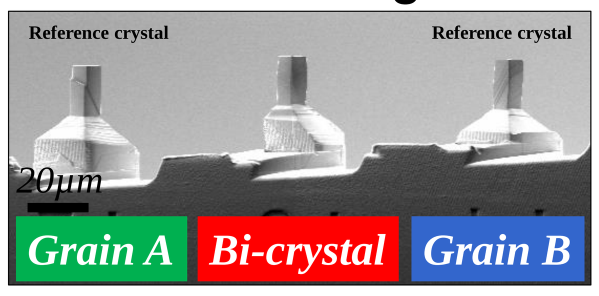
Meso- & micro sample preparation

electrochemical etching



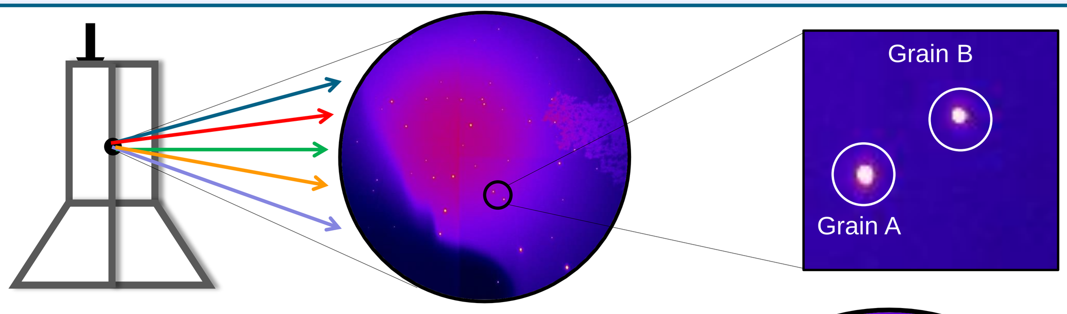
- etching: coarse 15V, fine 2V
- radius at the tip ~ few µm

FIB milling



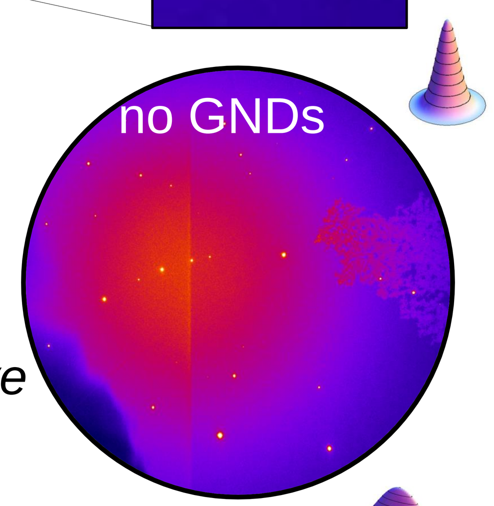
- milling: coarse 16 nA, fine 600 pA
- 5 µm
- no taper formation

in situ µLaue compression



- displacement control mode
- strain rate $10^{-3}\frac{1}{s}$

Engineering stress strain curve

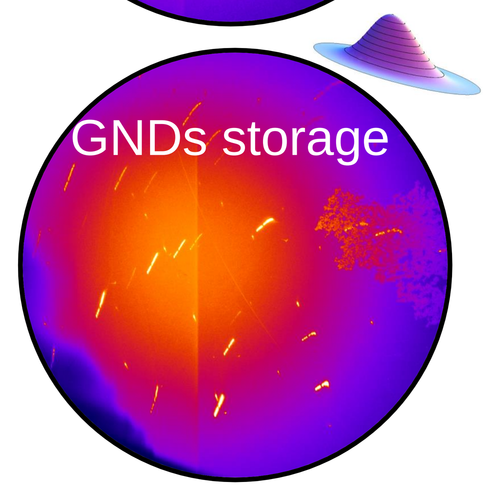


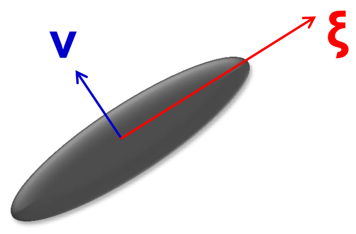
- crystallographic orientation

Point to origin misorientation

- *Peak width*

Estimate the GNDs density

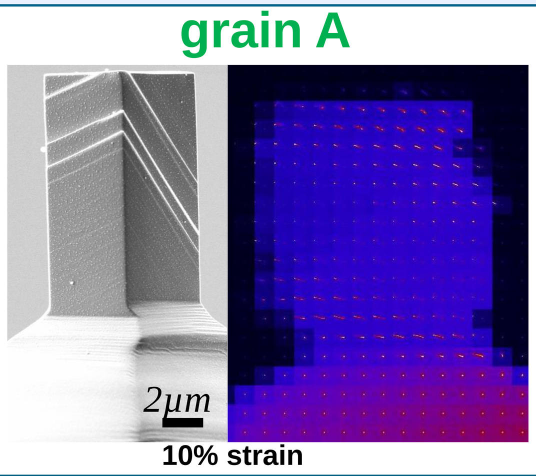


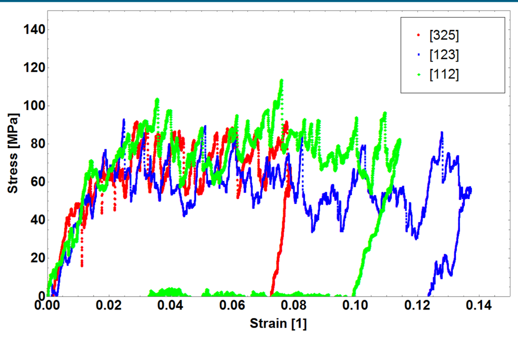


- *Streaking analysis (pending)*

Single crystals

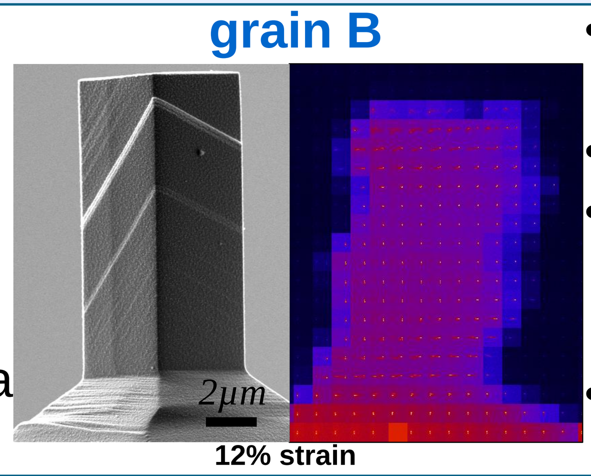
grain A





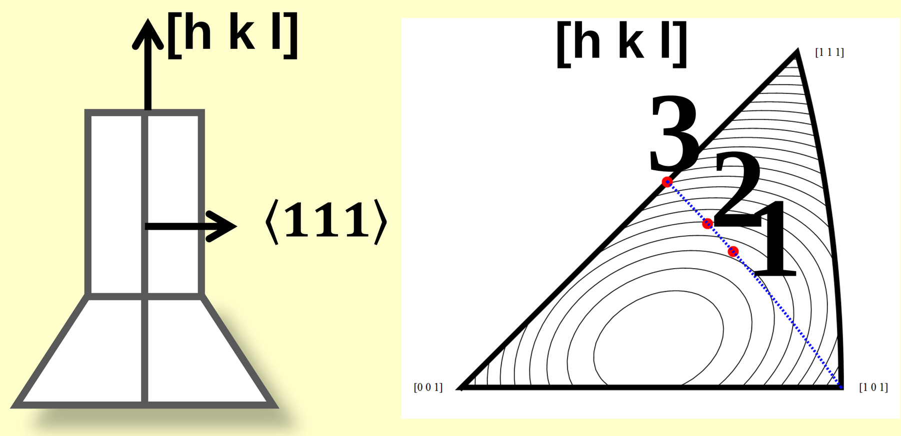
- flow stress @ 70MPa
- no hardening

grain B

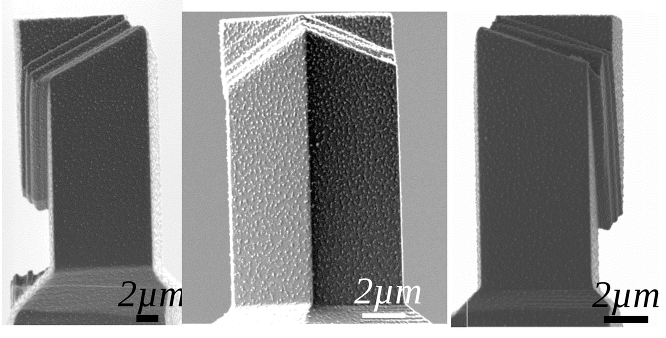


- primary slip system activated (single slip)
- large slip steps formed
- streaking only at top and bottom in the same direction → due to instrumental constrains [1]
- no streaking in the center → low amount of GNDs

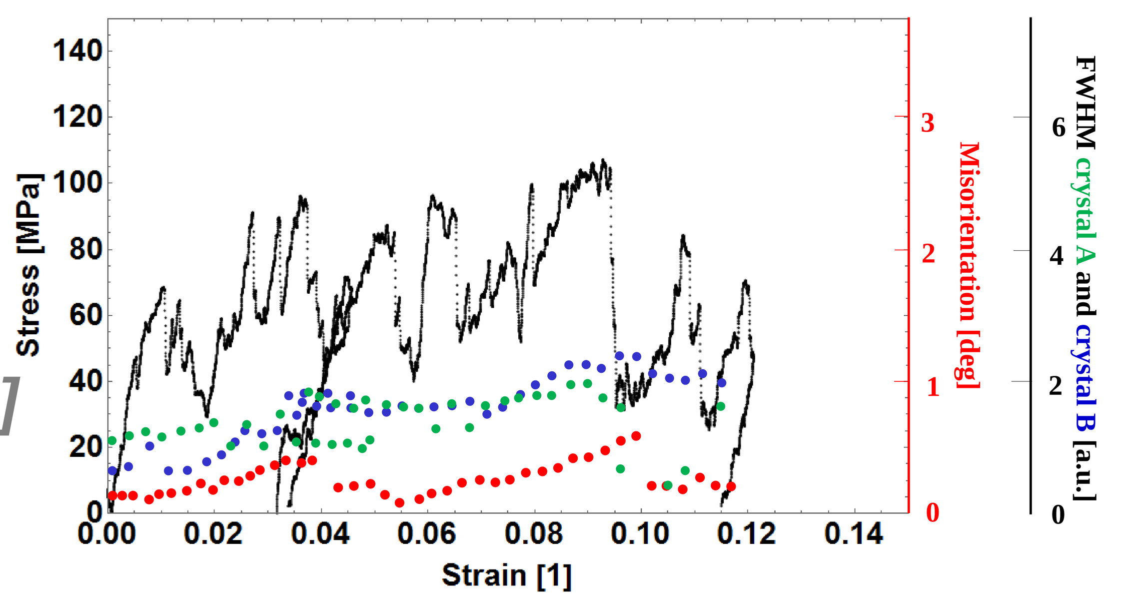
Samples containing a CTB

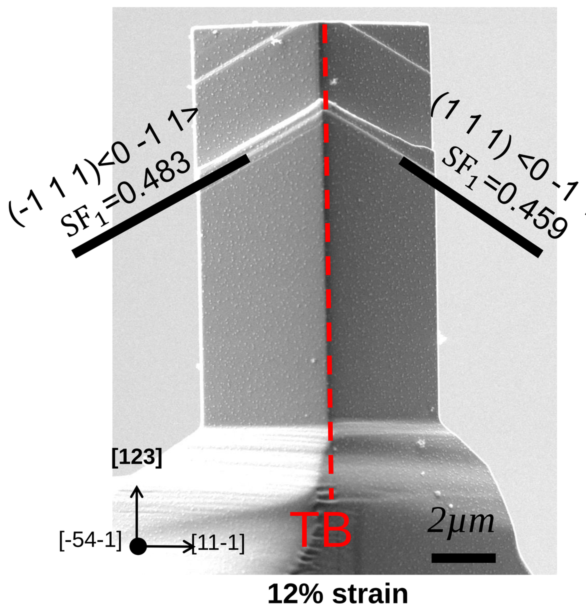


Stress-Strain Curves — *SEM after deformation*

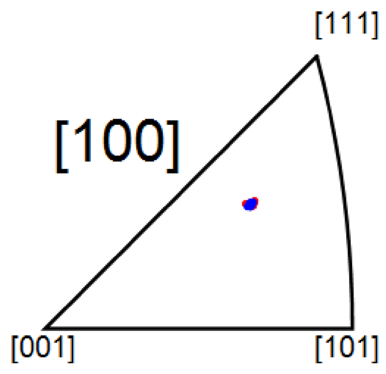


1. [123]

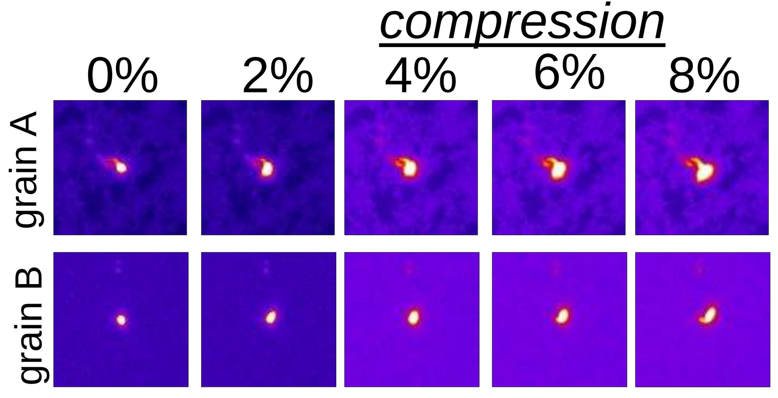




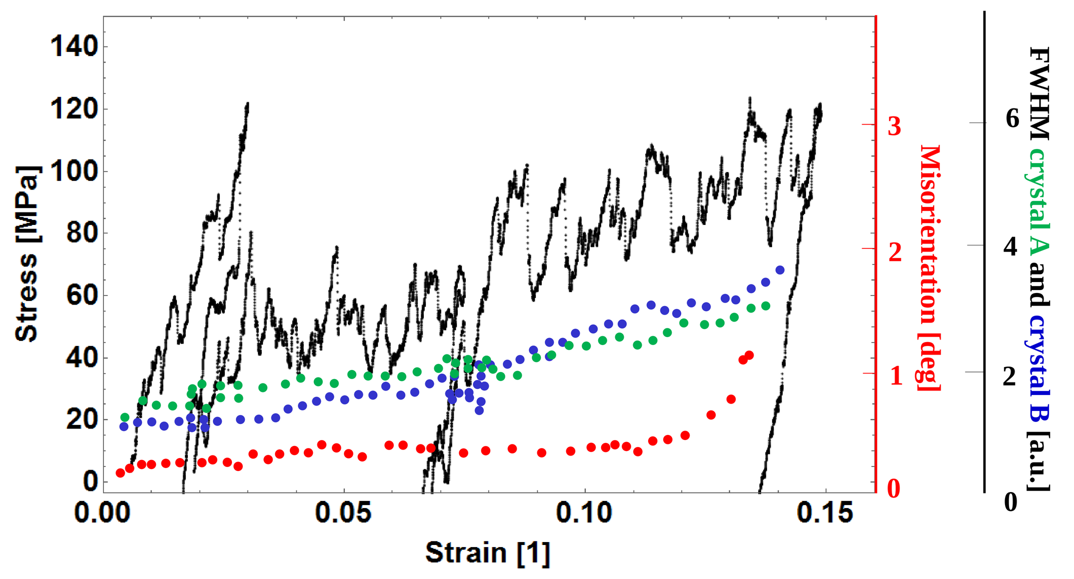
IPF after deformation

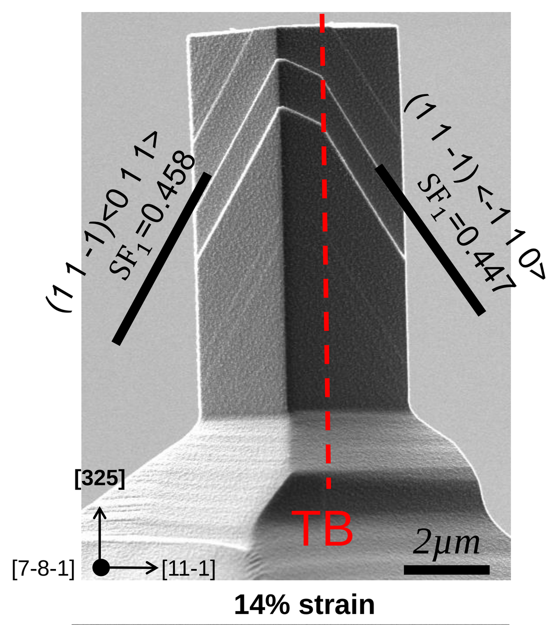


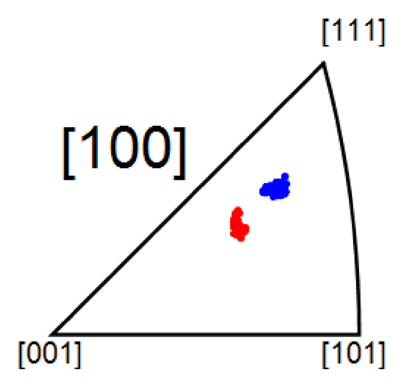
Laue spot evolution of CTB crystals during compression

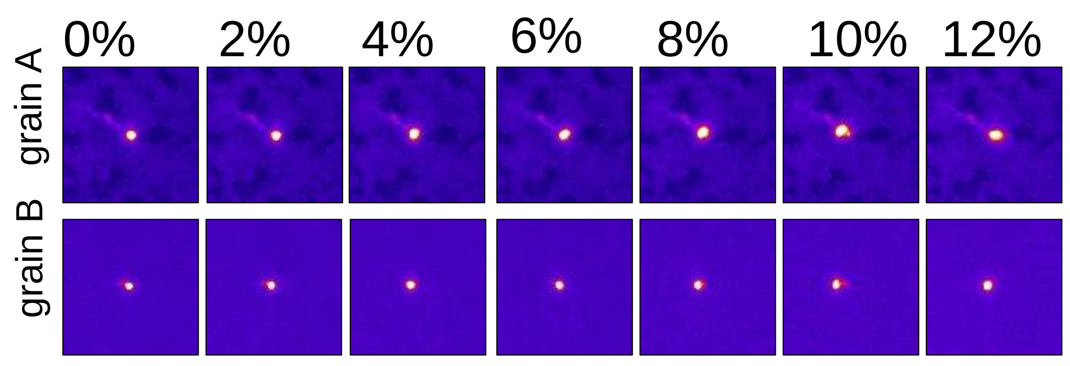


2. [325]

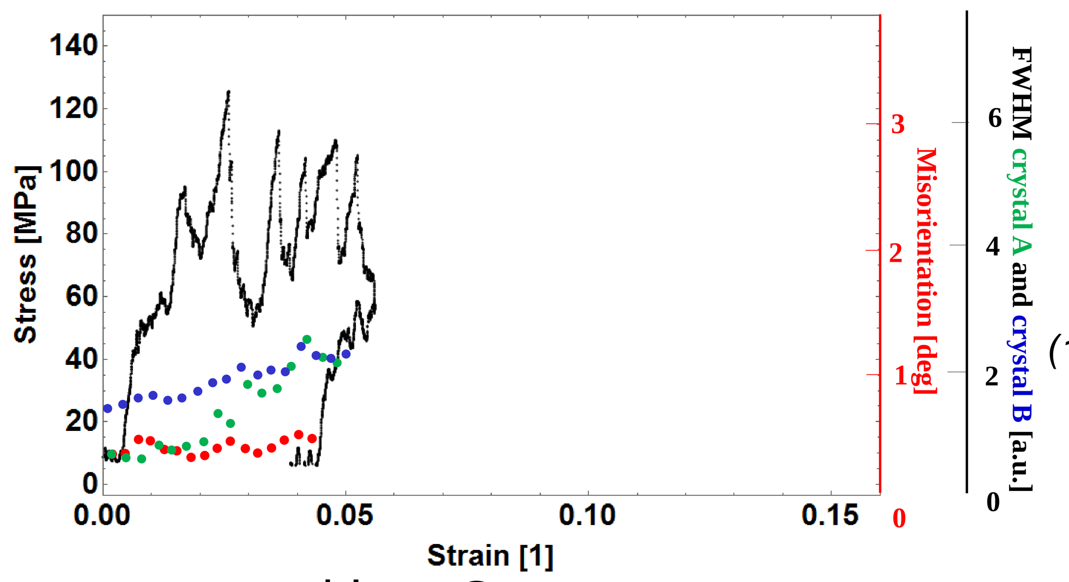


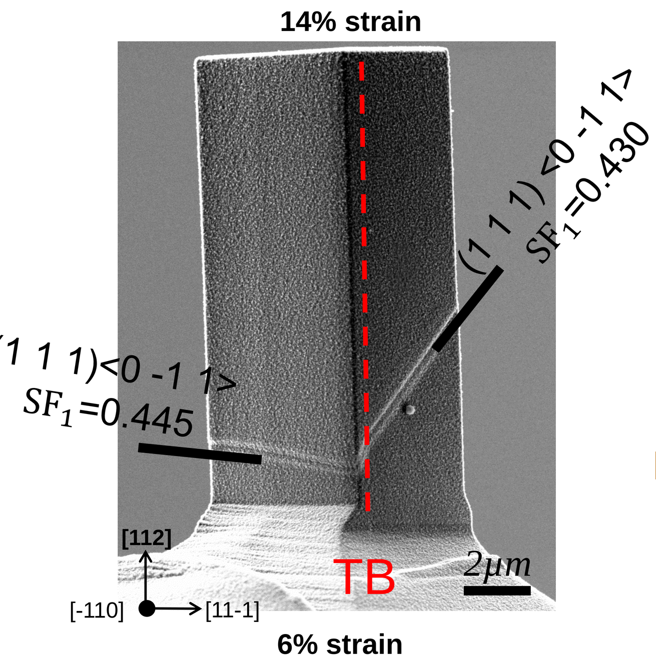


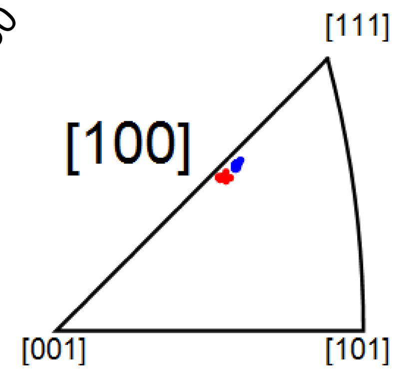


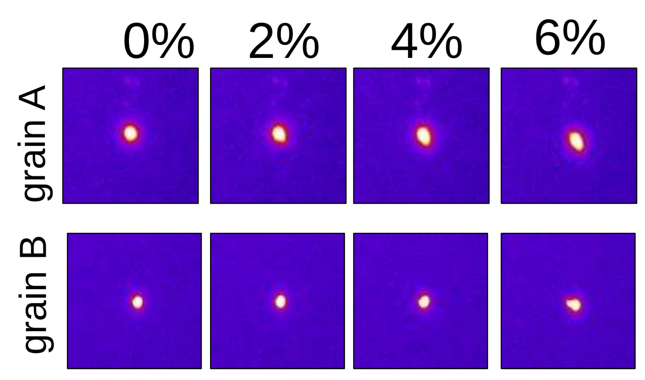


3. [112]









- flow stress comparable to Sxx
- no hardening observed
- only small change in misorientation (≤ 0.5 grad) below 10% strain
- peak shape stays circulat → low amount of GNDs

- primary slip system activated (single slip)
- large *slip steps*
- slip steps meet at TB as observed by Imrich [2]

- peak shape stays unaffected during straining up to about 10% independently of the compression direction
- unresolvable low amount of GNDs
- "single crystal" like behavior

Conclusions

- Stress-Strain behavior, occurrence of the large slip steps and diffraction peak shape during deformation show "single crystal" like behavior
- For all orientations the CTB does not occur as a obstacle for dislocation movement

References

[1] Kirchlechner at all Acta Materialia 59, 2011
[2] Imrich at all, Acta Materialia 73, 2014

Acknowledgements

MPIE, Düsseldorf, Germany
Srividya Subramanian — Peak shape analysis
Jürgen Wichert — bi-crystalline samples production
Gerhard Bialkowski — bi-crystalline samples preparation