



MAX-PLANCK-GESELLSCHAFT

Max-Planck-Institut für Eisenforschung GmbH
Düsseldorf



VDEh

Experimental Investigation of Plastic Grain Interaction

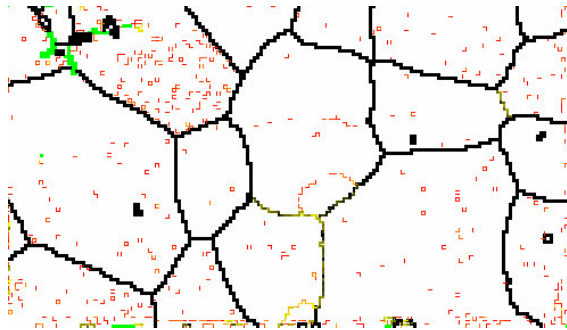
M. Sachtleber, Z. Zhao, D. Raabe

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Max-Planck-Str. 1, 40237 Düsseldorf, Germany, sachtleber@mpie.de

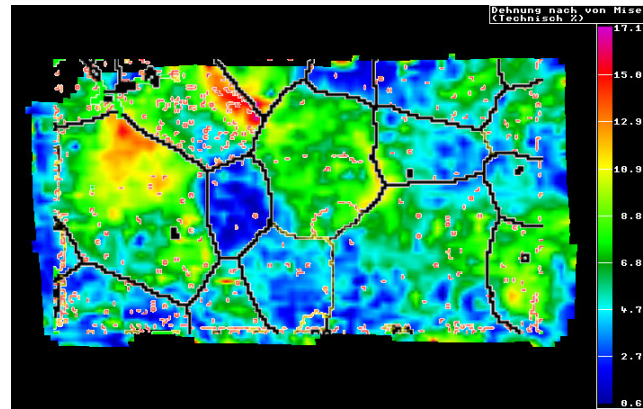
Sachtleber, Raabe
Plasticity 2002

MICROSTRUCTURE PHYSICS AND METAL FORMING

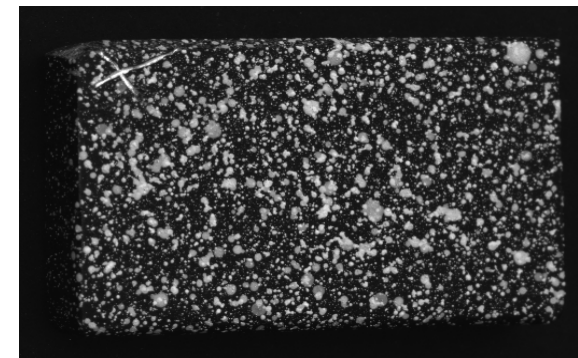




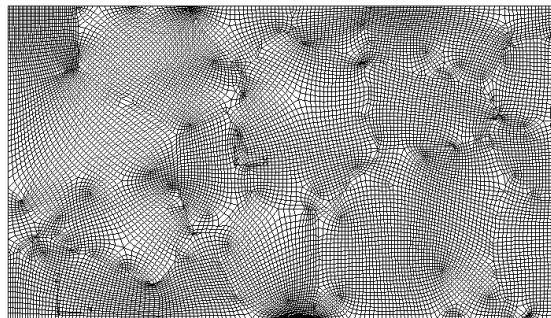
Orientation Mapping



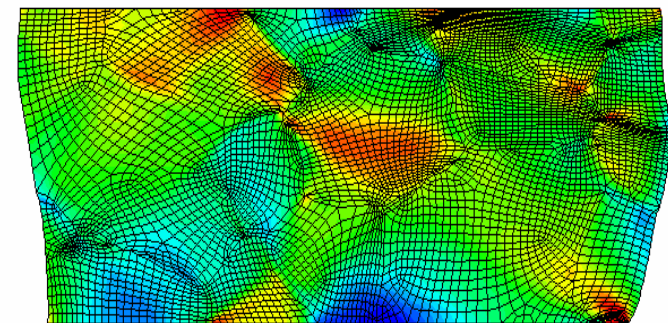
Strain Mapping



Photogrammetry



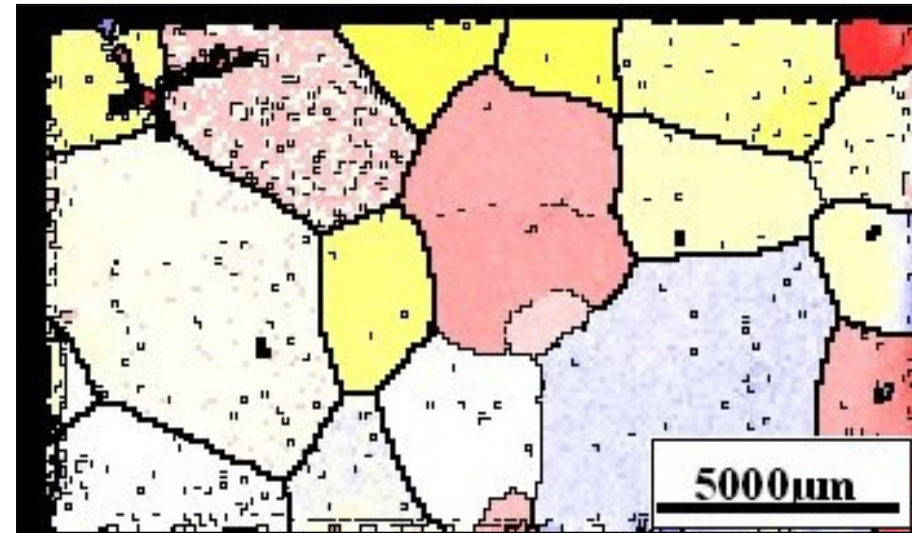
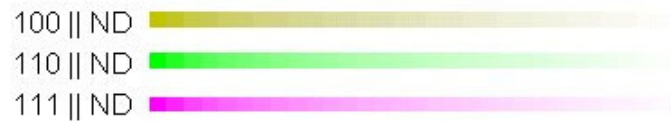
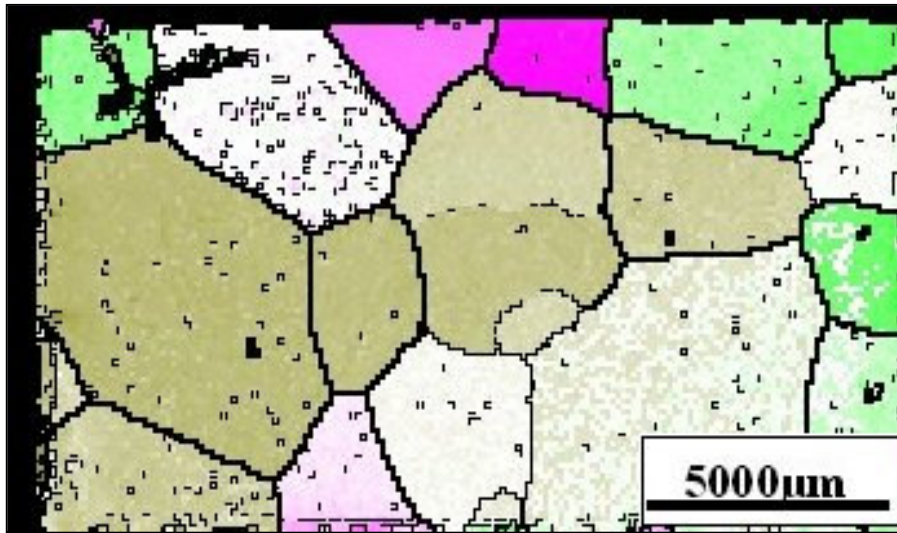
FEM-Mesh



FEM-Simulation

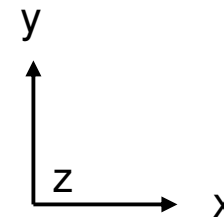
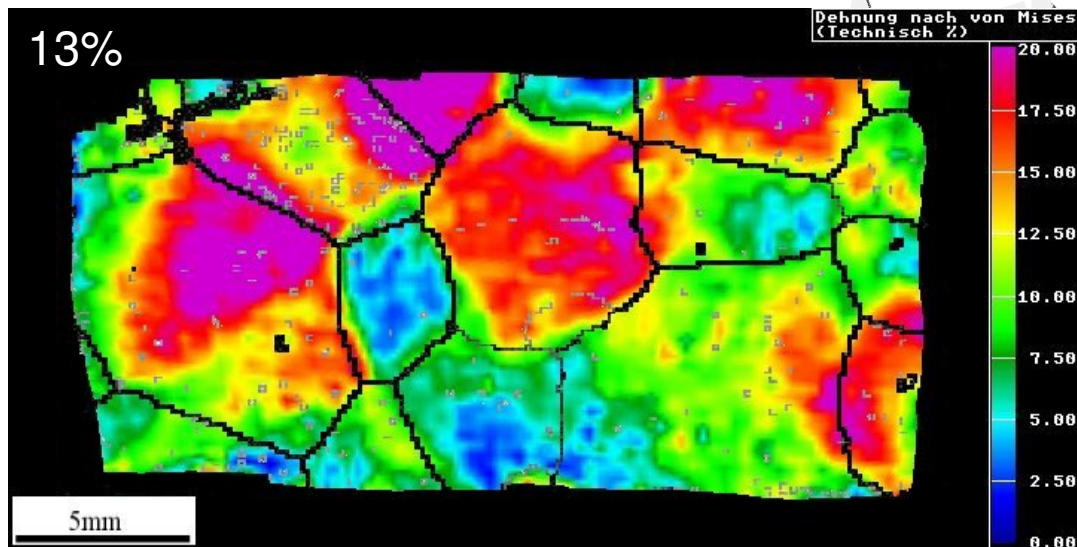
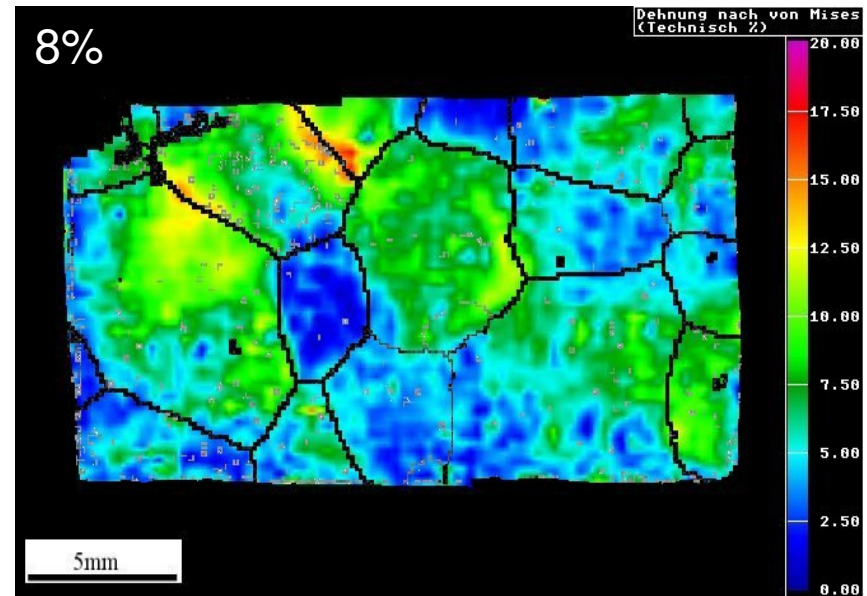
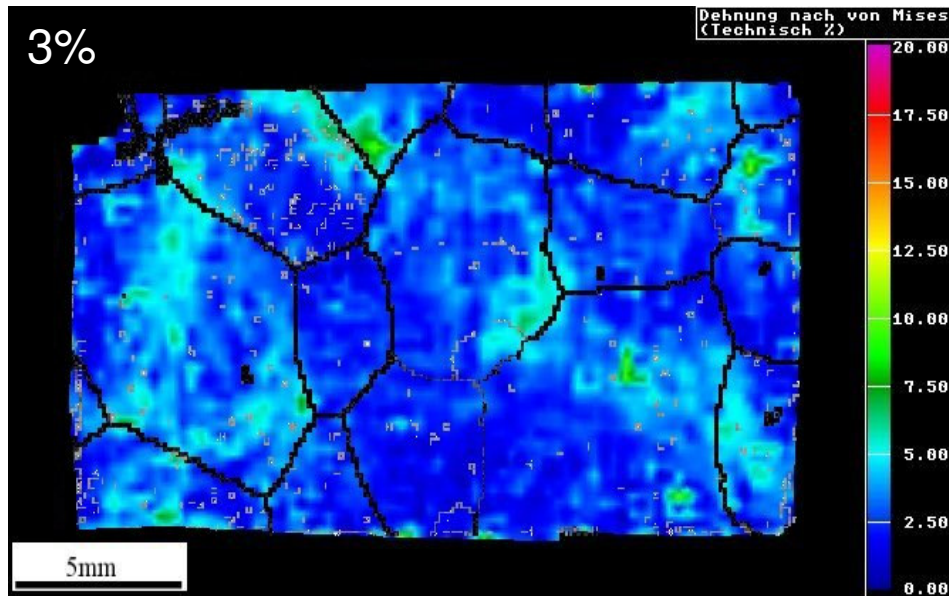
Mapping

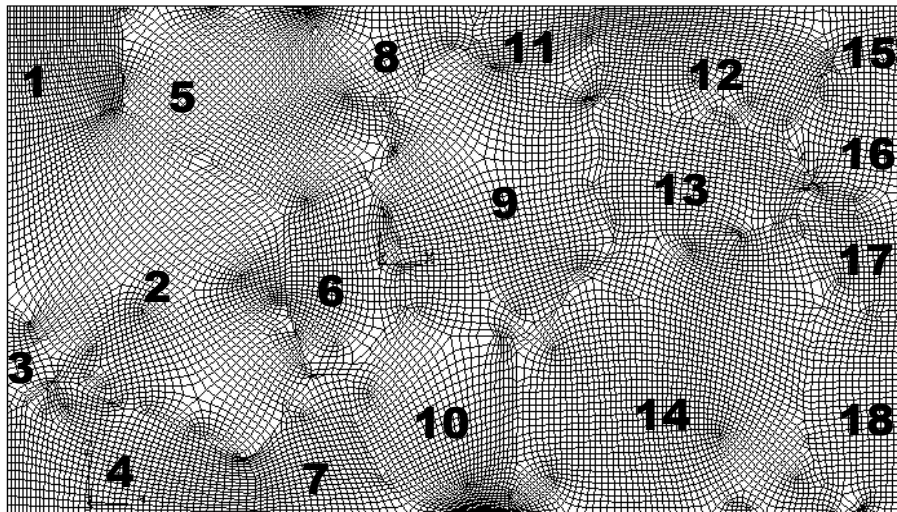
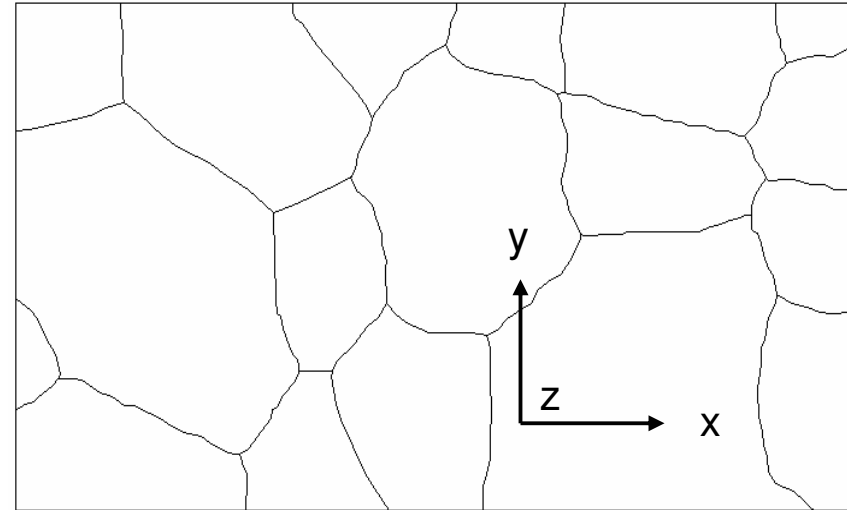
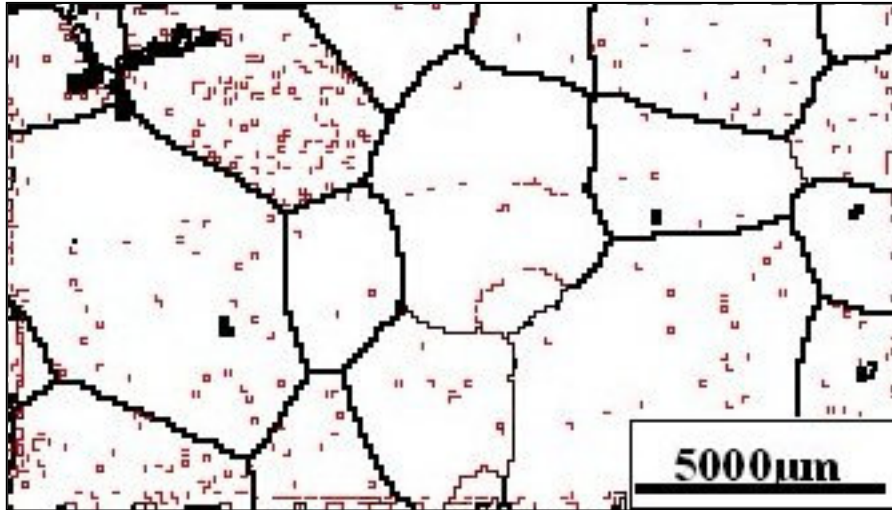




- ➔ 99,9% Al
- ➔ Columnar grain morphology (quasi 2D)
- ➔ Grain diameter $\underline{d} = 3.5 \text{ mm}$
- ➔ OM scan step size $100 \mu\text{m}$

- grain boundaries $> 15^\circ$
- grain boundaries $> 5^\circ$





bilinear element, 4 nodes, 4 integration points

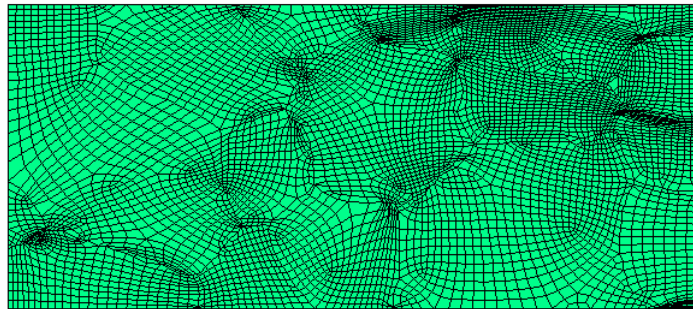
5705 elements

12 slip systems $\{111\}\langle 110\rangle$ & viscoplastic hardening

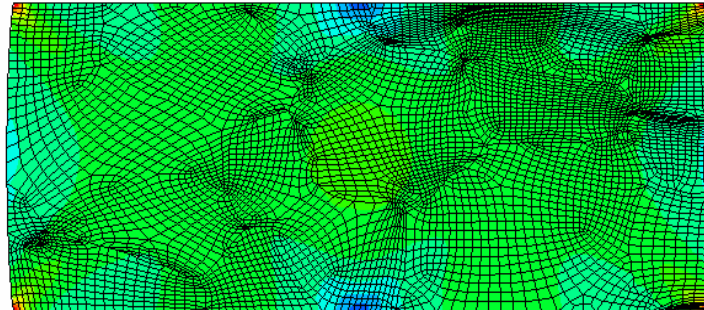
fully implicit time-integration crystal plasticity method

[Kalidindi et. al.]

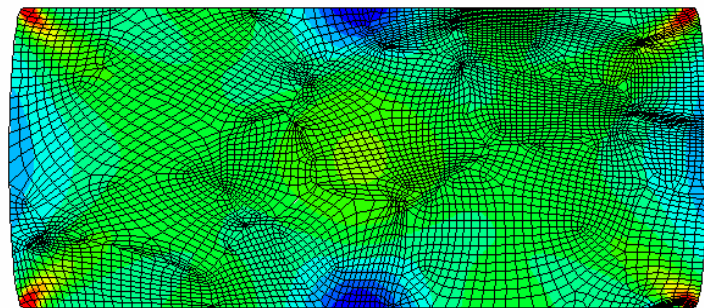
Continuum FEM Simulation



$\mu = 0.0$

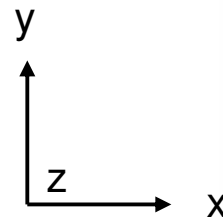
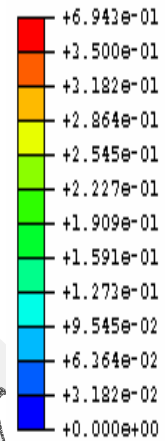


$\mu = 0.1$

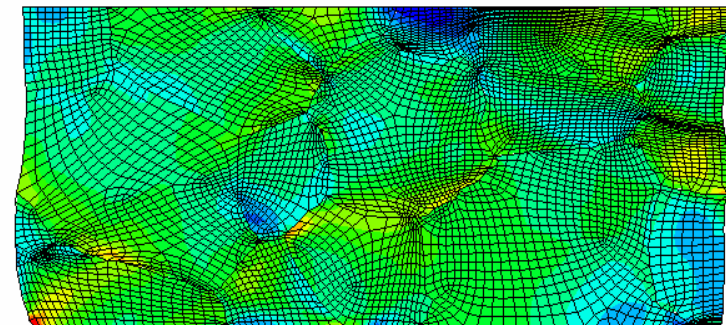


$\mu = 0.2$

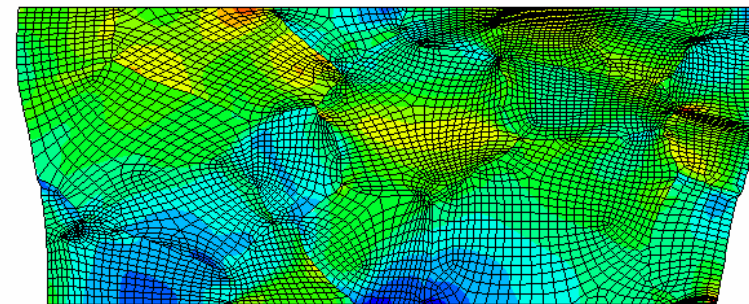
von Mises strain



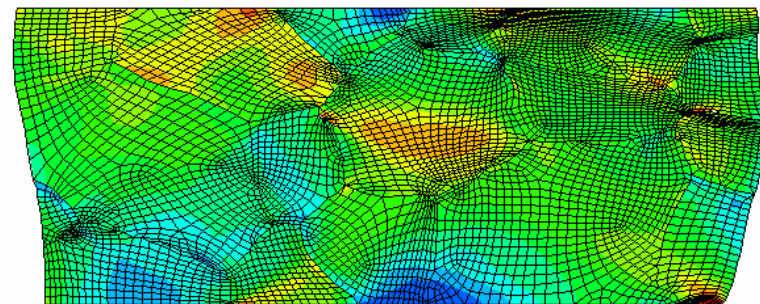
Crystal Plasticity FEM Simulation



$\mu = 0.0001$

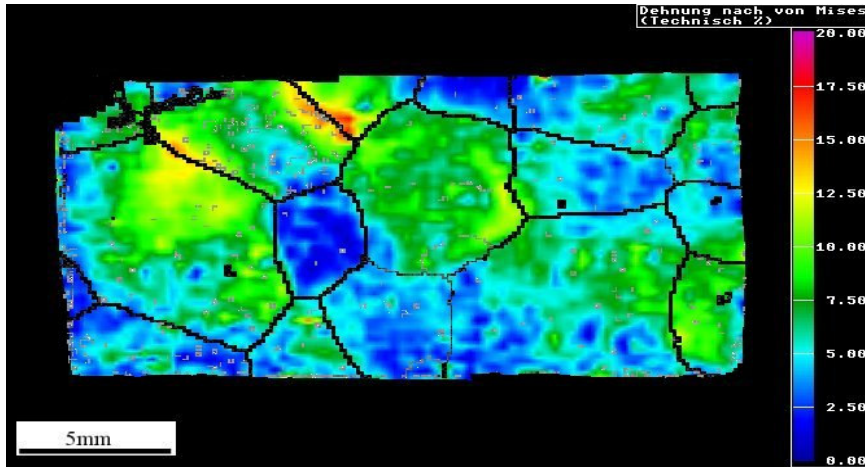


$\mu = 0.1$

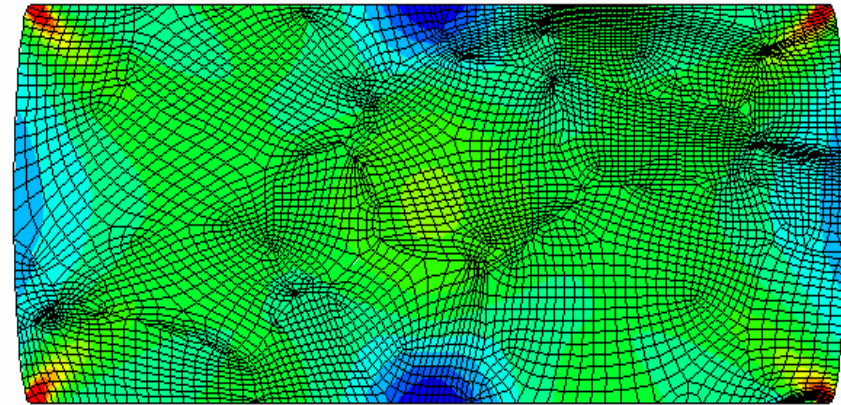


$\mu = 0.2$

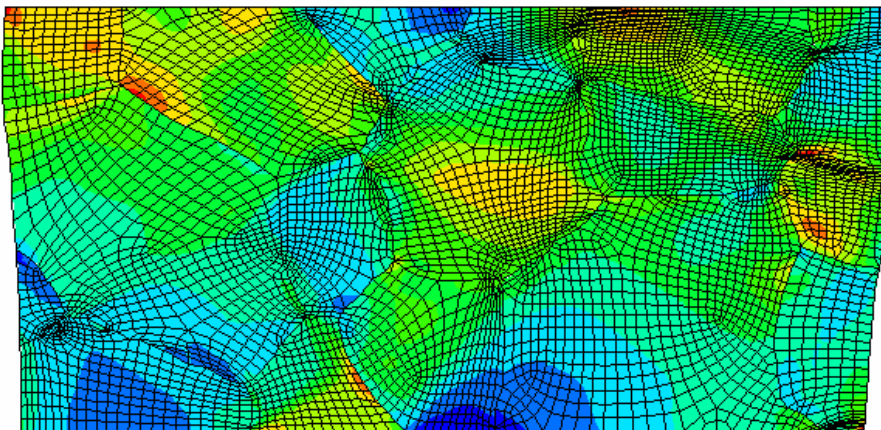




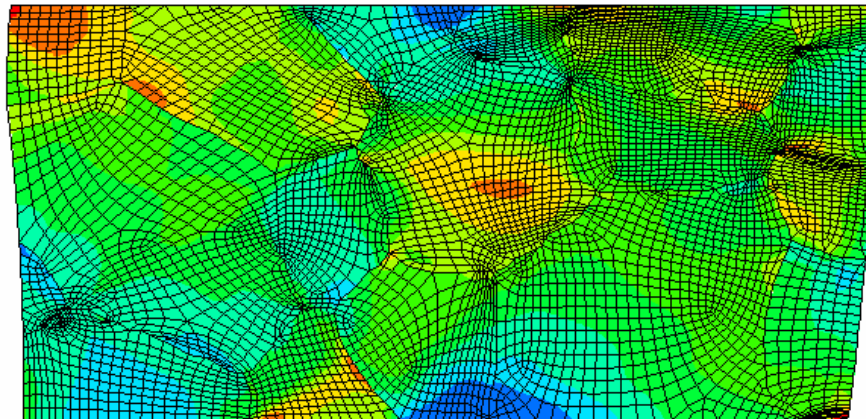
Experimental Strain Mapping



Continuum FEM Simulation ($\mu = 0,2$)

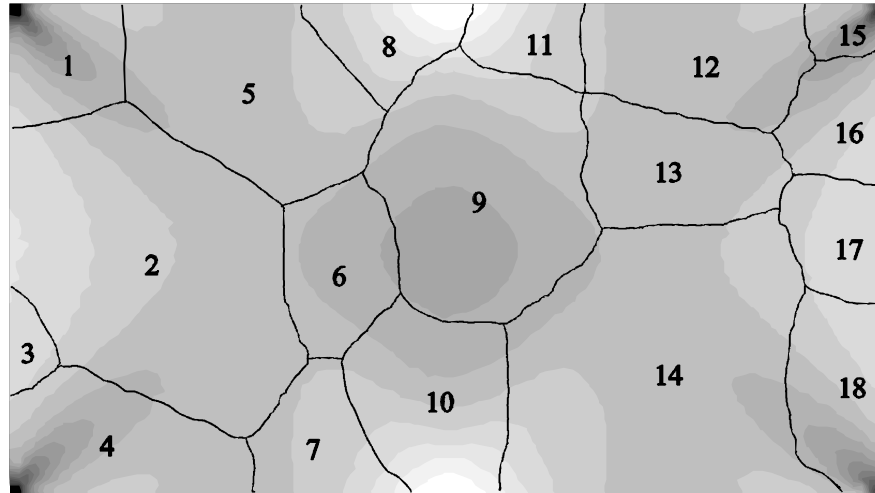
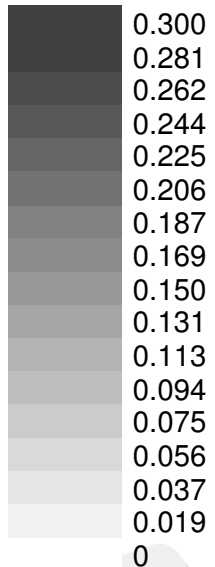


Cristal Plasticity FEM Simulation ($\mu = 0,1$)

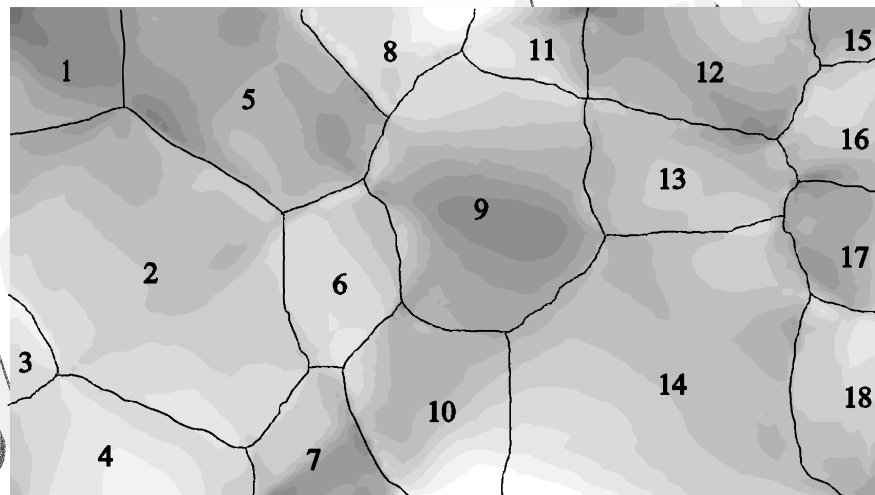


Cristal Plasticity FEM Simulation ($\mu = 0,2$)

von Mises Strain



Continuum FEM Simulation

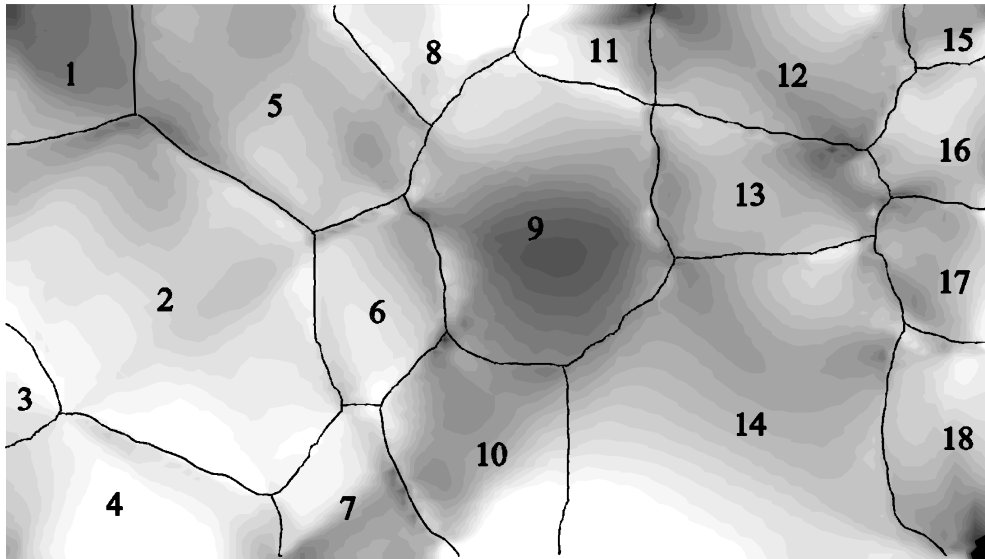
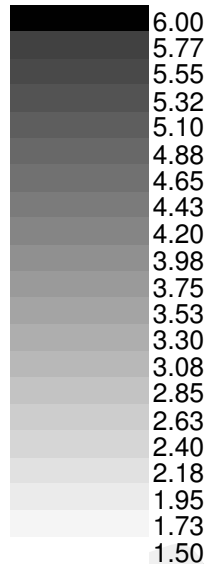


Cristal Plasticity FEM Simulation

→ von Mises strain

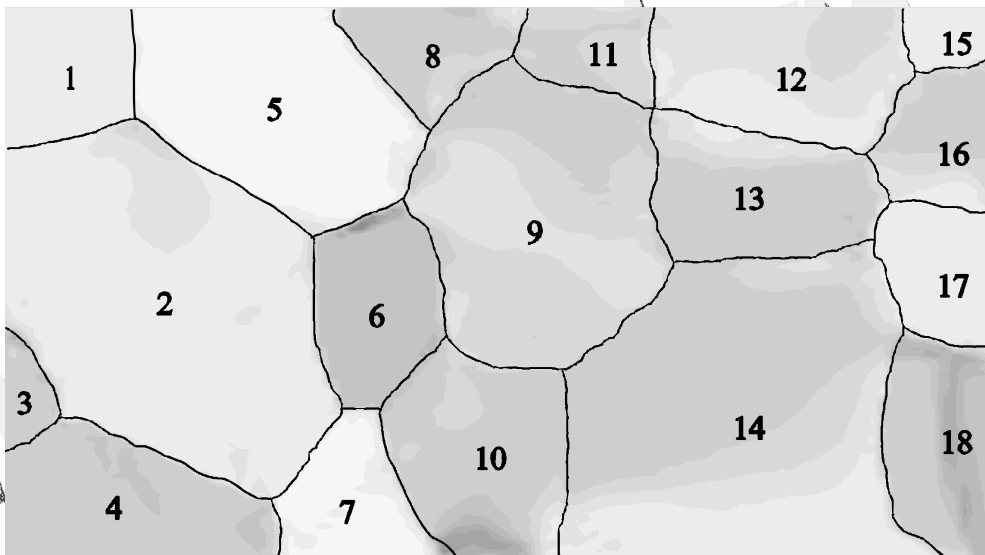
→ 8% hight reduction

→ $\mu = 0,2$



→ macromechanics
Taylor-Factor

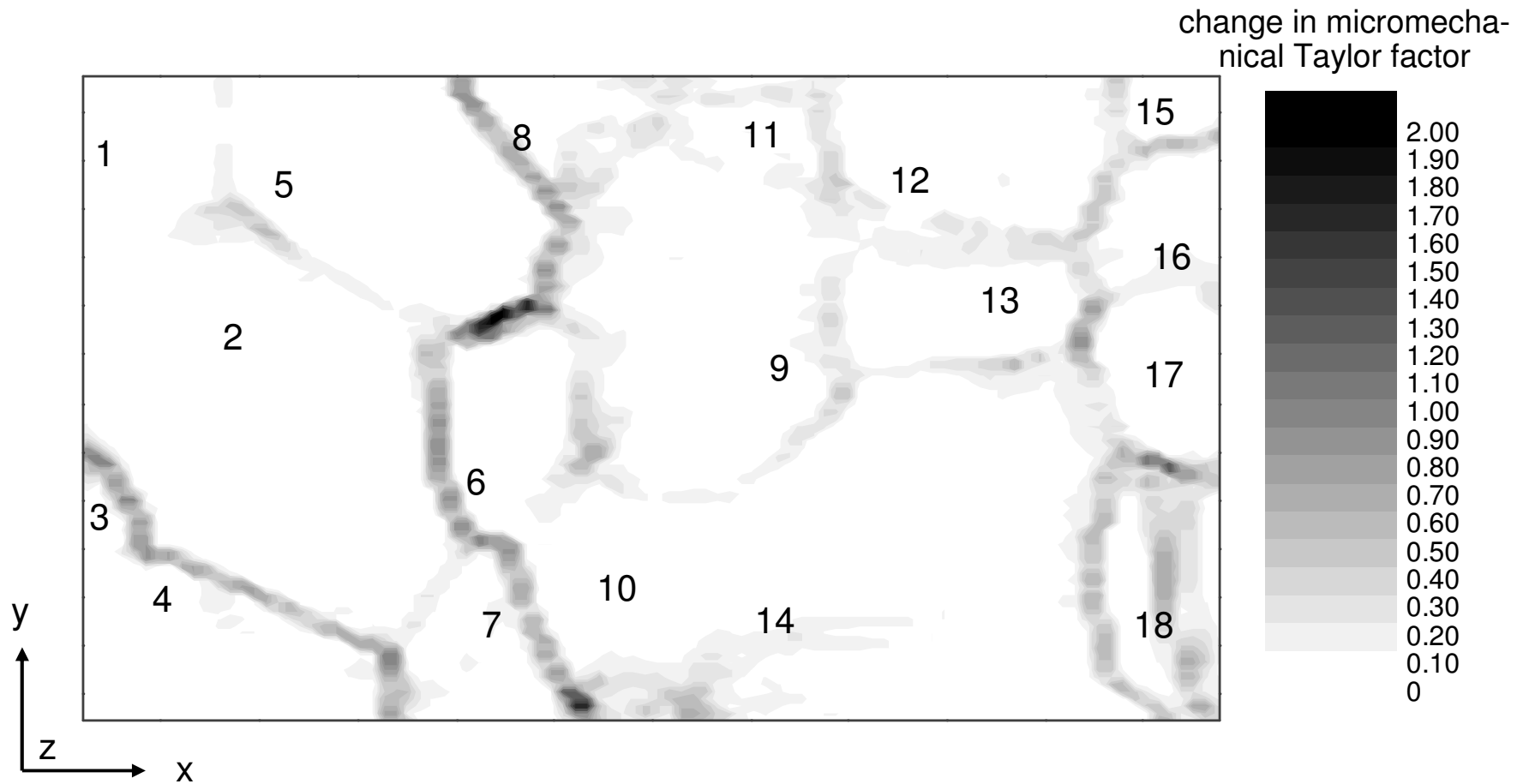
$$\sum \gamma^{\text{local}} / \langle \epsilon_{\text{vM}} \rangle^{\text{global}}$$



→ micromechanics
Taylor-Factor

$$\sum \gamma^{\text{local}} / \langle \epsilon_{\text{vM}} \rangle^{\text{local}}$$





- ➔ Heterogeneity in accumulated plastic strain (90% from mean)
- ➔ Grain scale heterogeneity is determined by two factors:
 1. Macroscopic boundary conditions (geometry, friction)
 2. Local crystal kinematics

“Micromechanical and macromechanical effect in grain scale polycrystal plasticity experimentation and simulation”,

D. Raabe, M. Sachtleber, Z. Zhao, F. Roters, S. Zaefferer: *Acta mater.*,49 (2001) 3433 - 3441

