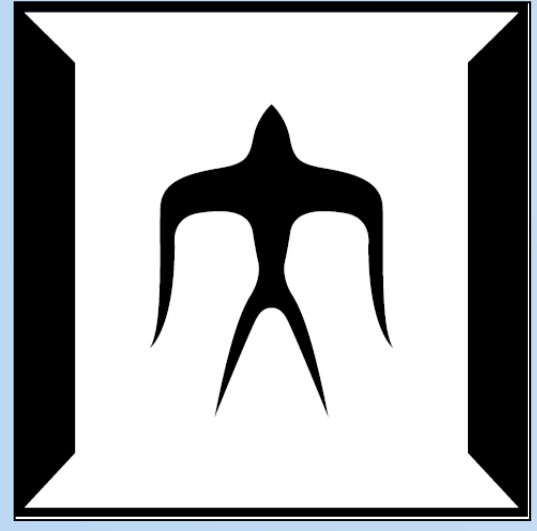
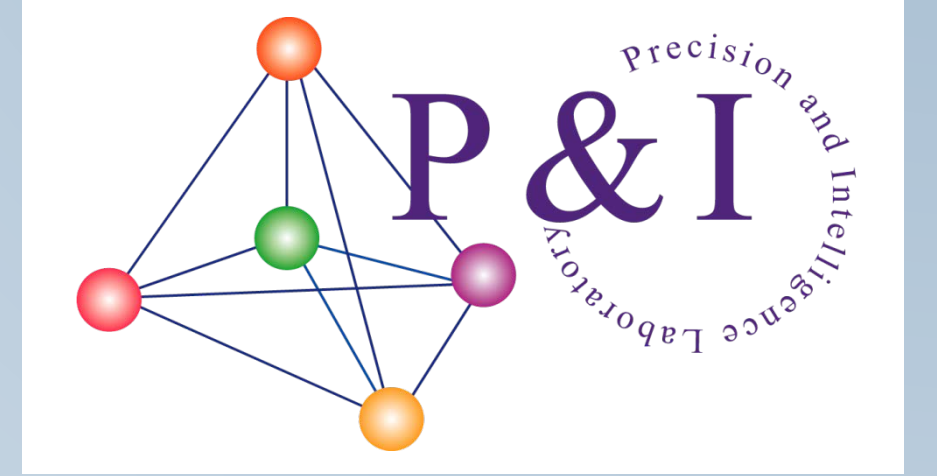


The Precipitation Strengthening Behavior of Cu-Ni-Si Alloy as Micro-Components Evaluated by Micro-Tensile Tests

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Introduction

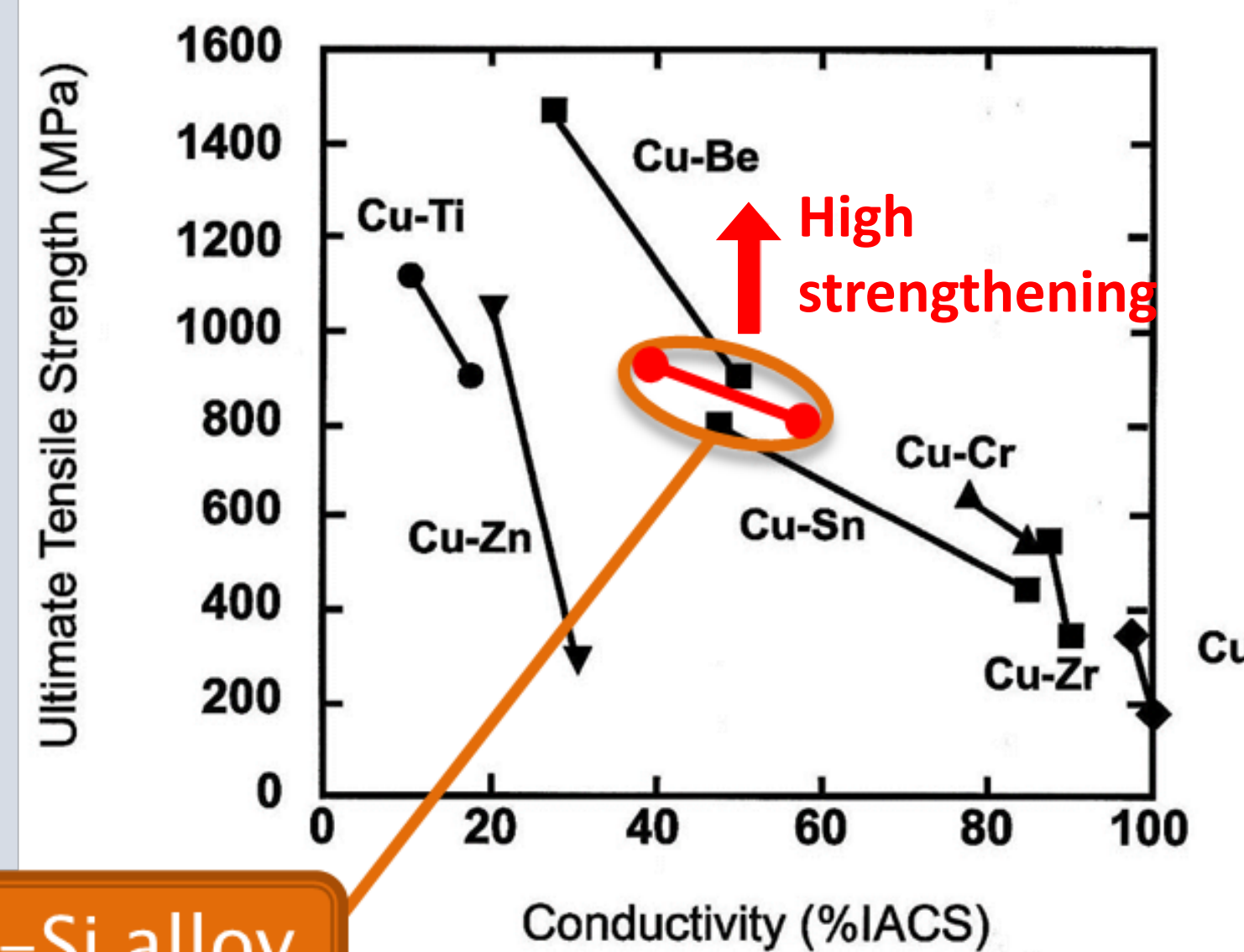
Cu-Ni-Si alloy

Precipitation strengthening-type alloy

- High strength
- High electrical conductivity
- Excellent bending workability

Micro-mechanical data of Cu alloy is limited

Cu-Ni-Si alloy



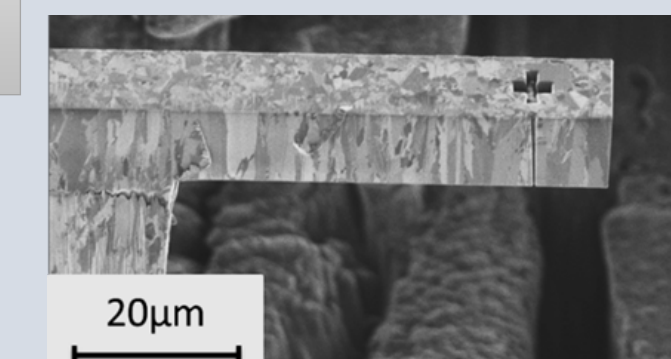
Micro-mechanical tests

Miniaturization and weight reduction of the electronic equipment

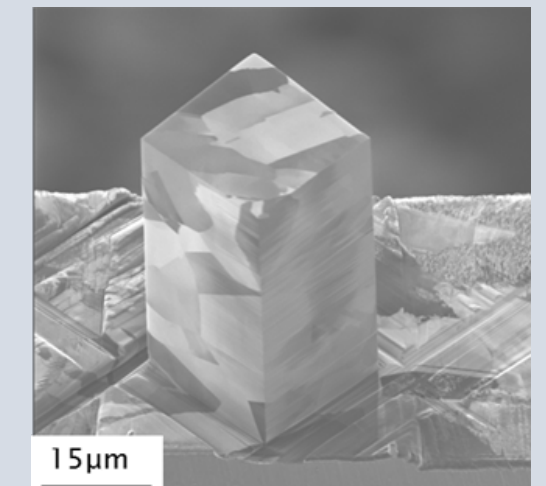
Clarify local characteristic of the materials in the micro-domain

Make sample in micro-domain

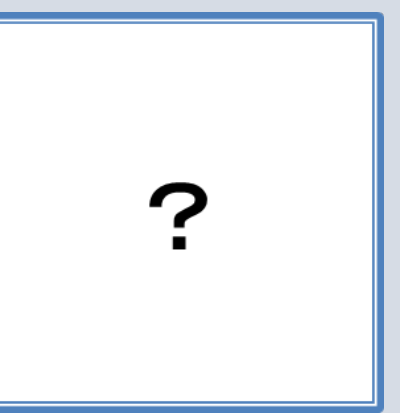
Micro-mechanical test



Micro-bending^[1]



Micro-compression^[2]



?

Micro-tensile test is rarely performed in the world.

[1] Y. Imamura et al., *Microelectro. Eng.*, 100 (2012) pp. 25-27 [2] M. Mutoh et al., *Microelectro. Eng.*, 111 (2013) pp.118-121

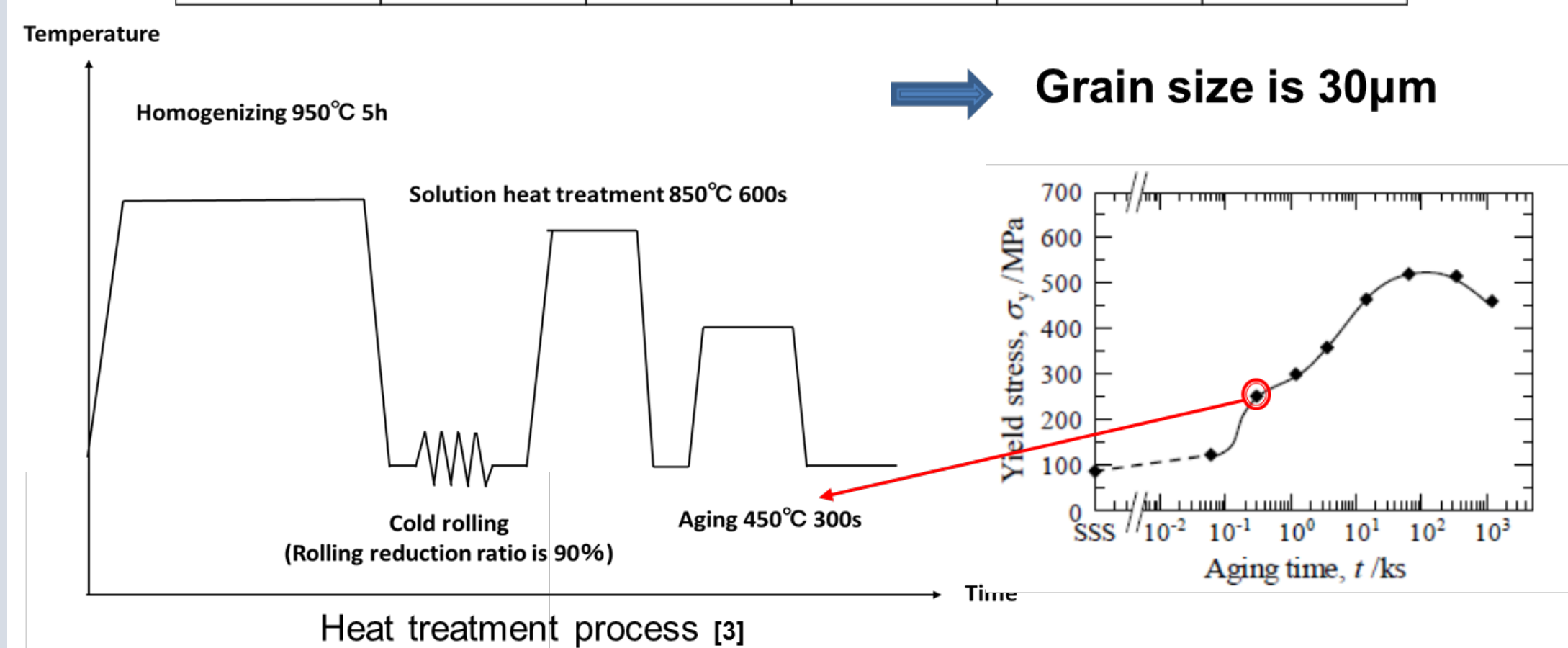
Experimental

Sample

- Pure copper (Cu99.99mass%) → Grain size is 10 μ m
- Cu-Ni-Si alloy

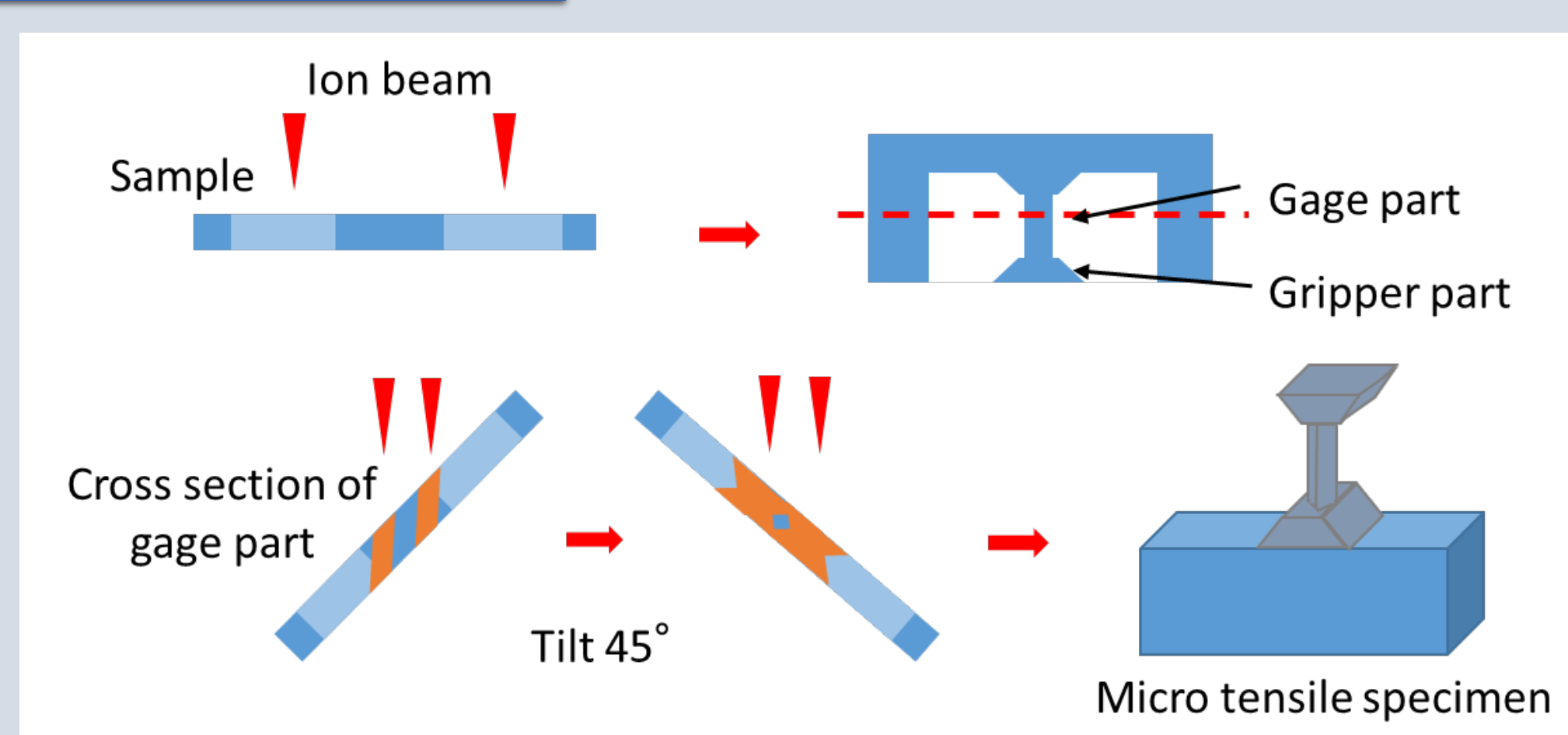
Composition of Cu-Ni-Si alloy (mass%)

Ni	Si	Zn	Sn	Mg	Cu
2.44	0.50	9.34	0.146	0.133	balance



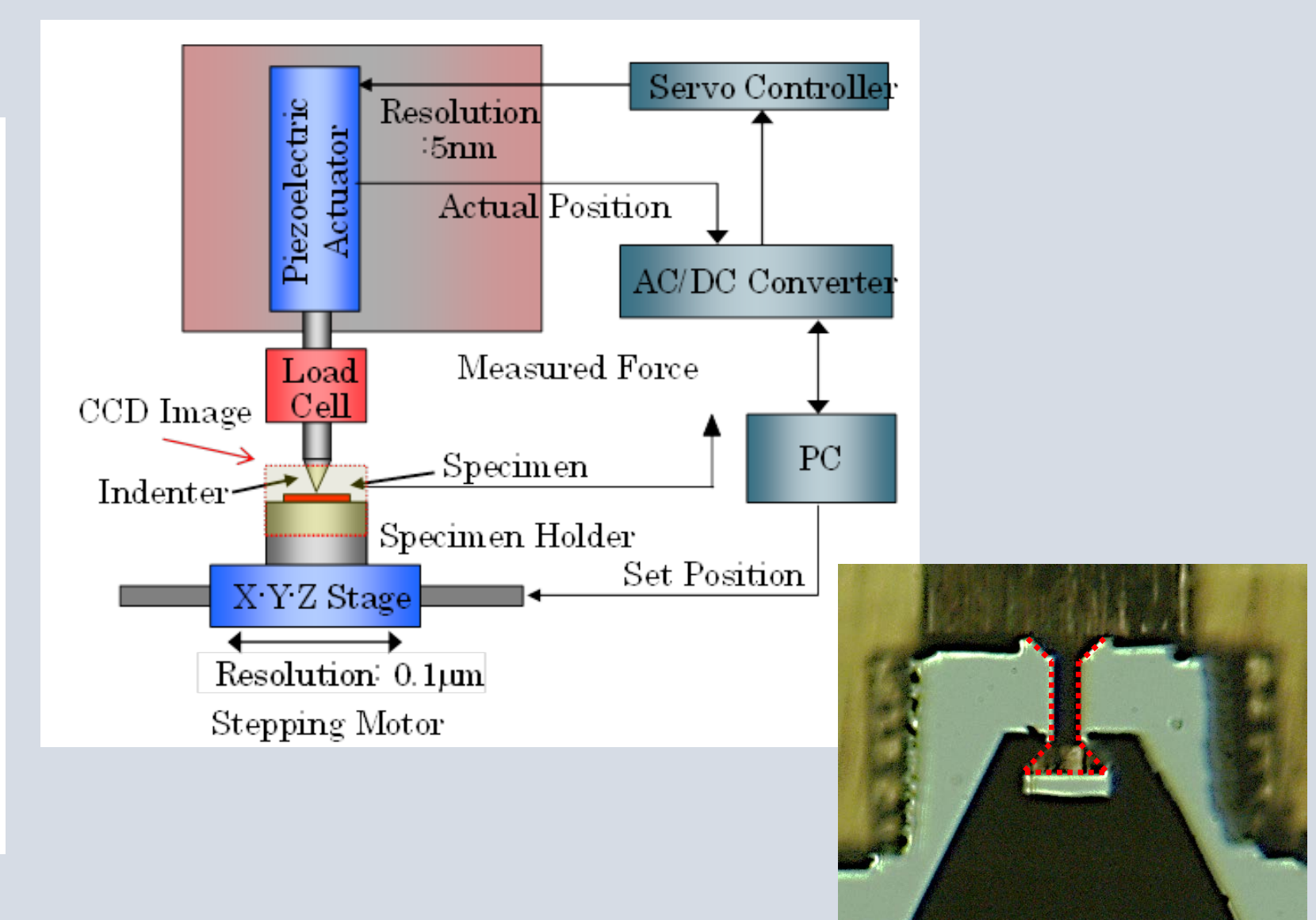
[3] A. Araki et al., *Materials Transactions*, Vol.55, No.3 (2014), 501-505

Procedures



Fabrication process of non-taper pillar by FIB

Sample size is 10 × 10 × 40 (μ m)



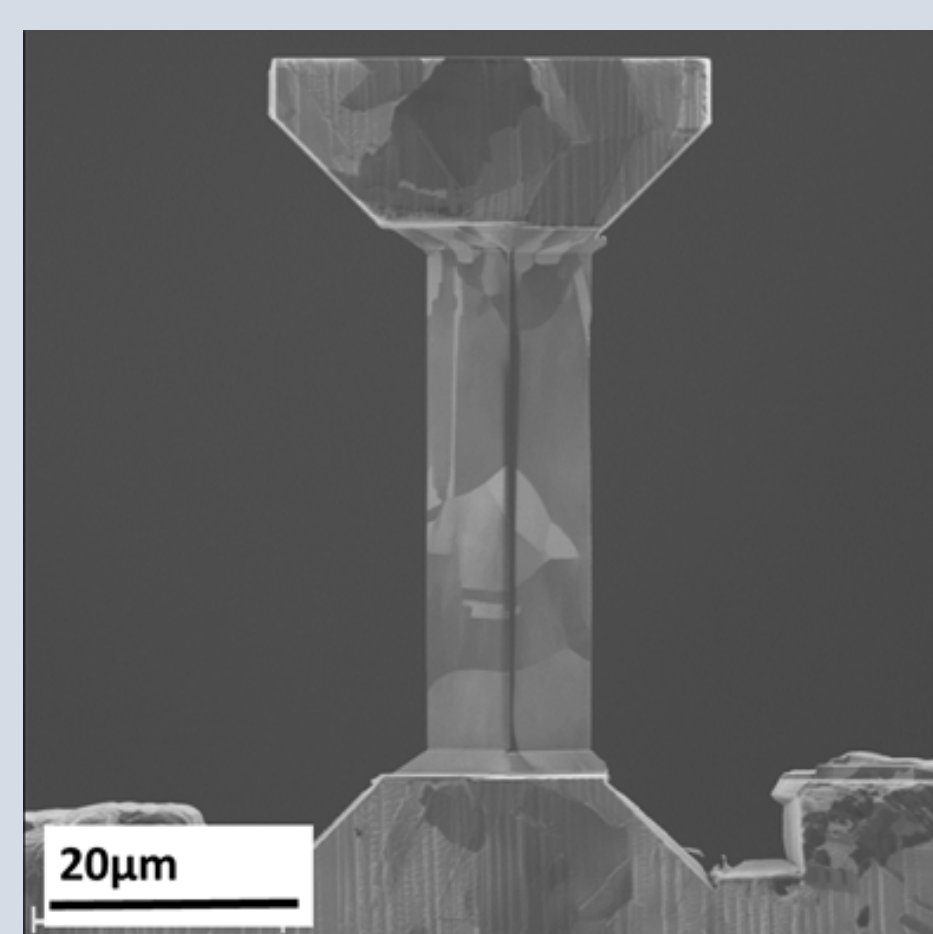
Micro-mechanical testing machine

Displacement is controlled at 0.1 μ m/sec.

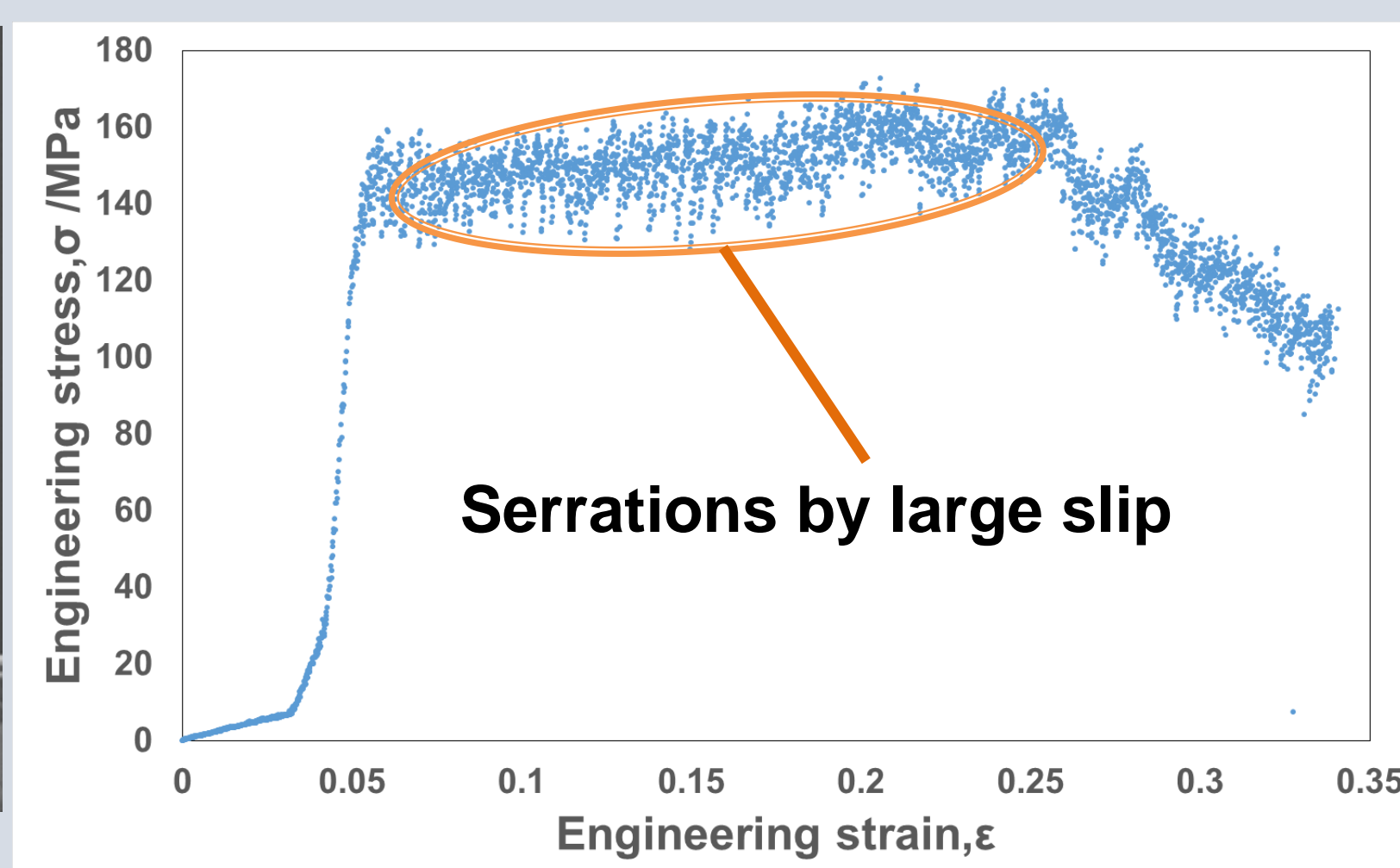
[4] Y. Kihara et al., *Microelectro. Eng.*, 141 (2015) 17-20

Results and Discussion

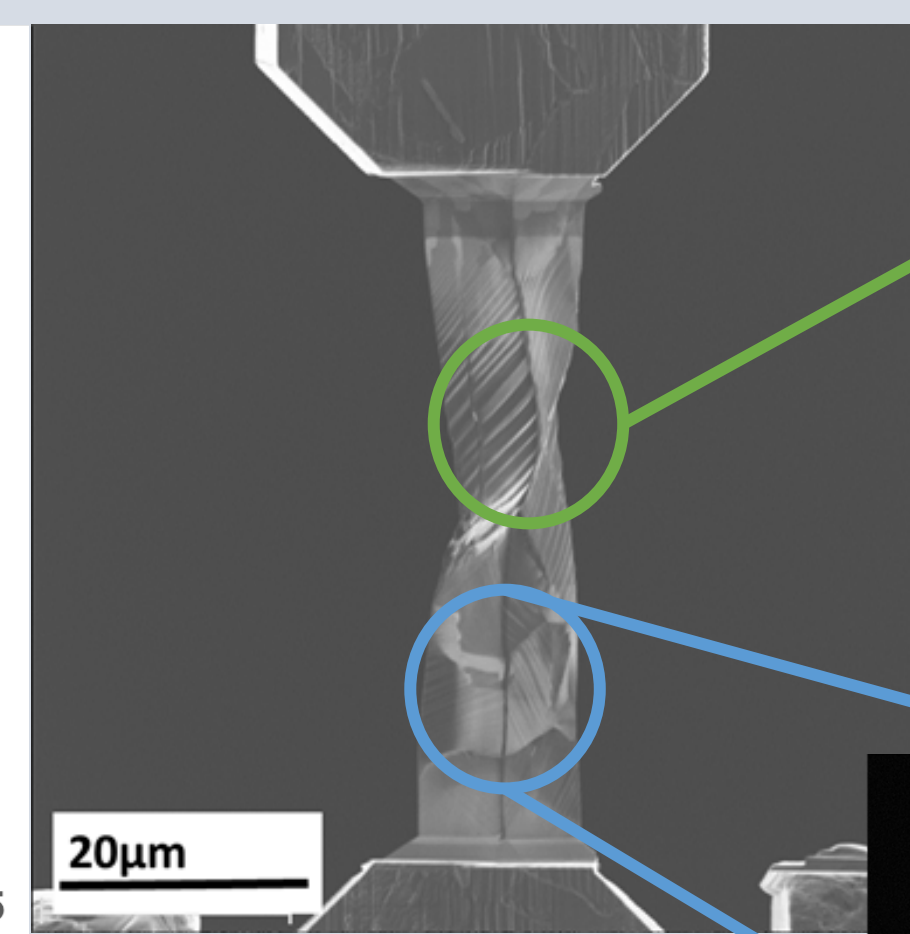
Pure copper



Before



SIM image and Stress-Strain curve



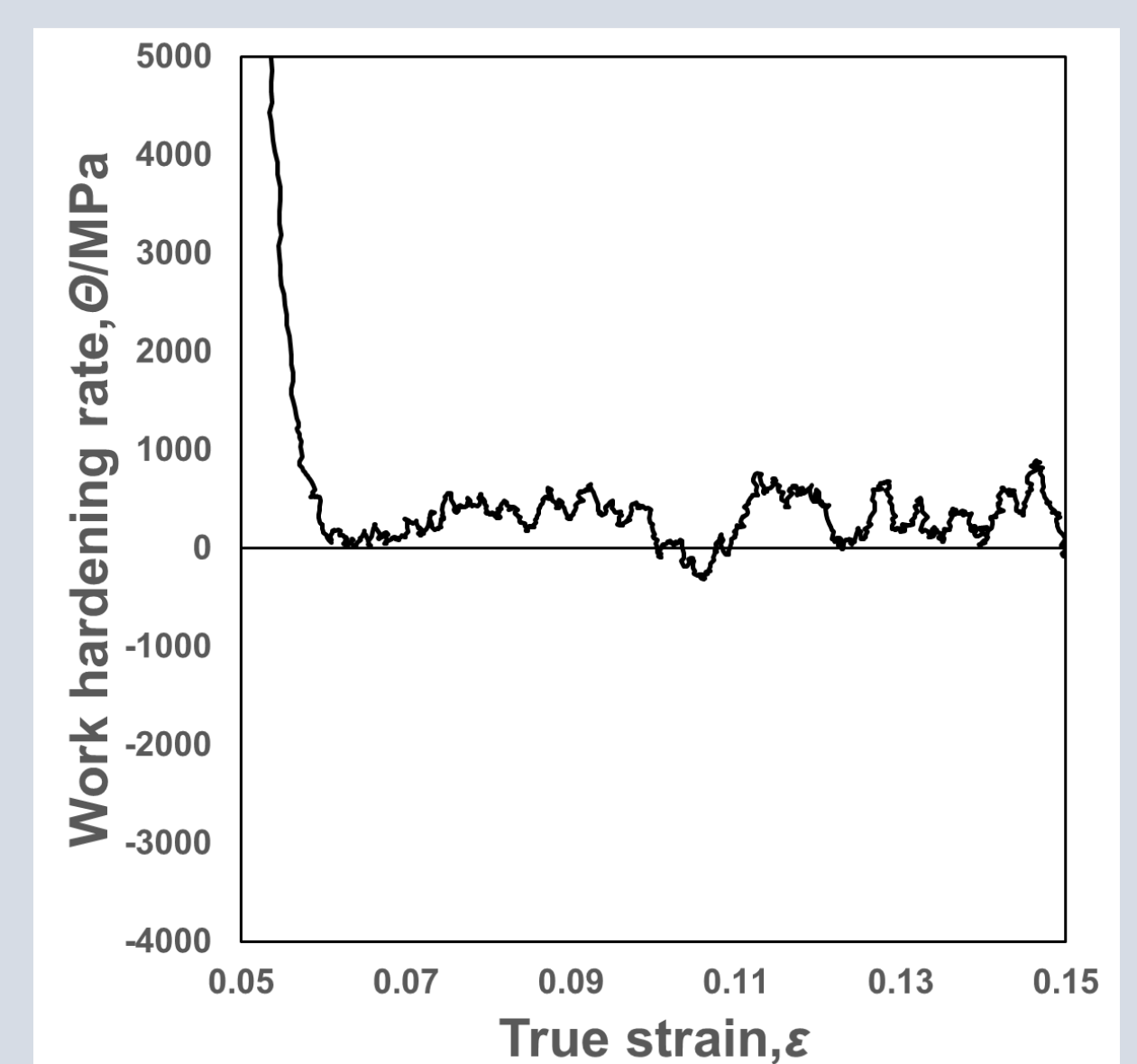
After

Concentration of slip lines
Necking

Work hardening did not occur

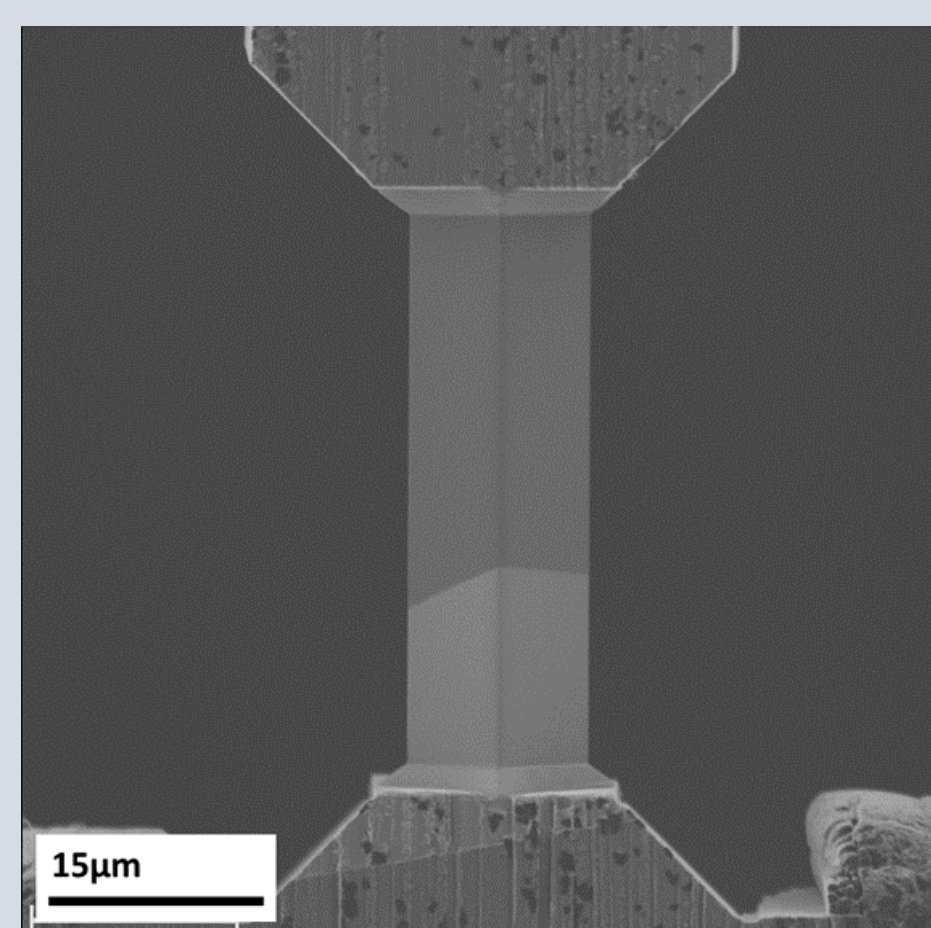
Slip lines were observed in each grain and have different directions

Enlarged SEM image

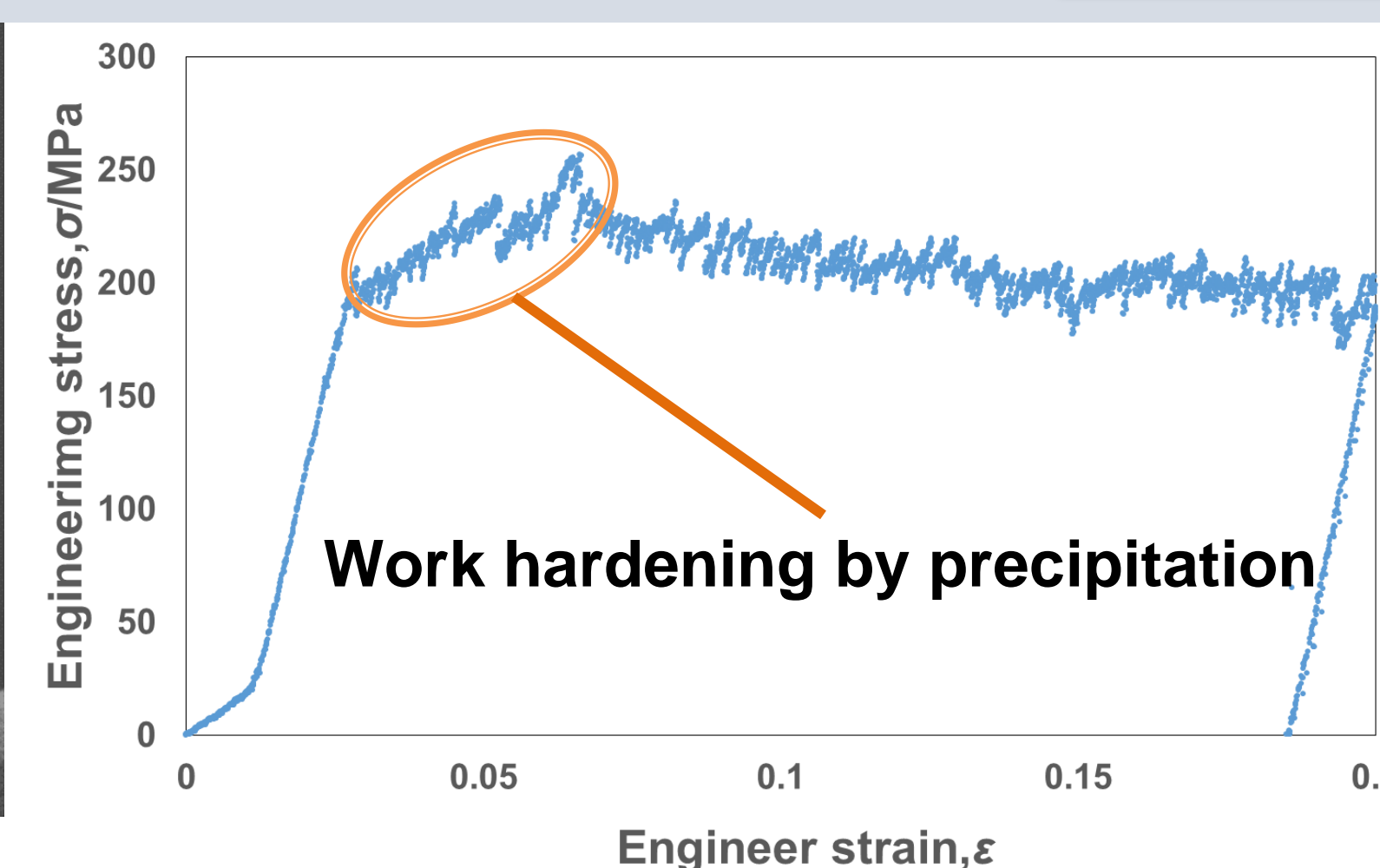


Work hardening rate

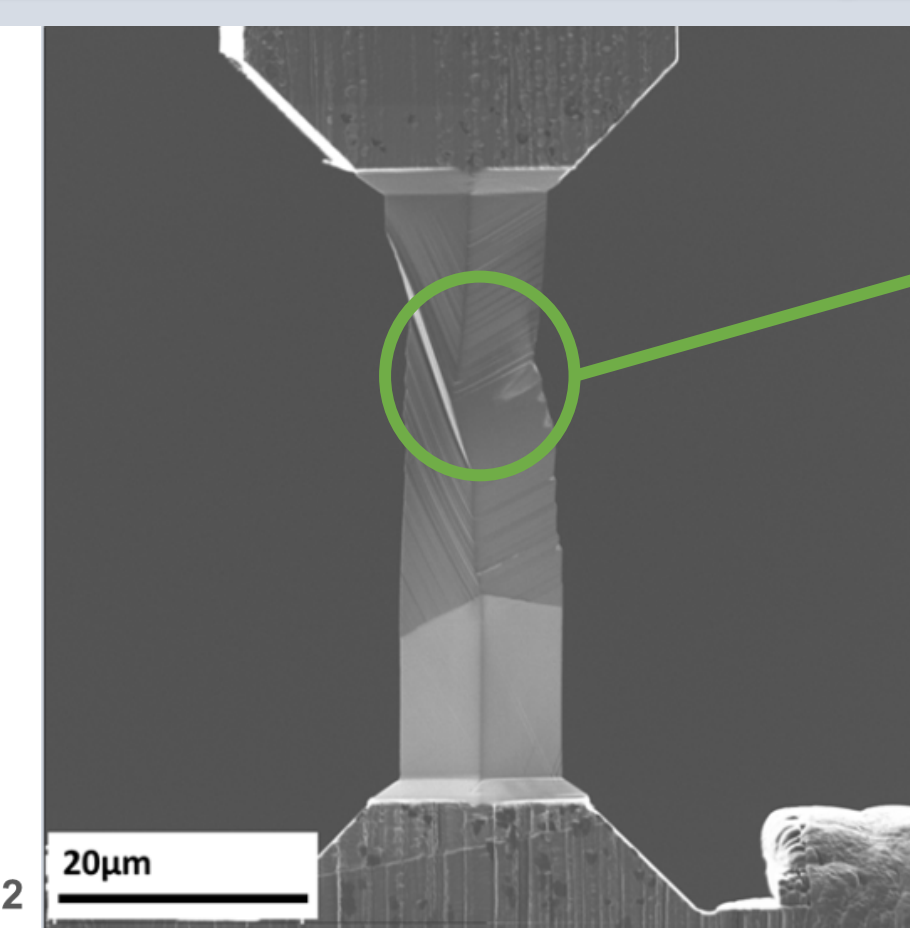
Cu-Ni-Si alloy



Before



SIM image and Stress-Strain curve

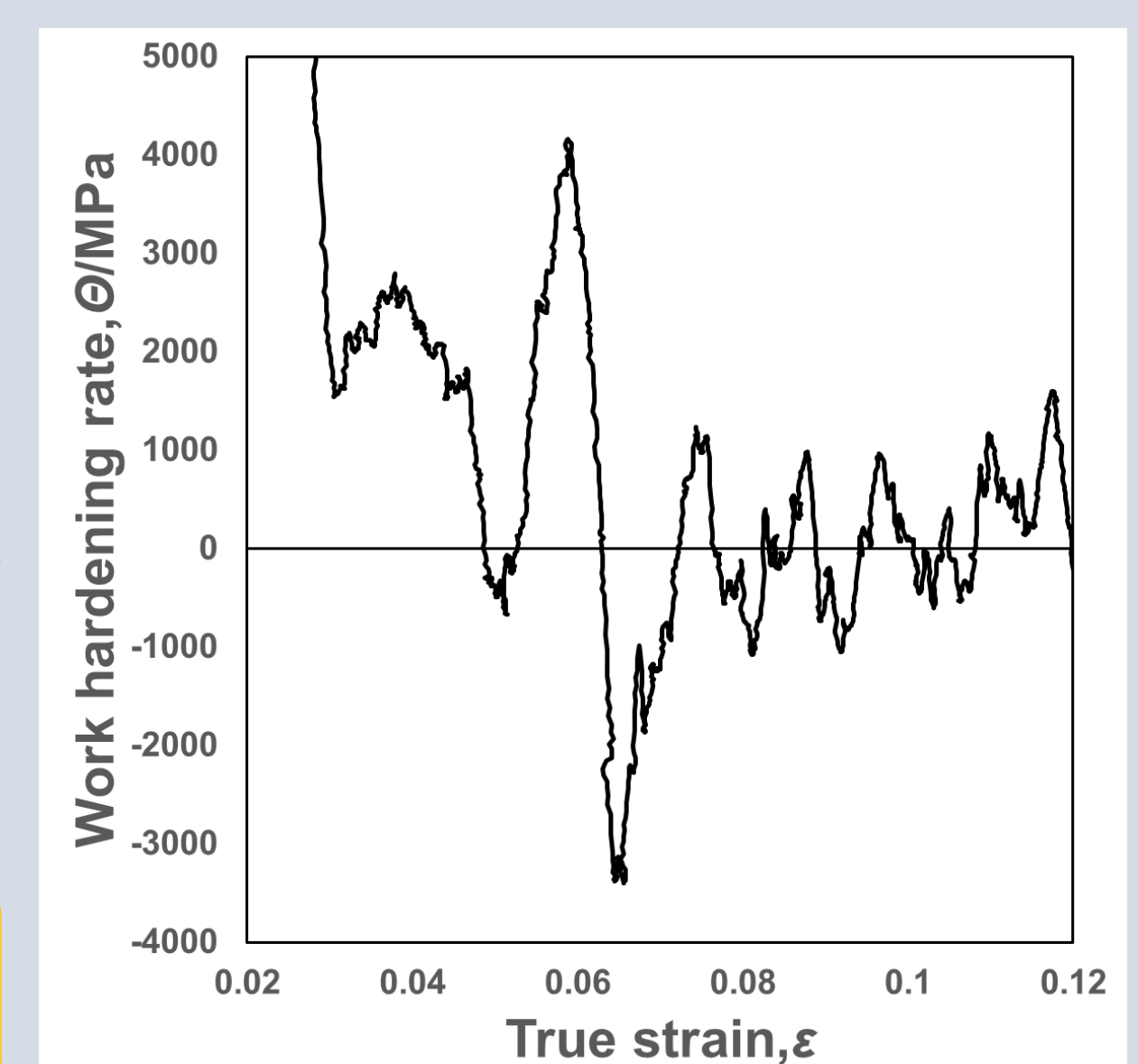


After

Deformation occurred only in the top grain

Repetition of large bursts and drops

Obstruction of dislocation moving by precipitates



Work hardening rate

Conclusions

- **Micro-tensile tests** were conducted for pure copper and **Cu-Ni-Si alloy**.
- Both **Serrations** and **necking** were observed in both samples.
- For Cu-Ni-Si alloy, an **increase** in the **work hardening rate** was observed.

Acknowledgement

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