Temperature dependence on tensile properties of Cu-40mass%Fe dual phase alloy

Yokohama National University
Norimitsu Koga, Weisi Zhang, Osamu Umezawa

Karlsruhe Institute of Technology
Valentin Tschan, Jan Sas, Klaus-Peter Weiss

Functional property and equilibrium diagram in Cu-Fe alloy

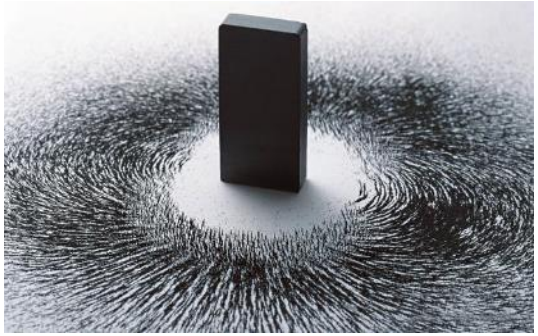
Cu

High Conductivity

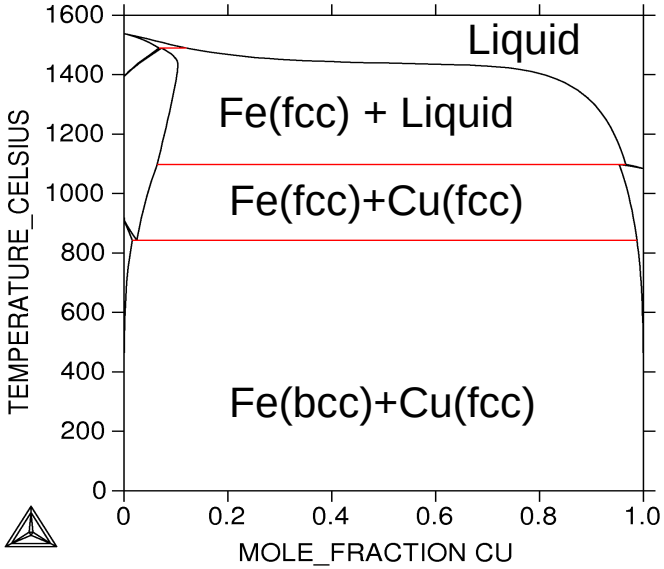
Cu – Fe alloy

Conductivity
Magnetic property
Shield material of electromagnetic wave
Mechanical property is unclear

Fe



Magnetic property



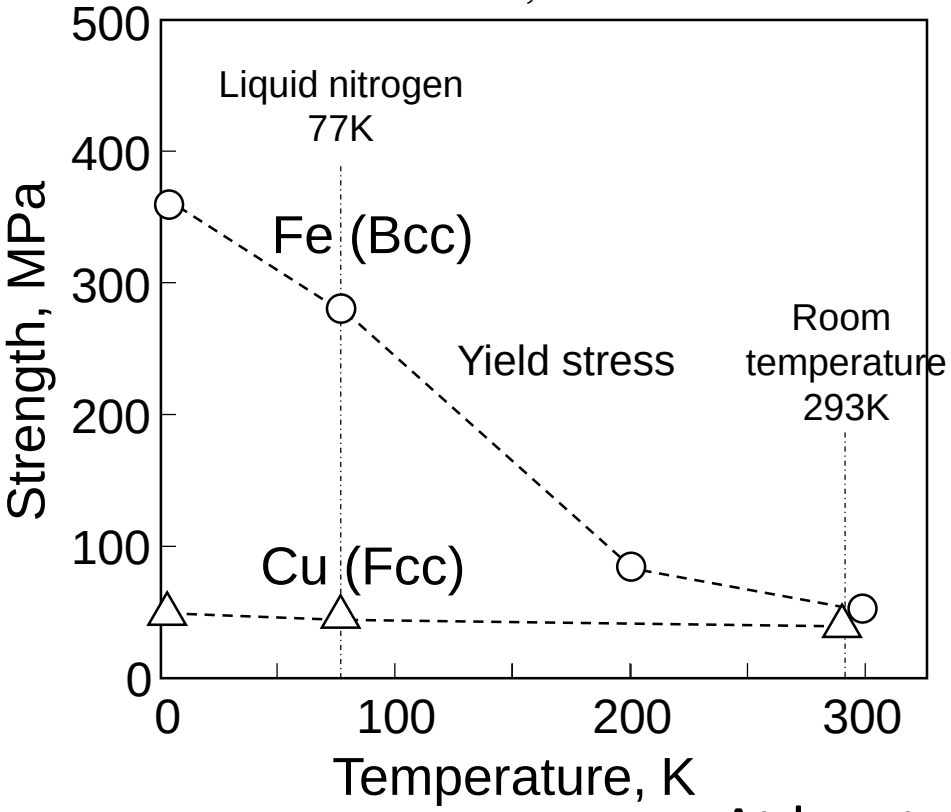
Cu - Fe binary alloy shows less mutual solubility.

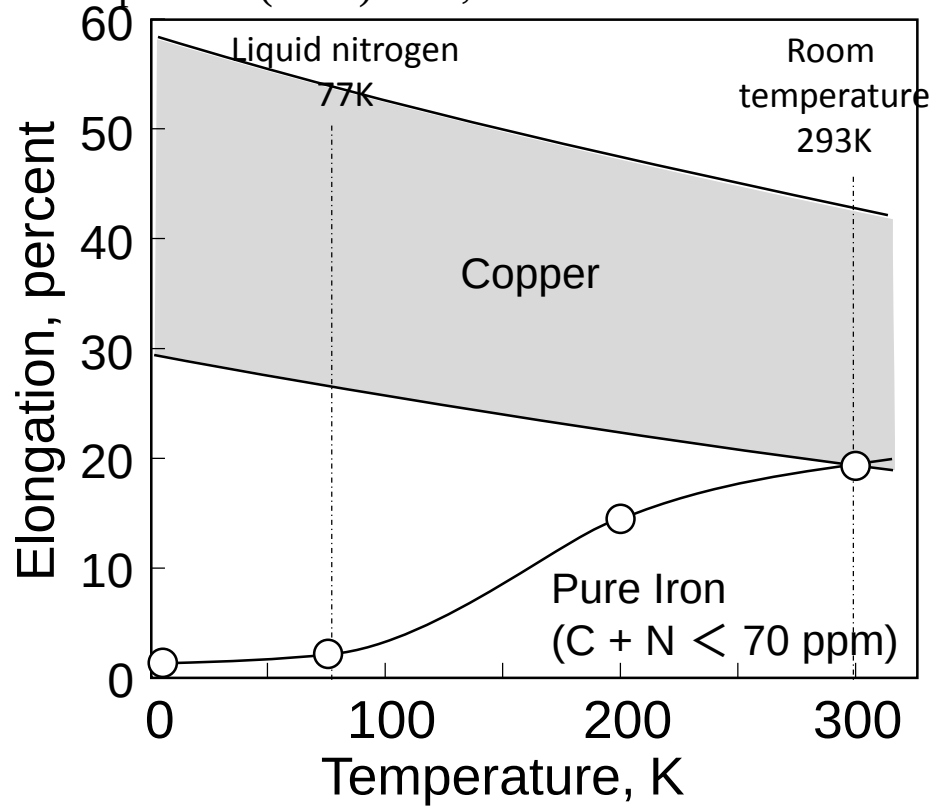
Cu(fcc) + Fe(bcc)
dual phase structure

Dependence of temperature on tensile property

Polycrystalline Cu or Fe single phase material

R.P.Reed , A.F.Clark: Materials at low temperature(1983)P256,P258





At low temperature

Fe(bcc) High yield stress

Cu(fcc) Low yield stress

Fcc + Bcc
dual phase
materials
tensile property ?

Fe(bcc) Low elongation

Cu(fcc) high elongation

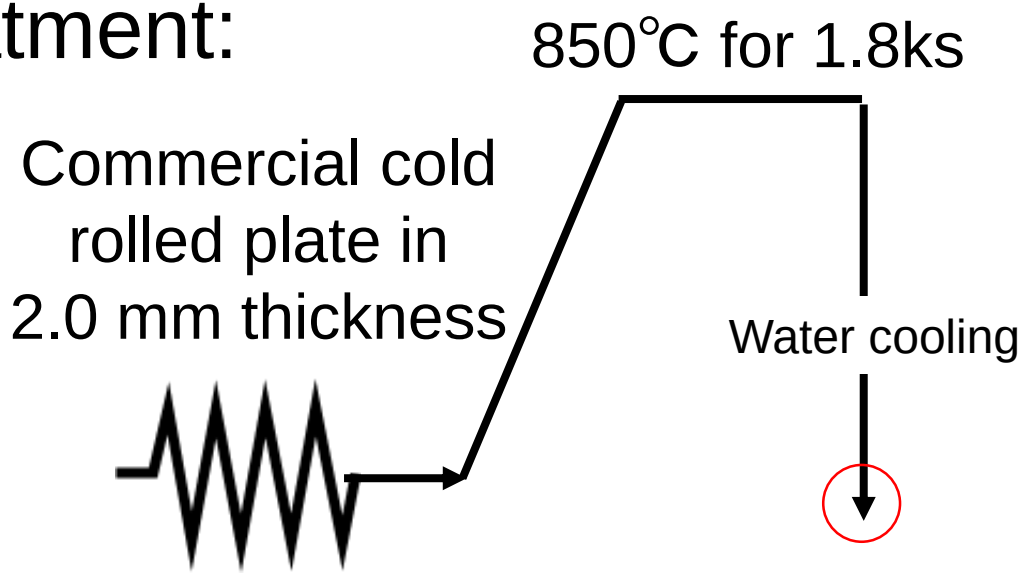
Purpose

- Tensile properties, deformation and fracture behavior of the cold rolled Cu-40mass%Fe alloy at low temperature had been evaluated in order to reveal the temperature dependence on tensile property in fcc + bcc dual phase structure.

Experimental procedure

Materials: Cu – 40%Fe alloy

Heat treatment:



Tensile test at 293 K, 77 K and 8 K.

OM and SEM observation, EDS, EBSD, DIC analysis

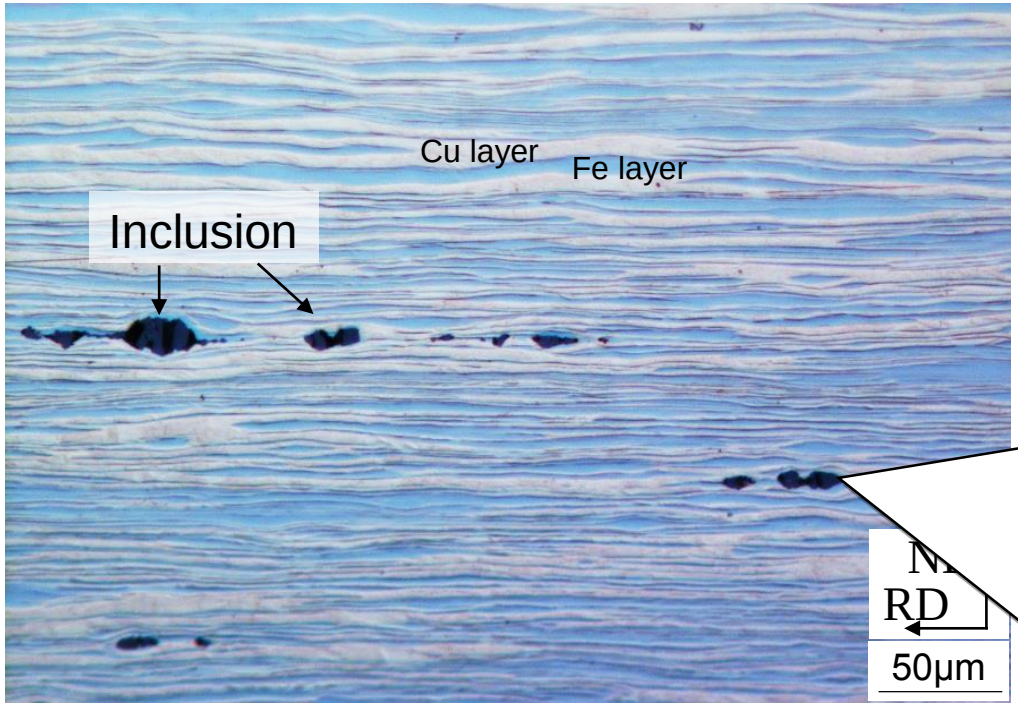
1.Microstructure

2.Tensile property

3.deformation and fracture behavior

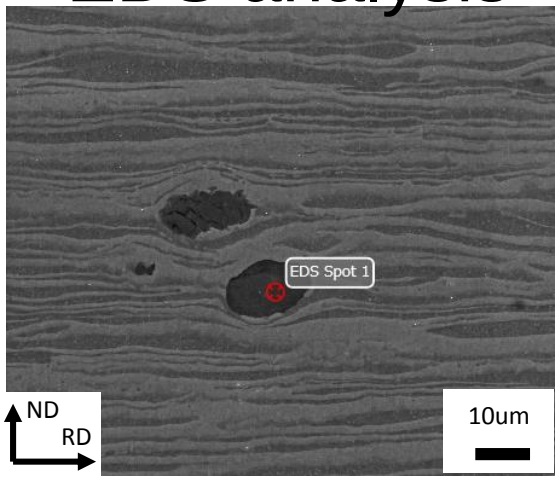
OM image and analysis of inclusion

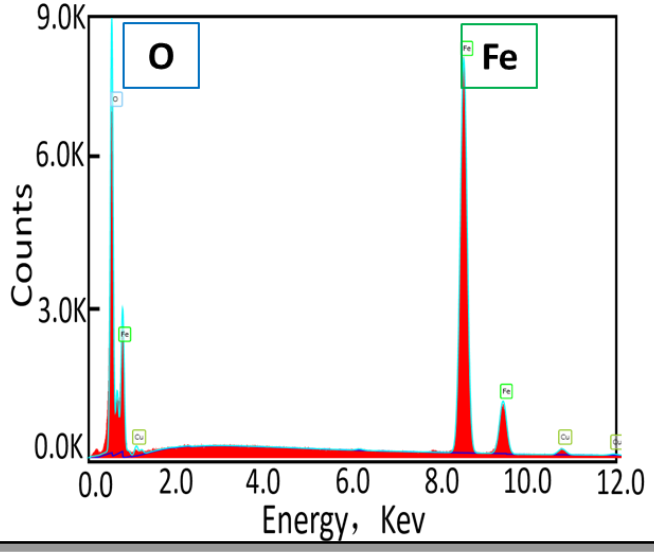
OM image



Width of layer is approximately 3 μm

EDS analysis



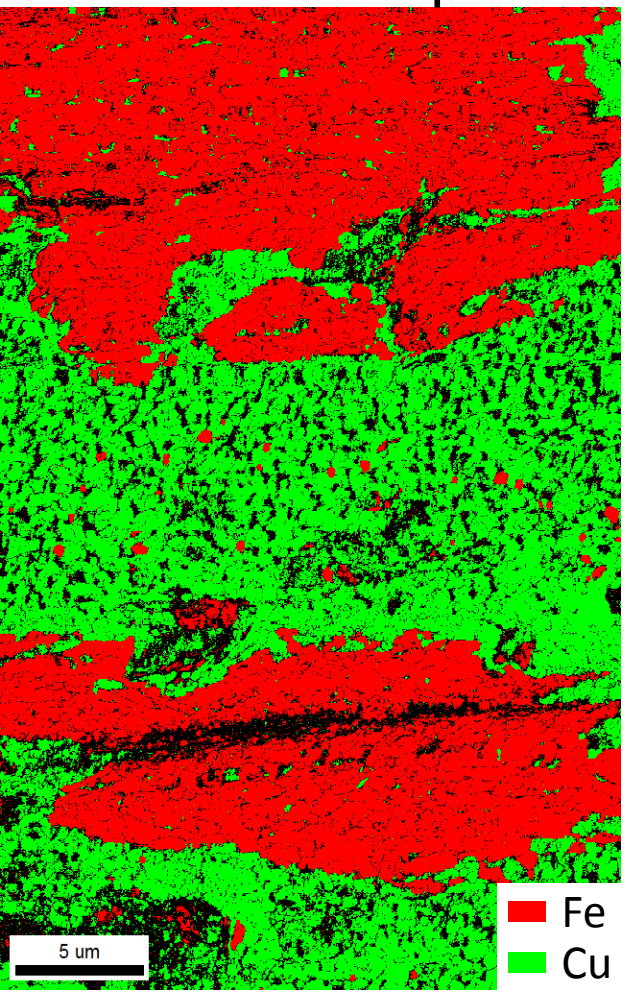


Cu ＋ Fe layer structure

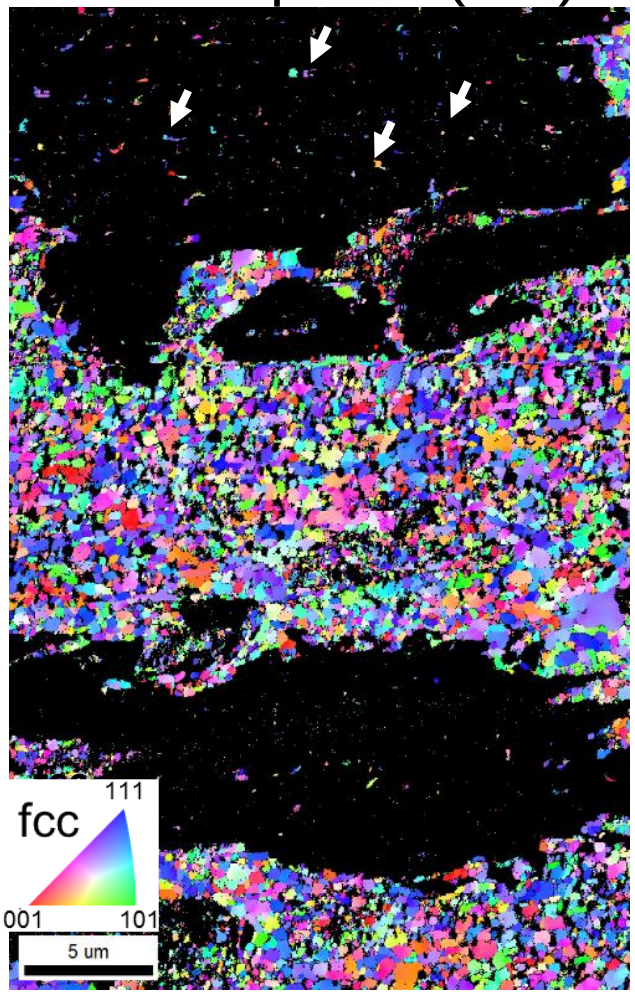
Inclusions(iron oxide)

Phase map and Inverse pole figure in each phase

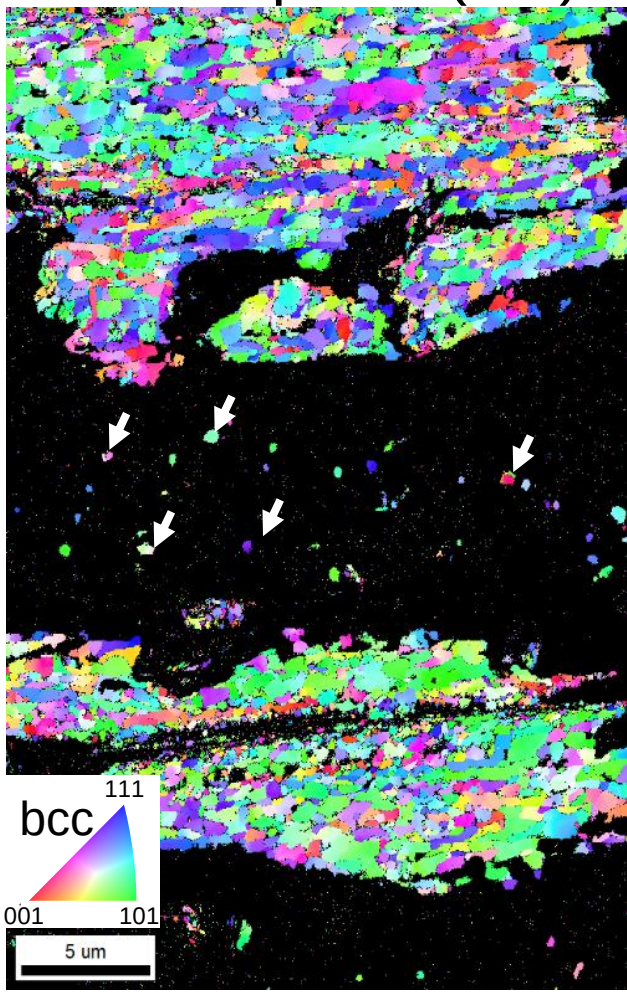
Phase map



IPF Cu phase(RD)



IPF Fe phase(RD)



Each phase has ultra fine grains(<1μm)

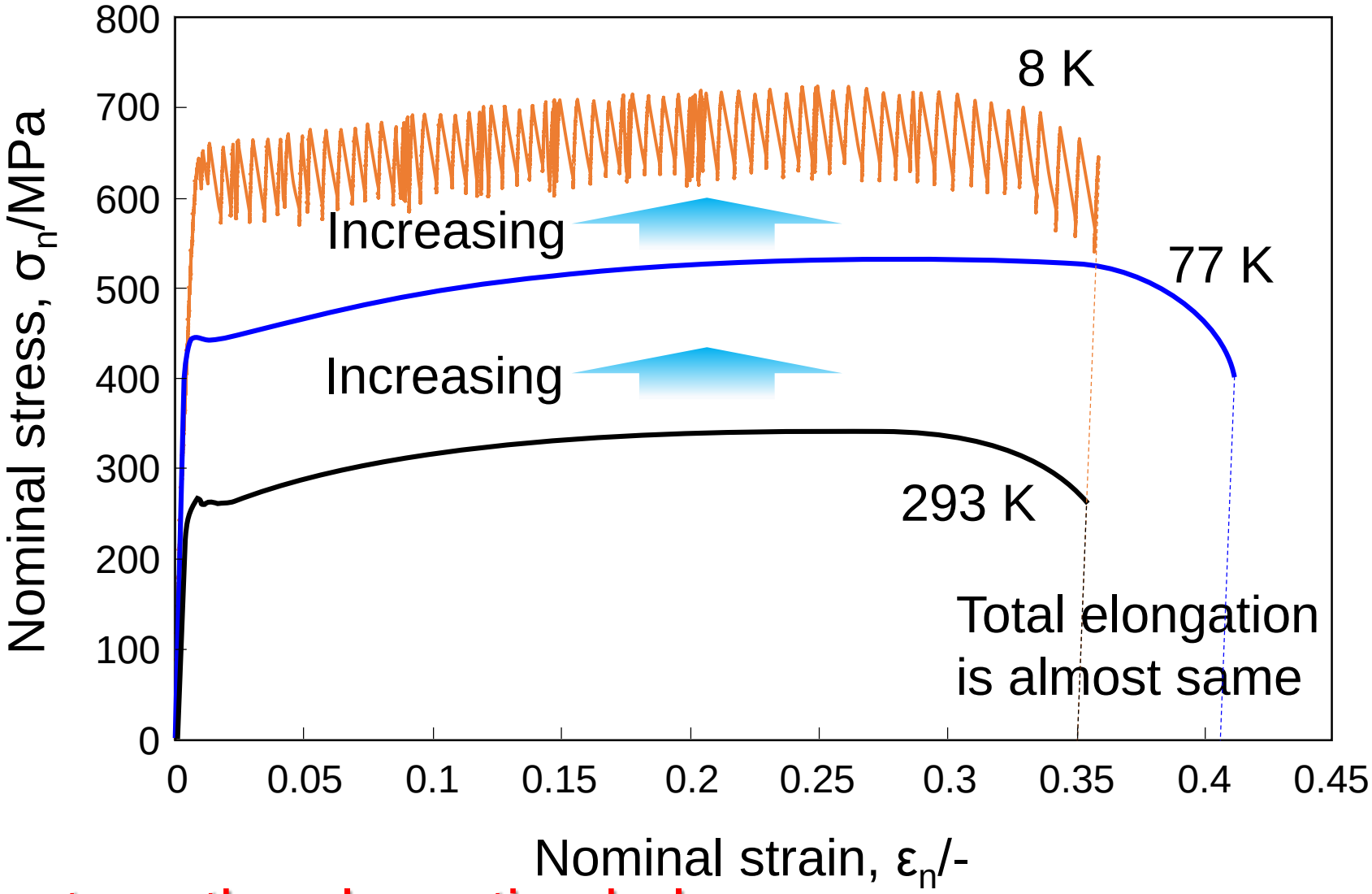
Fe and Cu layer have precipitates of Cu and Fe

1.Microstructure

2.Tensile property

3.deformation and fracture behavior

Tensile property at each temperature

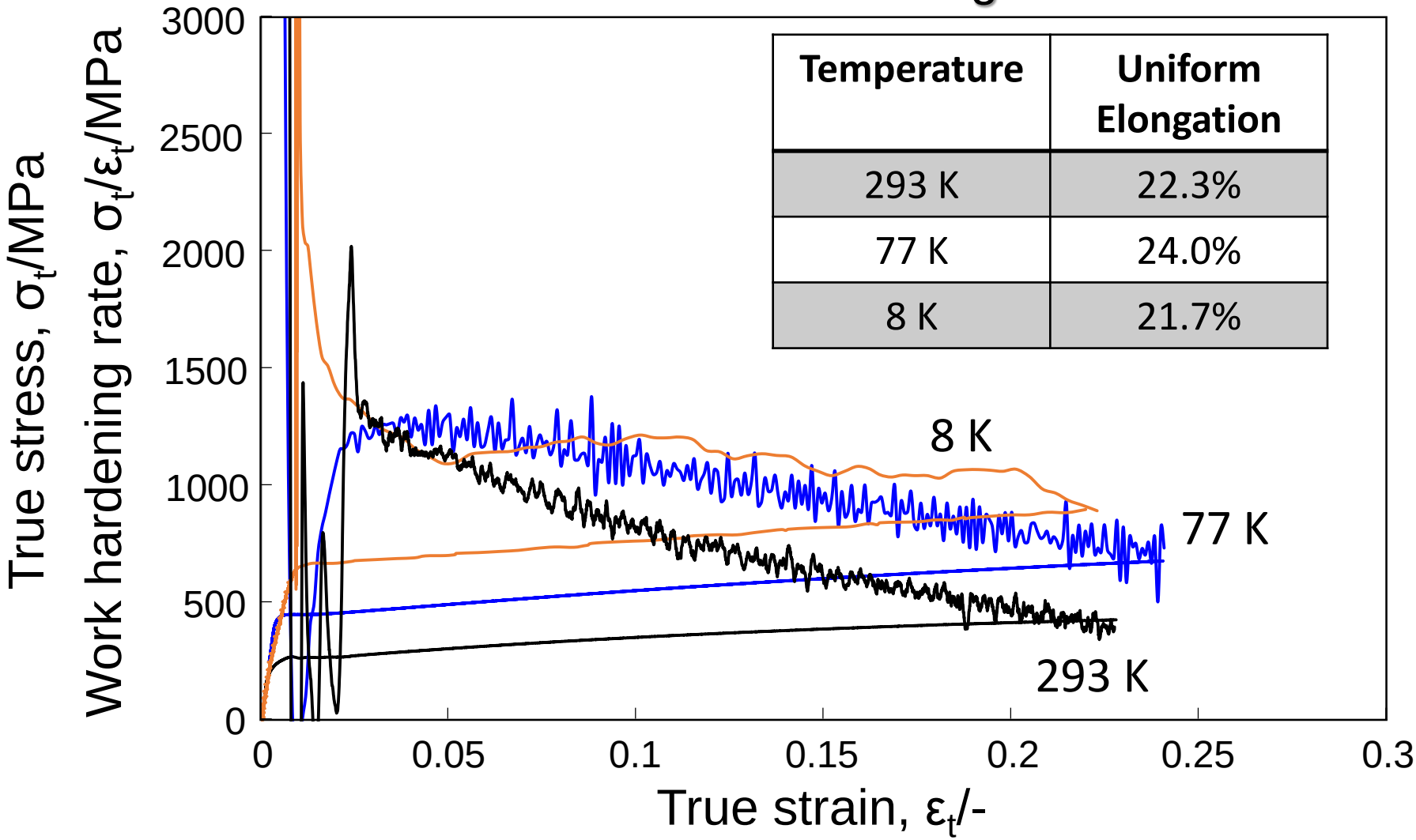


strength - elongation balance

is improved as lowering temperature

Work hardening rate in each temperature

Uniform Elongation is almost same

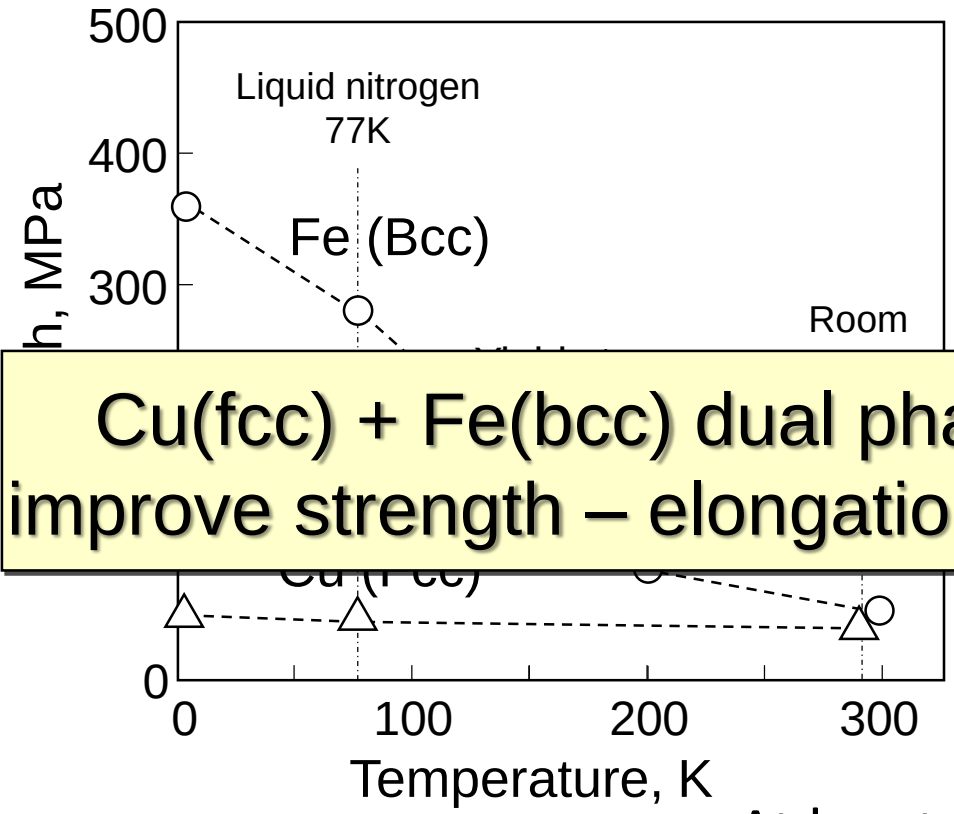


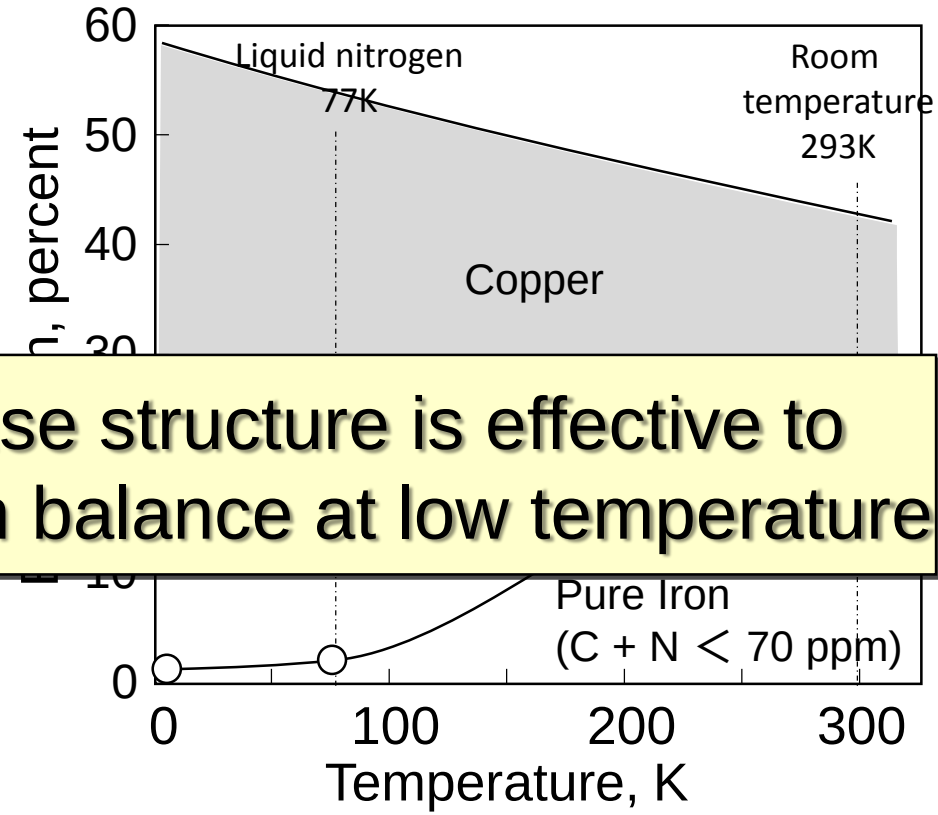
Temperature	Uniform Elongation
293 K	22.3%
77 K	24.0%
8 K	21.7%

Work hardening rate increase as lowering temperature

Dependence of temperature on tensile property

Polycrystalline Fe or Cu single phase material





Cu(fcc) + Fe(bcc) dual phase structure is effective to improve strength – elongation balance at low temperature

At low temperature

Bcc + Fcc dual phase materials tensile property ?

Fe(bcc) High yield stress

Cu(fcc) Low yield stress

Fe(bcc) Low elongation

Cu(fcc) high elongation

1.Microstructure

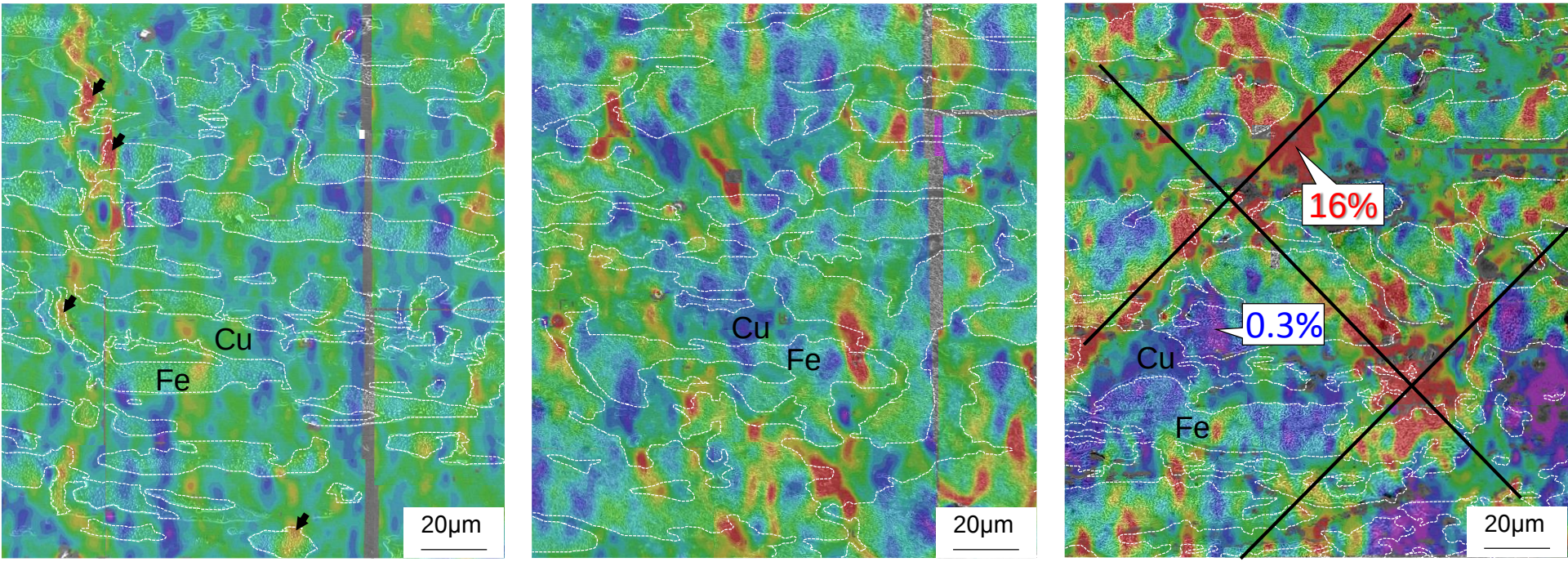
2.Tensile property

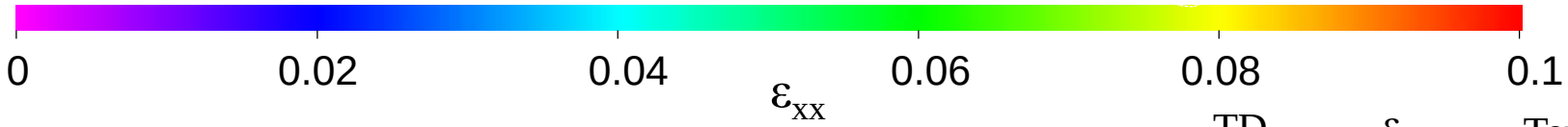
3.deformation and fracture behavior

Strain distribution in 5 % tensile deformed at 293 K, 77 K, 8 K

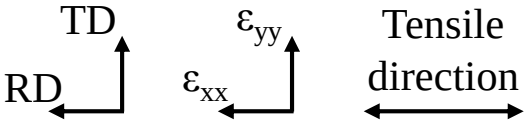
5 % tensile deformed

293 K | 77 K | 8 K





Strain tends to concentrate on Fe layer at 293 K



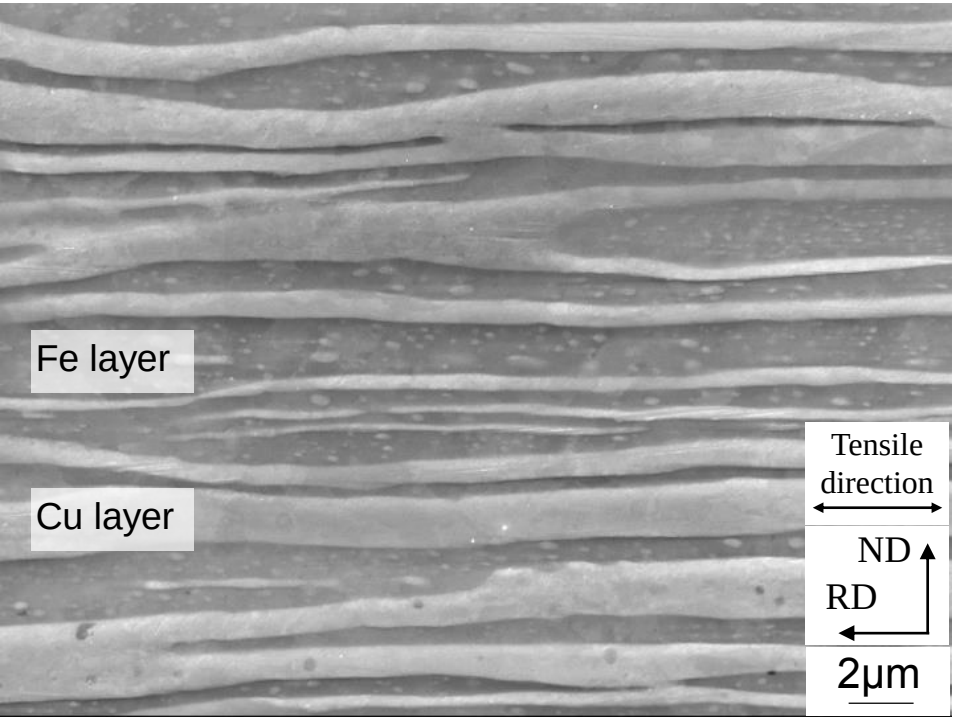
Strain was inhomogeneously distributed regardless of phases at 8 K

➡ is one of the reason for high work hardening at 8 K

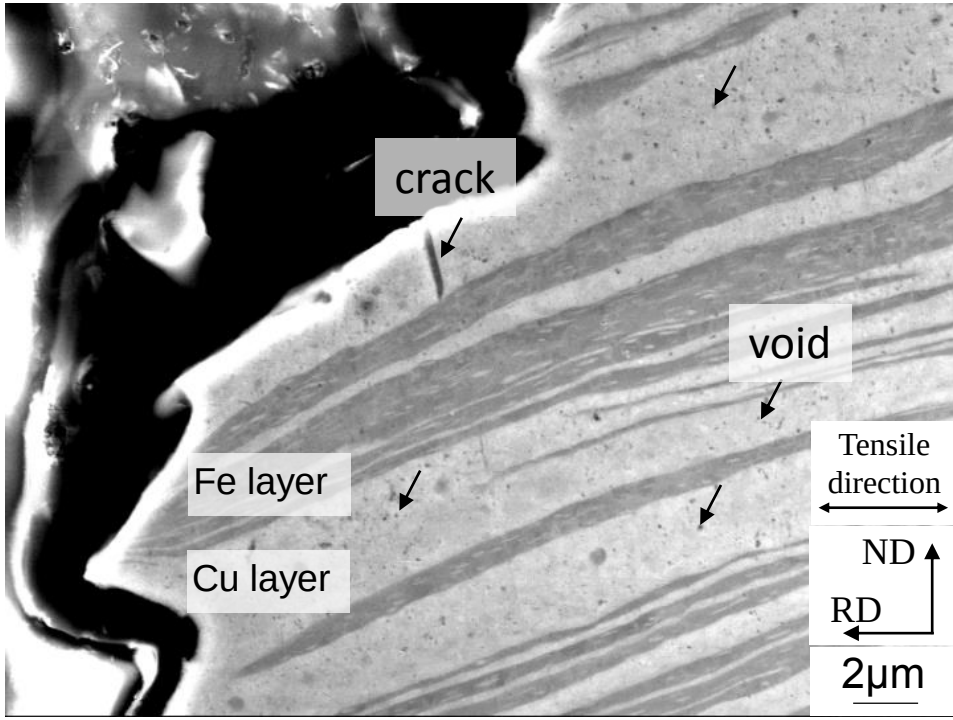
SEM images at uniform deformation and necking region

SEM images in fractured specimen at 8 K

Uniform deformation region



Necking region



No Voids or cracks

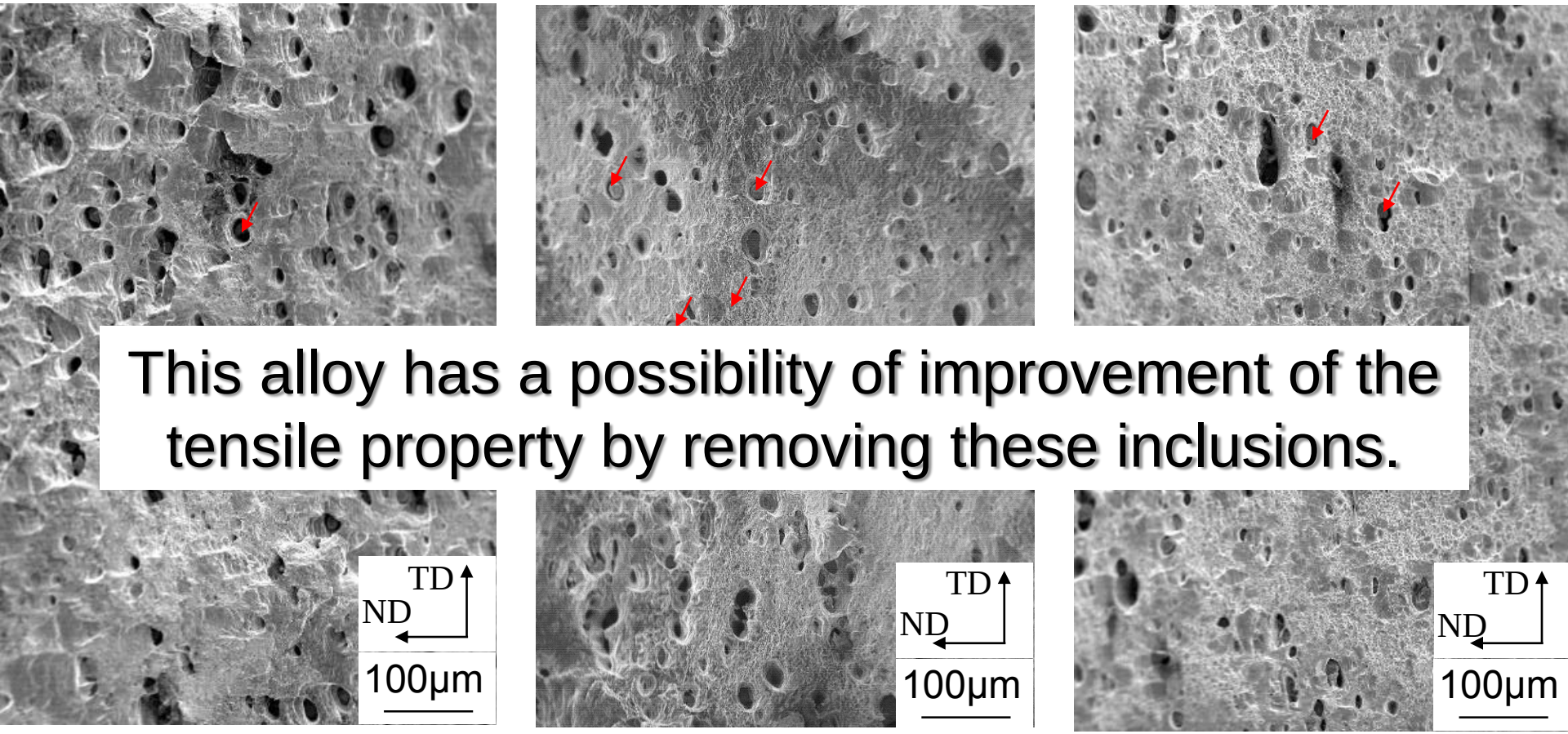
There are crack and a lot of voids inside only Cu layer

fine grain or Cu precipitates may suppress brittle fracture ➡ Fe layer has enough ductility even at 8 K

Fracture surface at 293 K, 77 K and 8 K.

Fracture surface

293 K | 77 K | 8 K



This alloy has a possibility of improvement of the tensile property by removing these inclusions.

There are a lot of course voids generated from inclusions.

➡ These voids easily connect each other, and then the specimen is broken.

Inclusions degrade elongation

Summary

- The annealed cold-rolled Cu-40%Fe alloy formed layer structure macroscopically and each layer had fine grains and Fe or Cu precipitates.

- Yield stress, tensile stress and work-hardening rate continuously increased as lowering temperature though elongation was hardly changed.

- Strain was inhomogeneously distributed at low temperature regardless of Cu and Fe layer, and voids and cracks tended to generate inside Cu layer at low temperature.

Thank you for your kind attention