Interstitial transformation-induced plasticity-assisted quinary CCAs/HEAs: Design, structure and mechanical behavior

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Outline

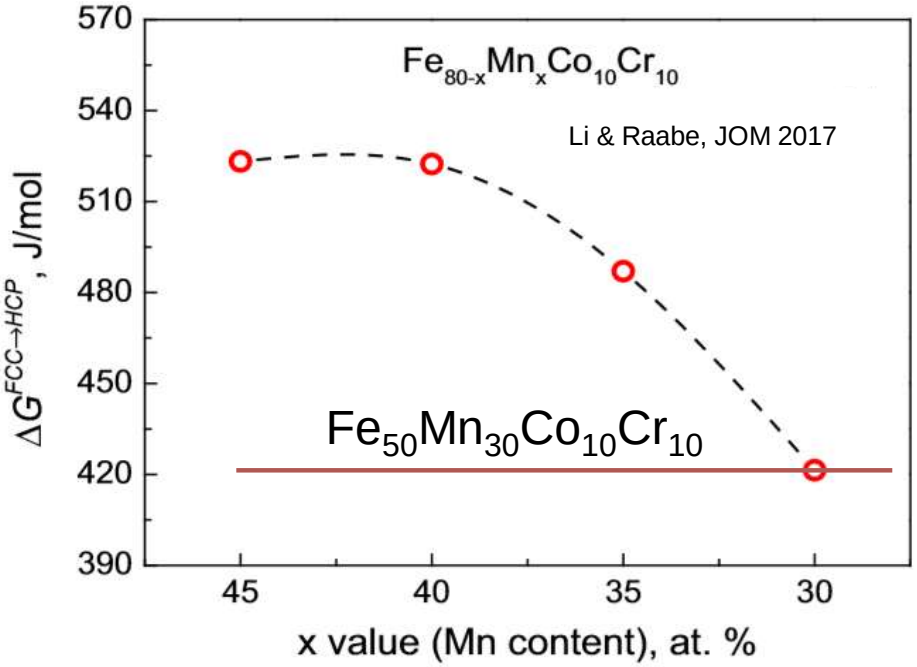
I **Background** – learn from the past

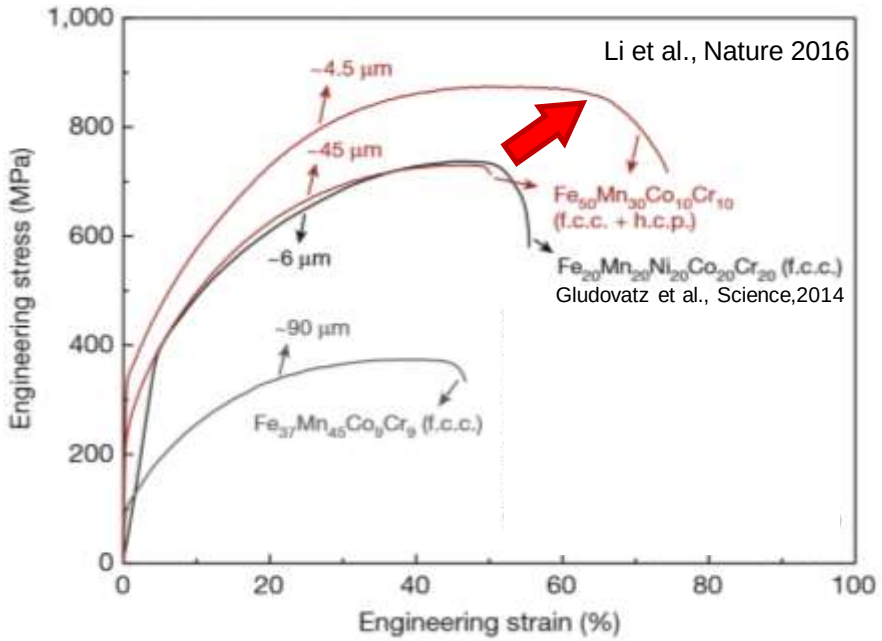
II **Motivation** – what is the target?

III **Experimental** – how can we achieve it?

IV **Further work** – what is the plan?

Background – Quaternary TRIP CCAs/HEAs





Lower stacking fault energy (SFE)

TRIP

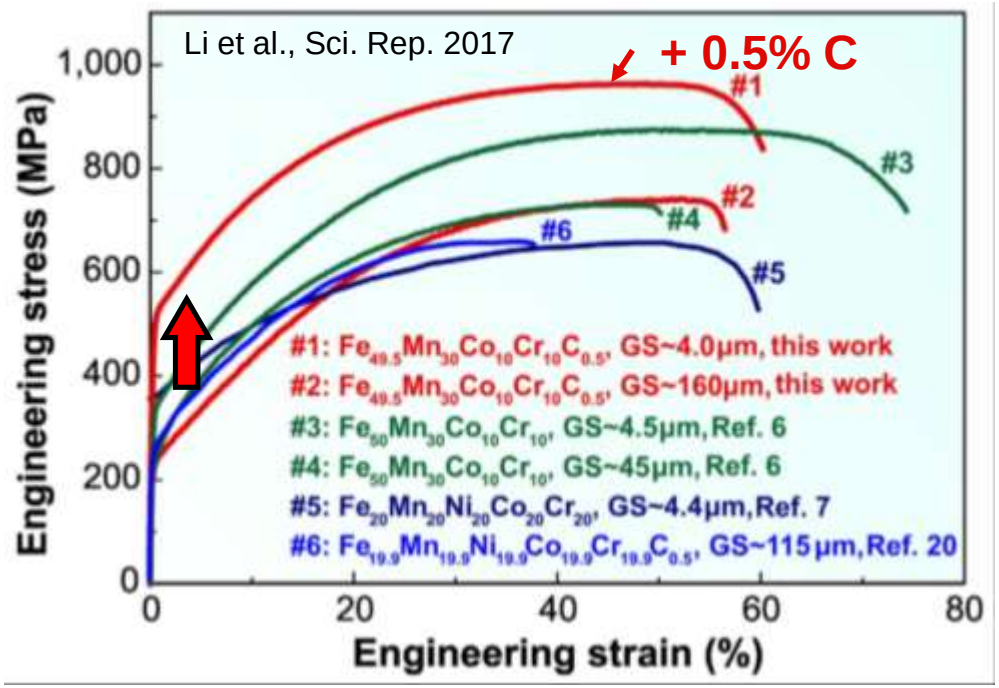
TWIP

Improved strength and ductility

TRIP: transformation induced plasticity

TWIP: twinning induced plasticity

Background – Quaternary iCCAs/iHEAs



Interstitial C addition

TRIP

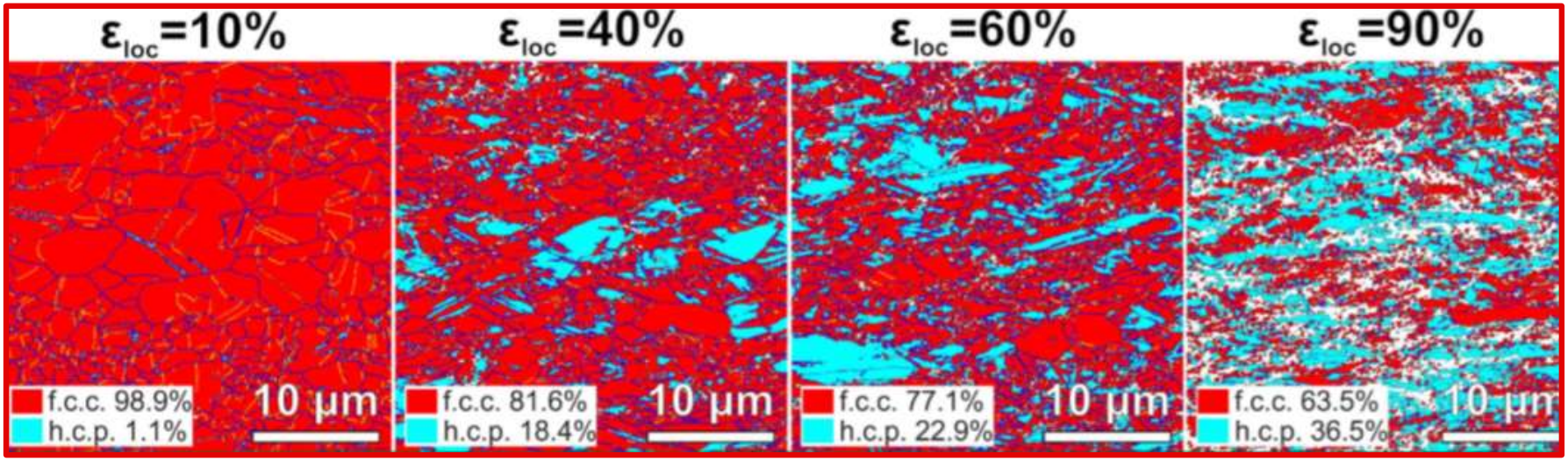
TWIP

Interstitial SSS

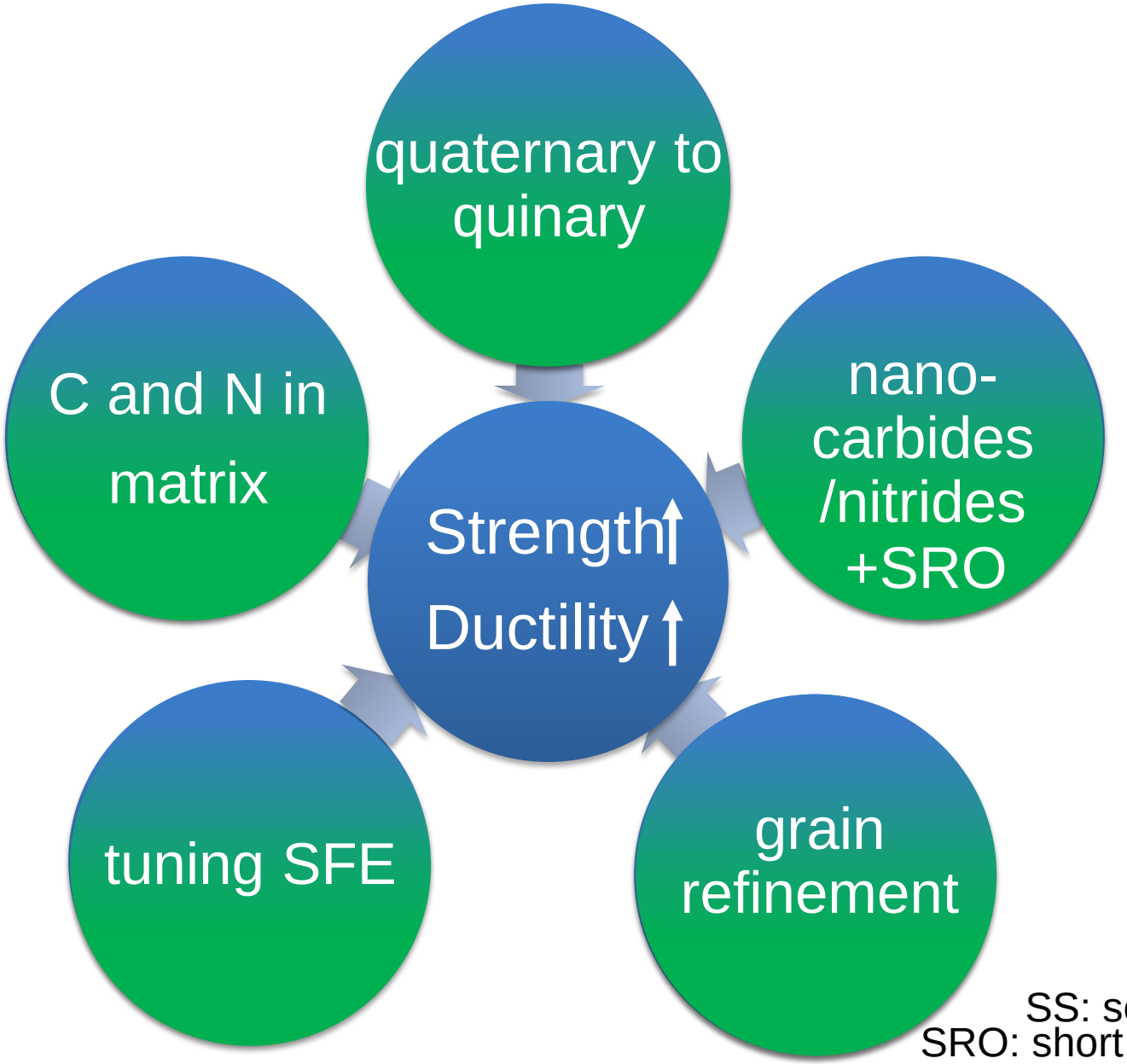
Nano-particles

iCCAs/iHEAs: Improved strength-ductility

SSS: solid solution strengthening



Motivation – what is the target?

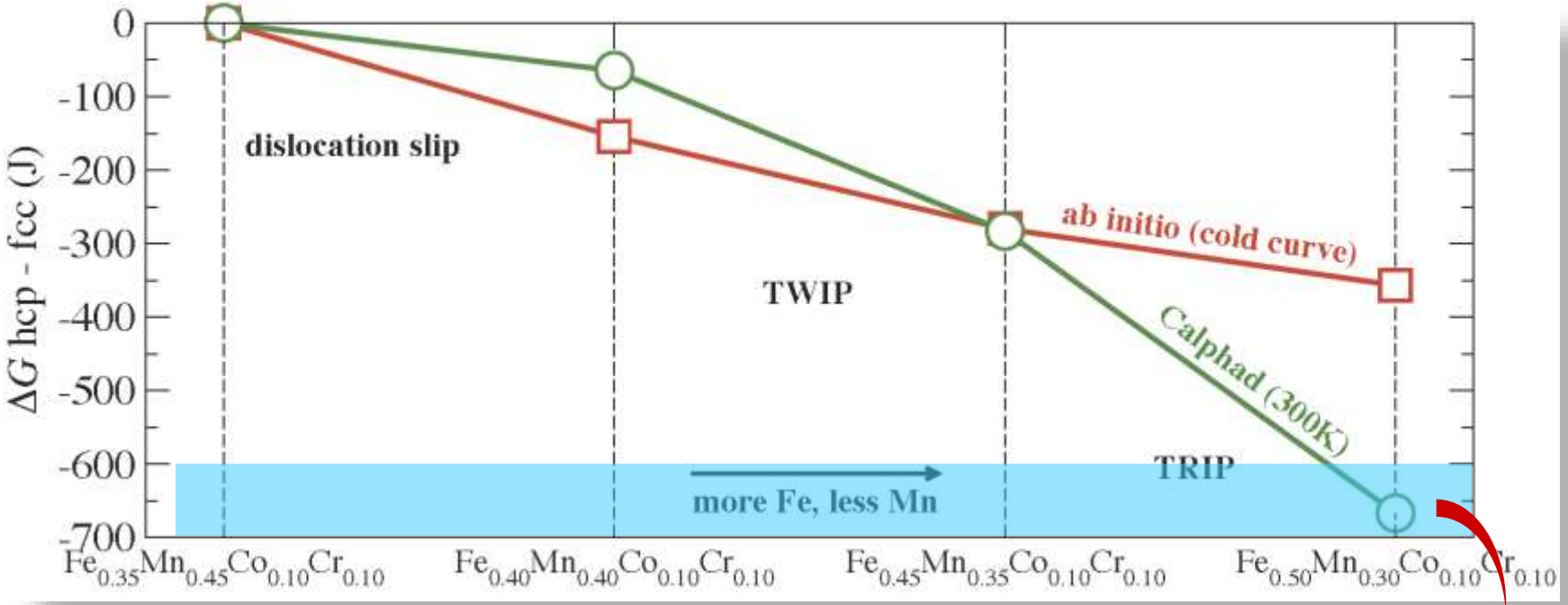


SS: solid solution
SRO: short range ordering

Alloy design – Quinary TRIP CCAs/HEAs

Guiding rule: SFE

→ Quinary CCAs/HEAs with SFE similar to quaternary $Fe_{50}Mn_{30}Co_{10}Cr_{10}$



$Co_{20}Cr_{20}Fe_xMn_yNi_z$ (x+y+z=60)

$Co_{20}Cr_{20}Fe_{34}Mn_{15}Ni_{11}$

MPIE: Grabowski, Körmann (unpublished)

Experimental – alloy fabrication

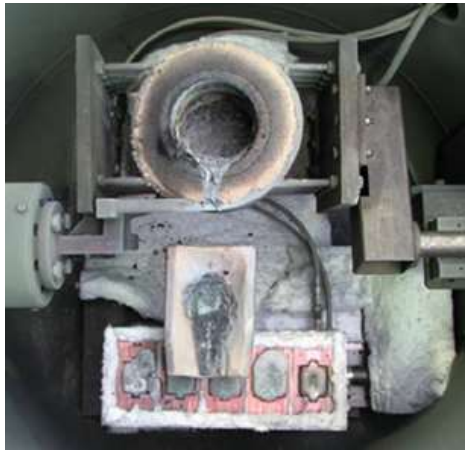
Set 1: coarse grains

$Co_{20}Cr_{20}Fe_{34}Mn_{15}Ni_{11}$

Casting → Hot rolling @900°C → Homogenization @1200°C, 2h → Water-quenching (WQ)

50% thickness reduction,

10 mm -> 5 mm



Ingot size: 10x50x150 mm^3

Composition by wet-chemical analysis

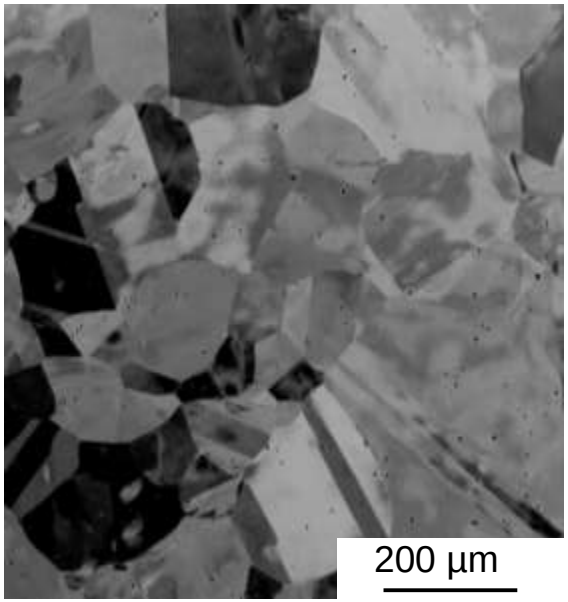
Element	Co	Cr	Mn	Ni	Fe
wt. %	21.7	18.9	15.1	11.9	Bal.

Set 2: refined grains

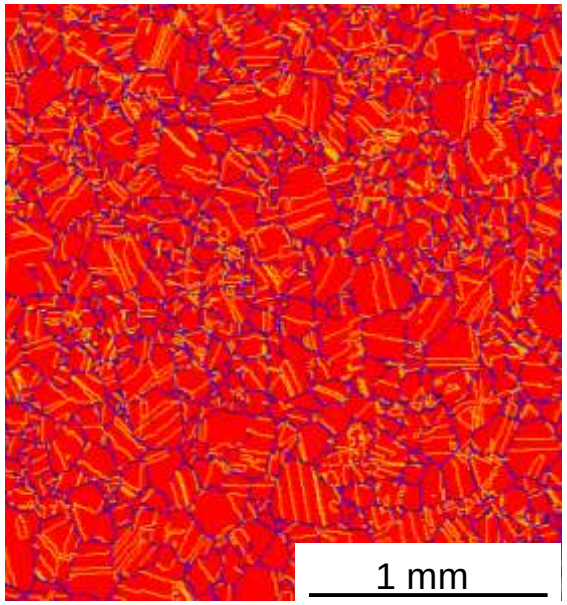
Homogenized state → Cold rolling 5 mm -> 1.5 mm → Annealing @900°C, Ar, WQ

Experimental – preliminary results

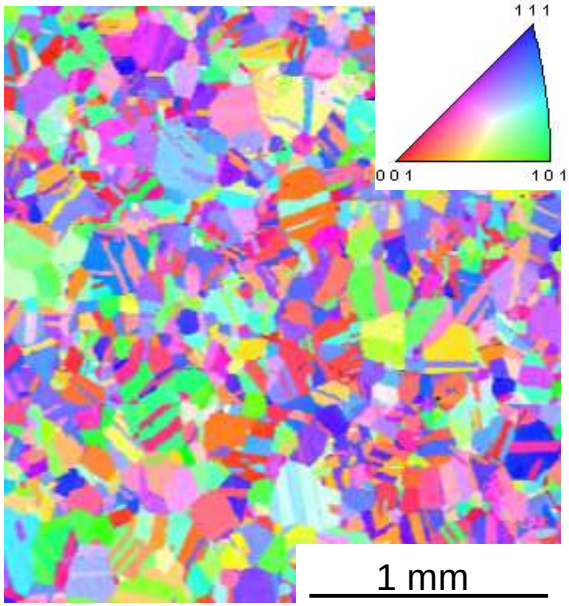
$Co_{20}Cr_{20}Fe_{34}Mn_{15}Ni_{11}$ – homogenized (1200°C, 2h)



BSE image



single FCC phase with many twins

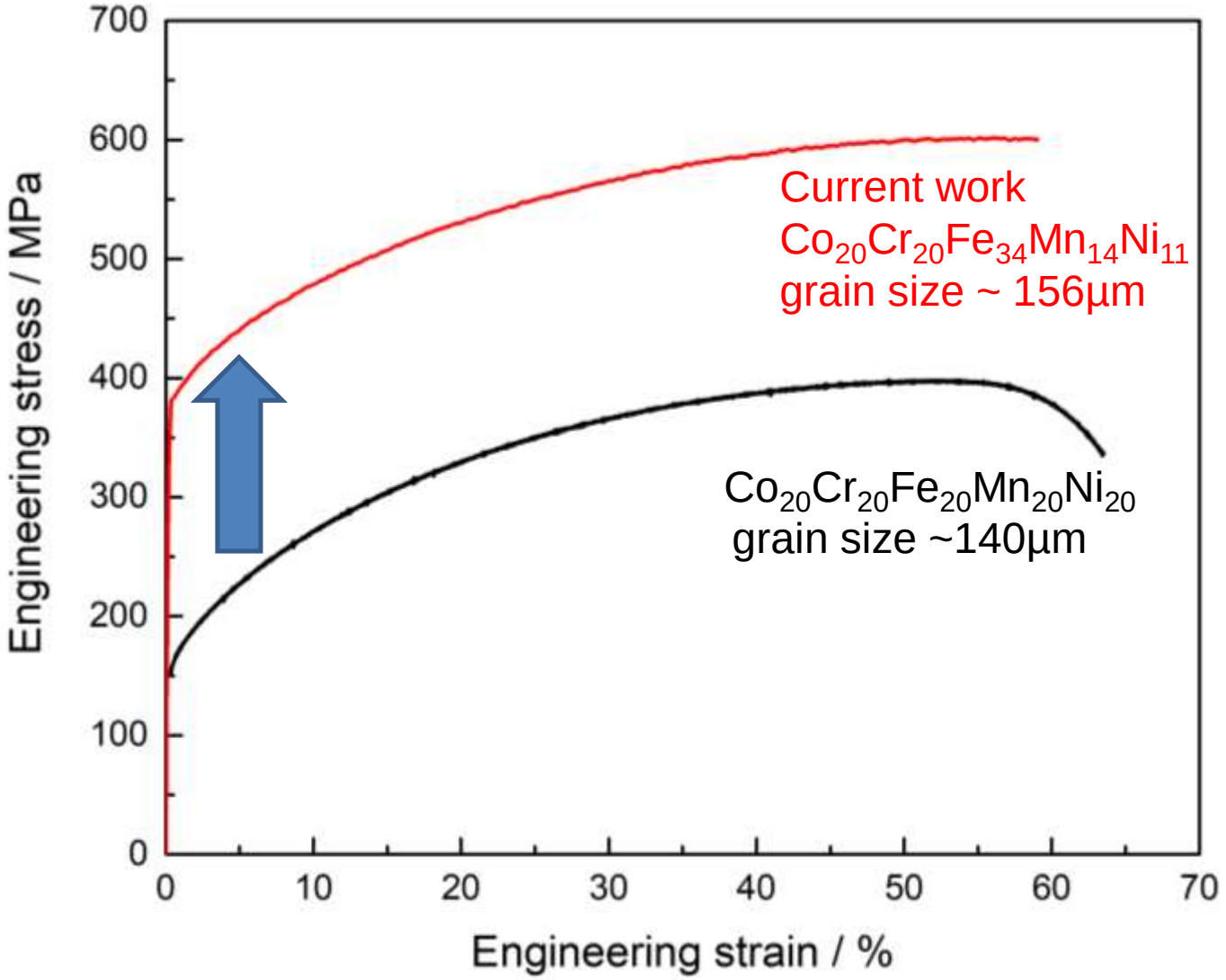


average grain size ~156 µm

BSE: back scattered electron

Experimental – preliminary results

$Co_{20}Cr_{20}Fe_{34}Mn_{15}Ni_{11}$ – homogenized (1200°C, 2h)



Experimental – preliminary results

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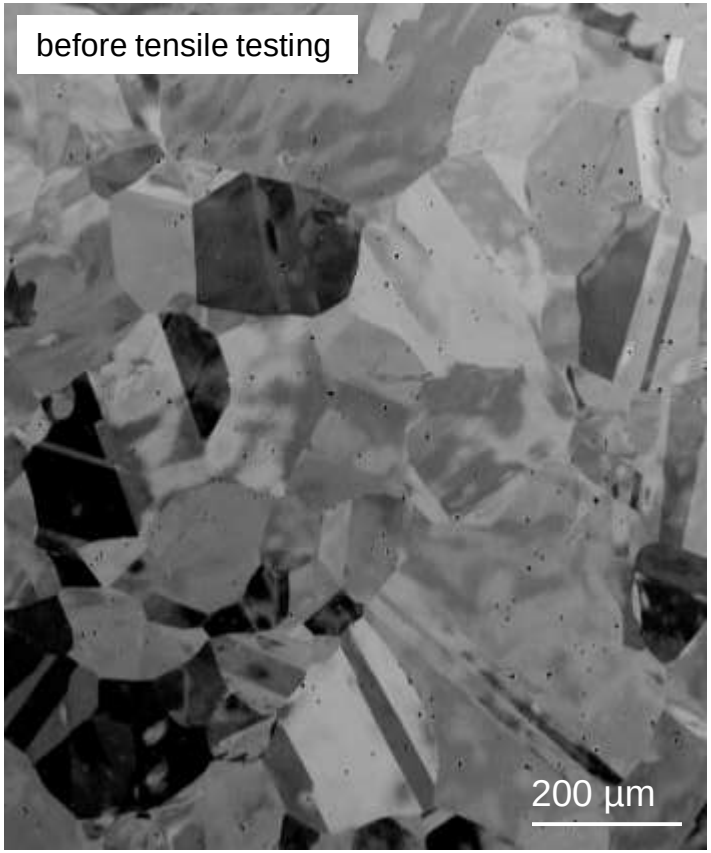
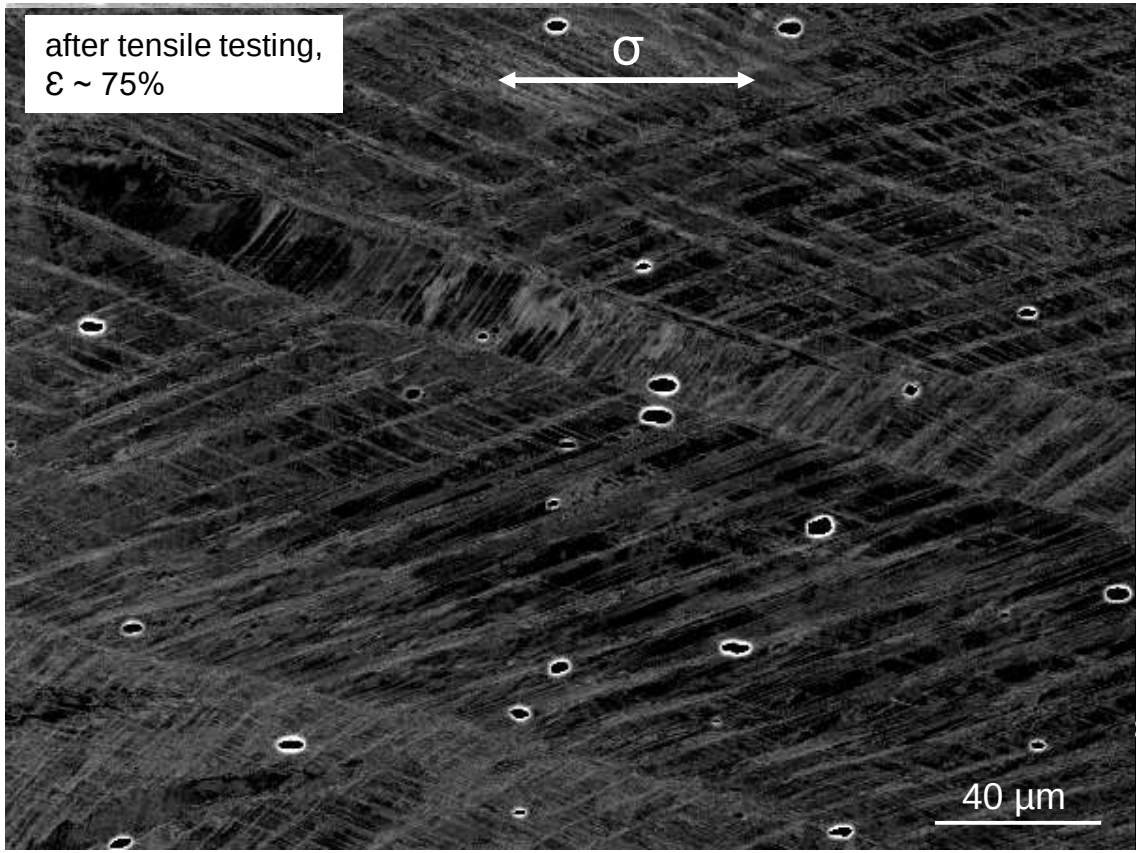
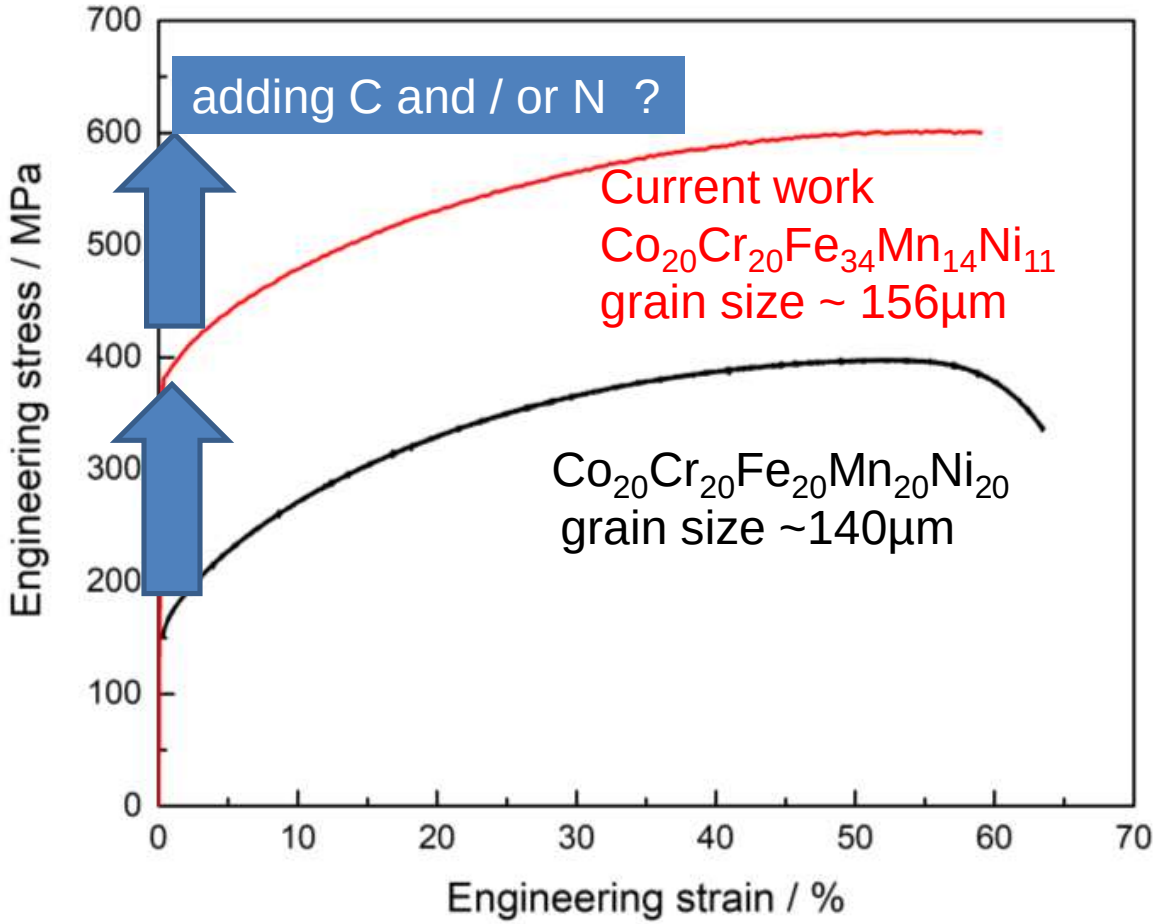




TRIP effect is observed

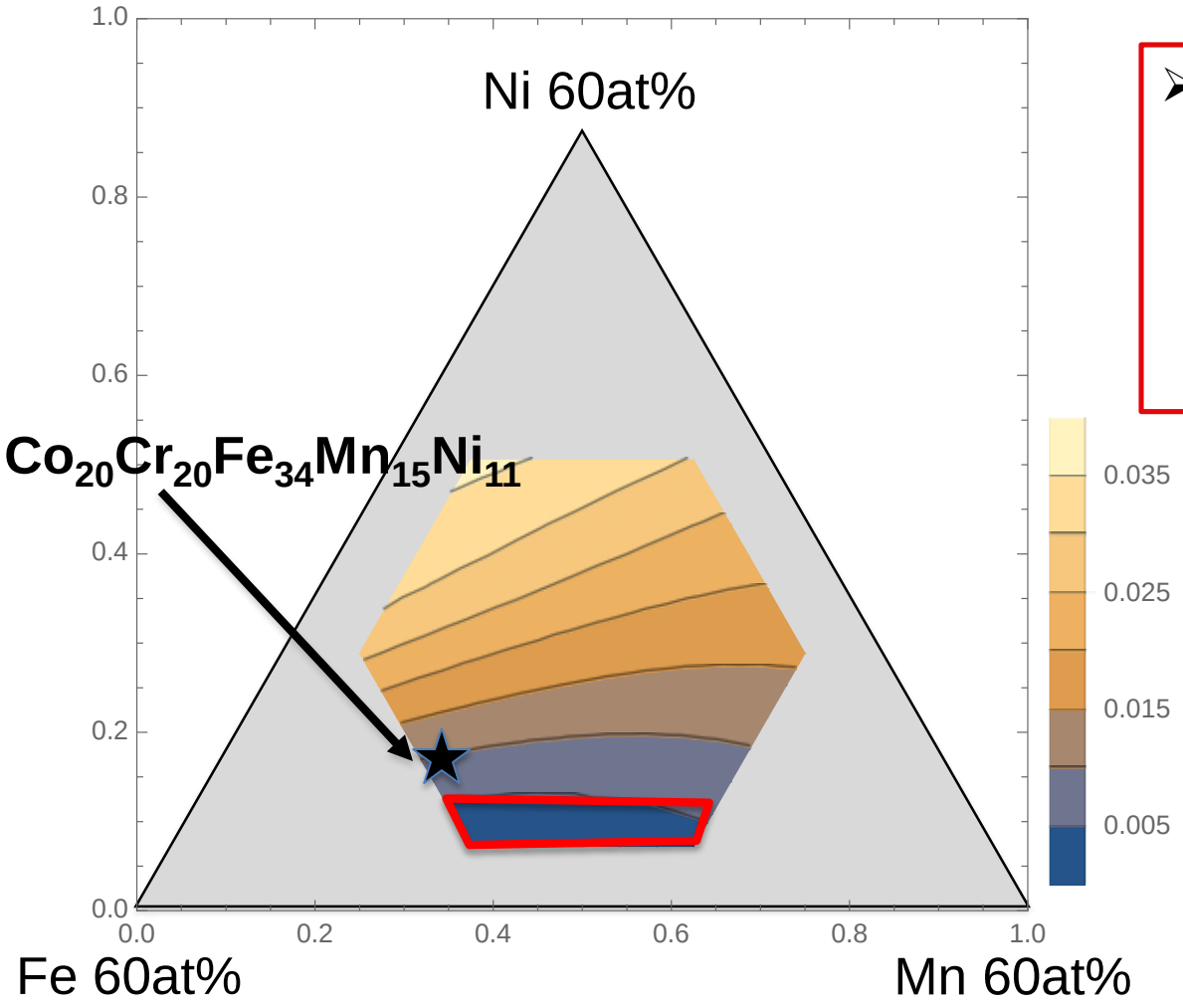
Further work - what is the plan?



- Adding intersitial C & N into the current CCAs/HEAs
- Designing more quinary TRIP CCAs/HEAs

Further work - what is the plan?

Co: 20; Cr: 20; Fe: 5~35; Mn: 5~35; Ni: 5~35



- Under *ab initio* guidance, new alloys within this region will be designed aiming for high strength and ductility. (input from Yuji and Fritz)

Thank you
for your attention!