In situ tensile deformation of silicon doped $Fe_{50-x}Mn_{30}Co_{10}Cr_{10}Si_x$ high entropy alloy

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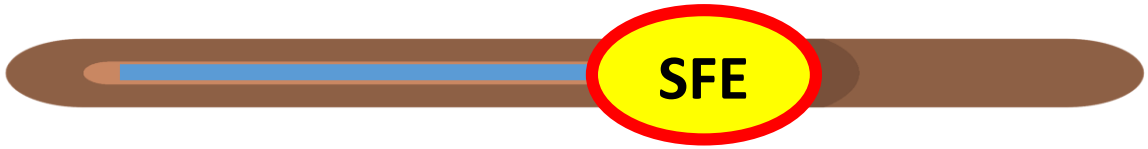
Deformation mechanism = f (stacking fault energy)

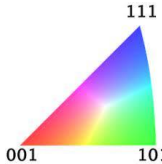
Stacking fault energy = f (alloying elements)



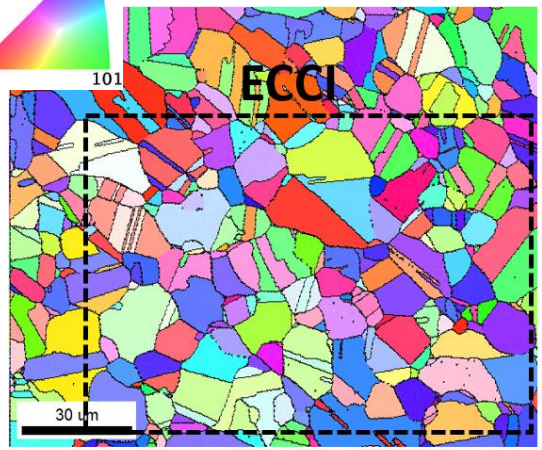
TRIP → TWIP → Planar slip

Initial Microstructure after Si doping

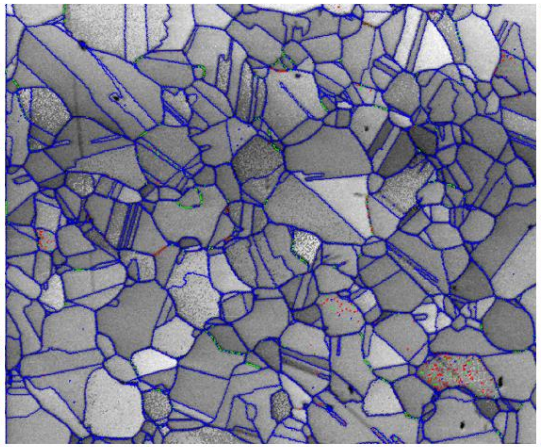
Results & Discussion



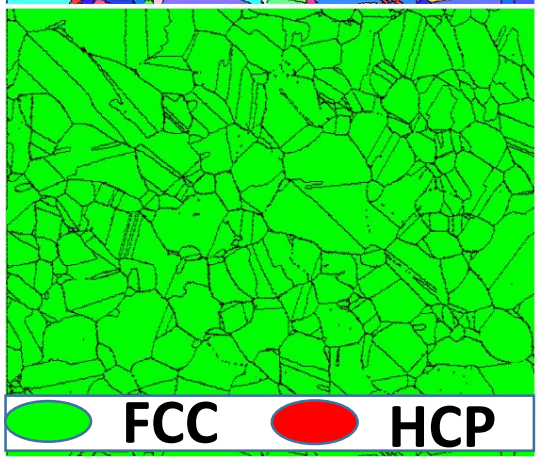
IPF-X



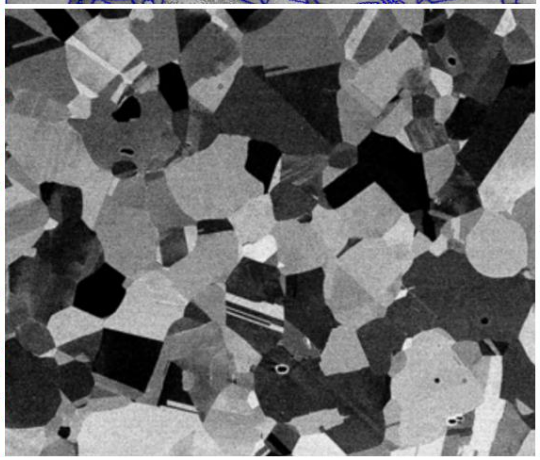
Boundary map (15-180)



EDS maps



Phase map



ECCI micrograph

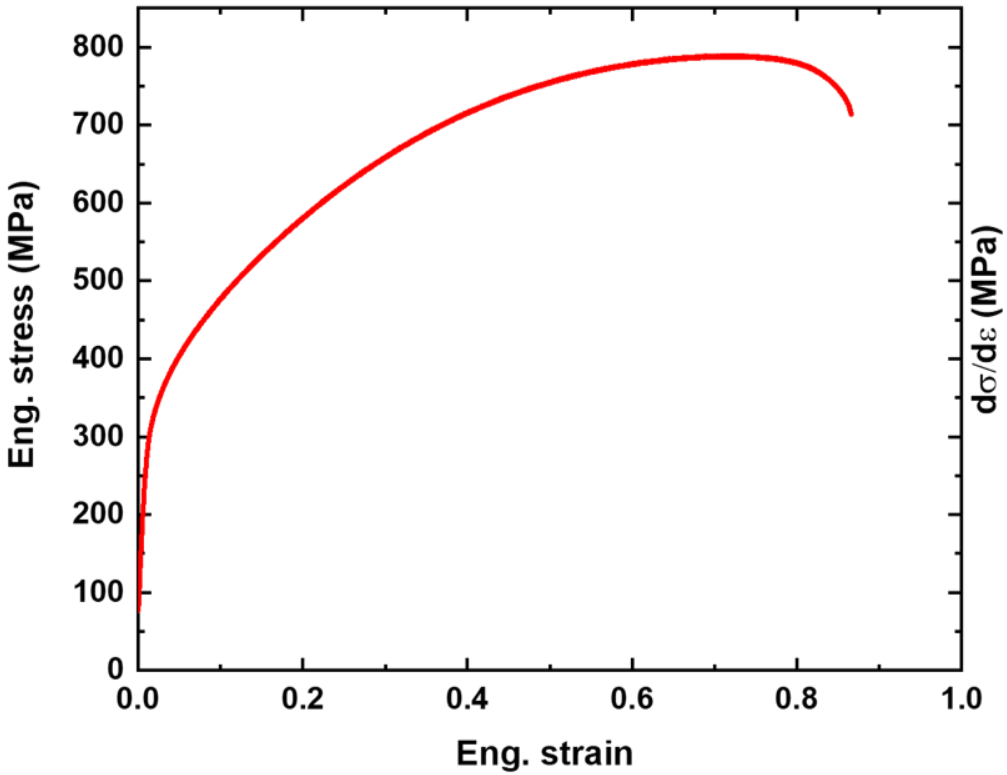
Wet chemical analysis

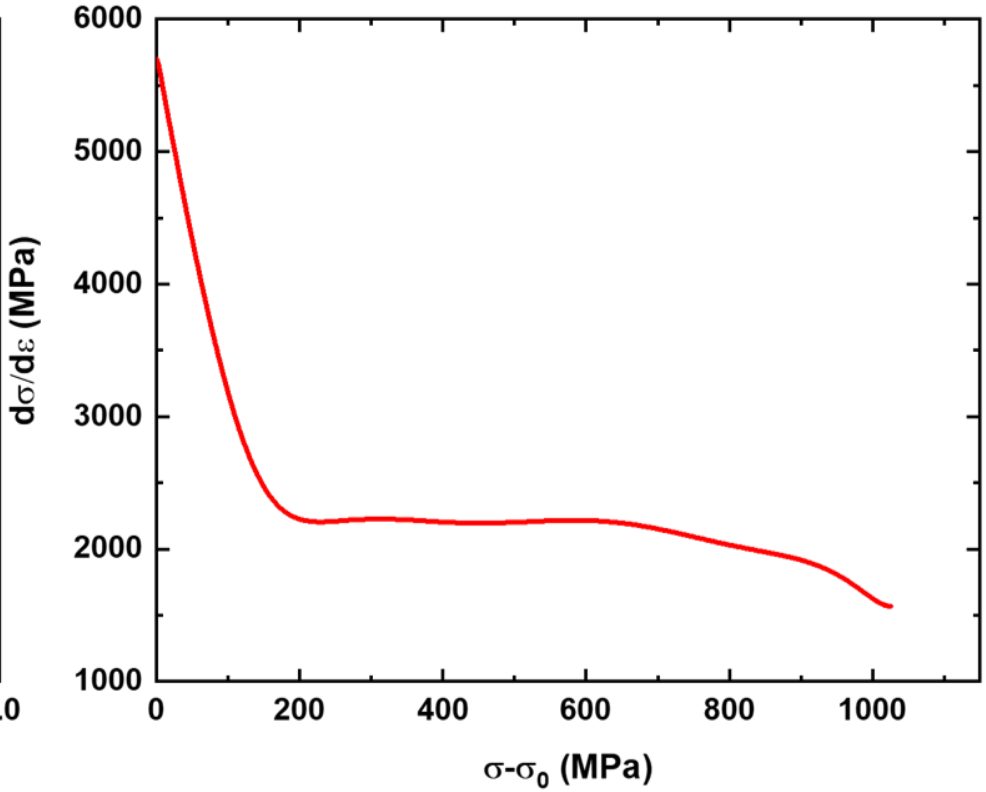
Element	Wt%
Si	0.19
Mn	30.9
Cr	9.18
Co	9.80
Fe	balance

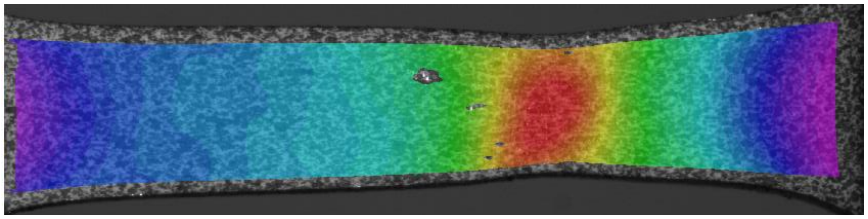
- Single phase microstructure
- No elemental segregation
- Unstained well annealed structure
- Silicon doping increased the gamma phase stability

Mechanical behaviour at static strain rate (10^{-3} s^{-1})

Results & Discussion





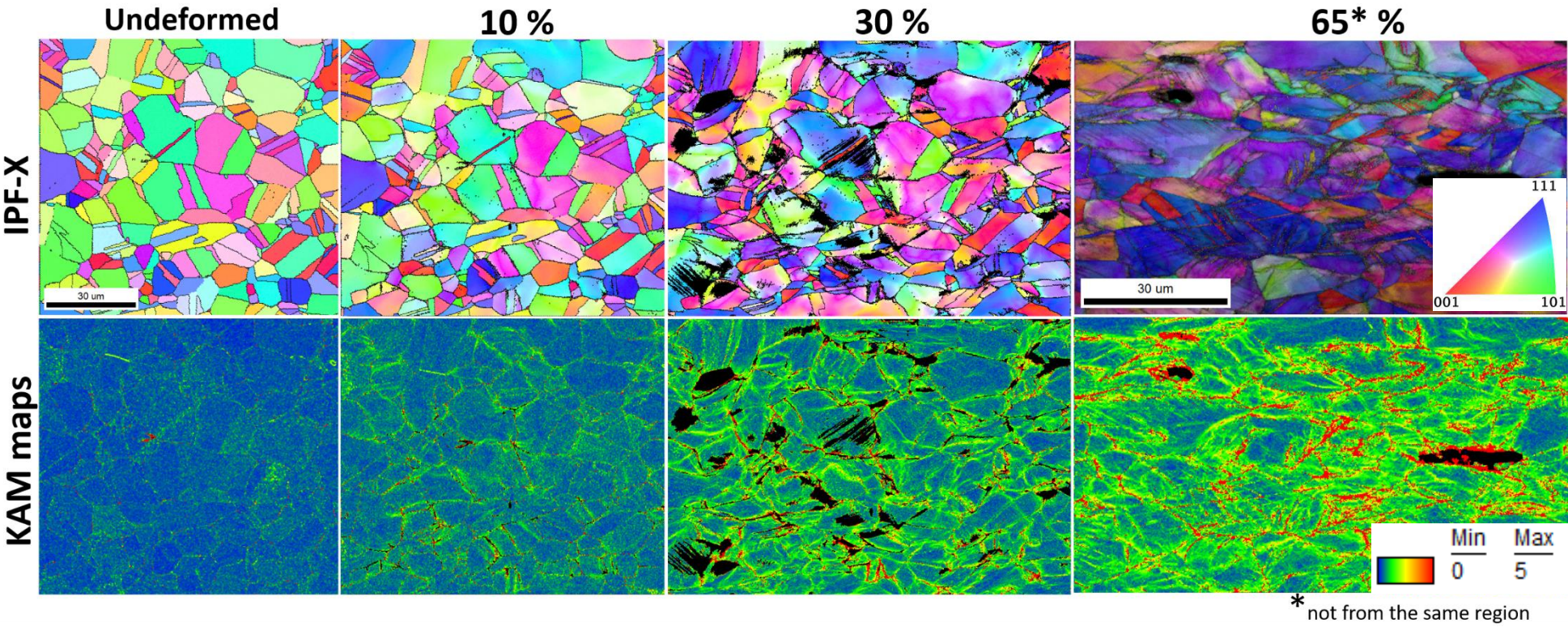


22 % 75 % 112 %

- High ductility and ultimate tensile strength
- Sustained work hardening as indicated from the plateau of Kocks-Mecking plot
- Plateau indicate the operation of secondary deformation mechanism along with slip

In situ EBSD results

Results & Discussion

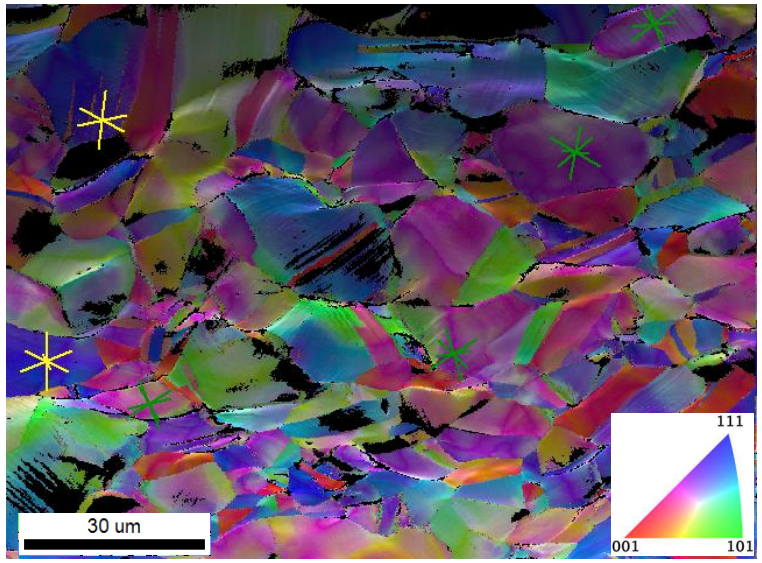


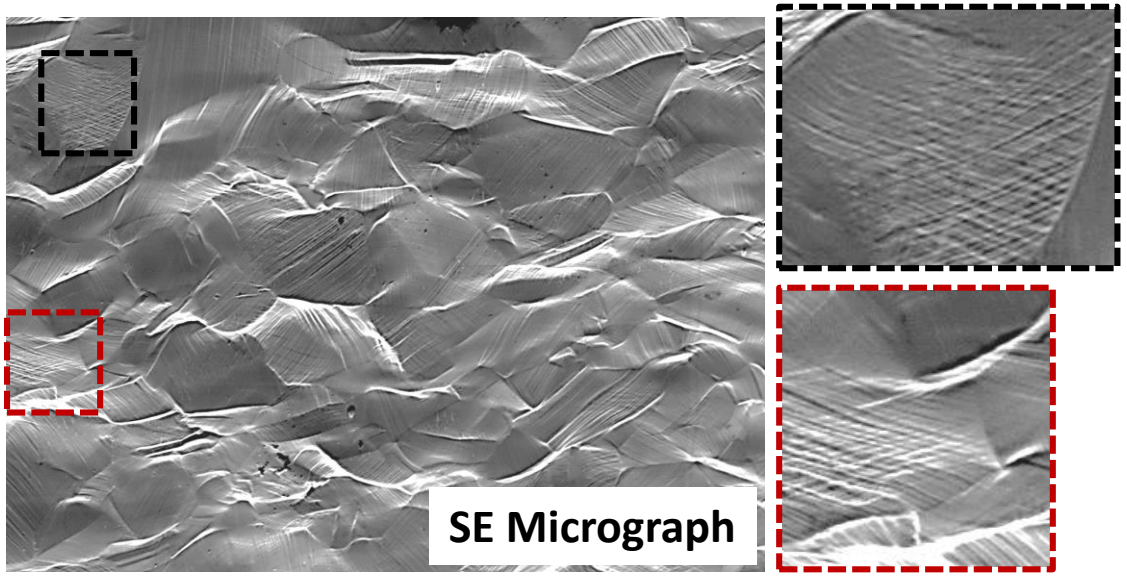
- No deformation induced gamma to epsilon transformation
- High misorientation near the grain boundaries
- Reorientation towards <111> fibre
- High misorientation near grain boundaries indicate planer slip

Post marten microstructure evaluation

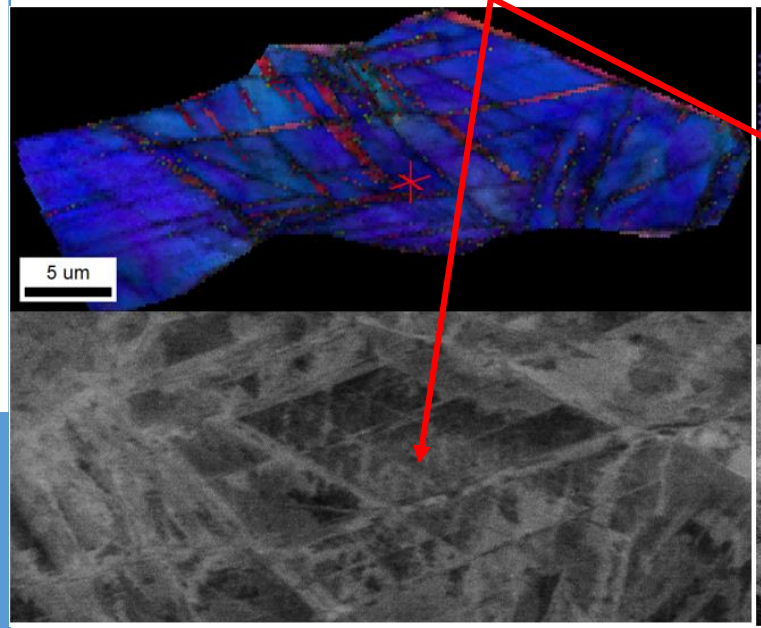
Results & Discussion

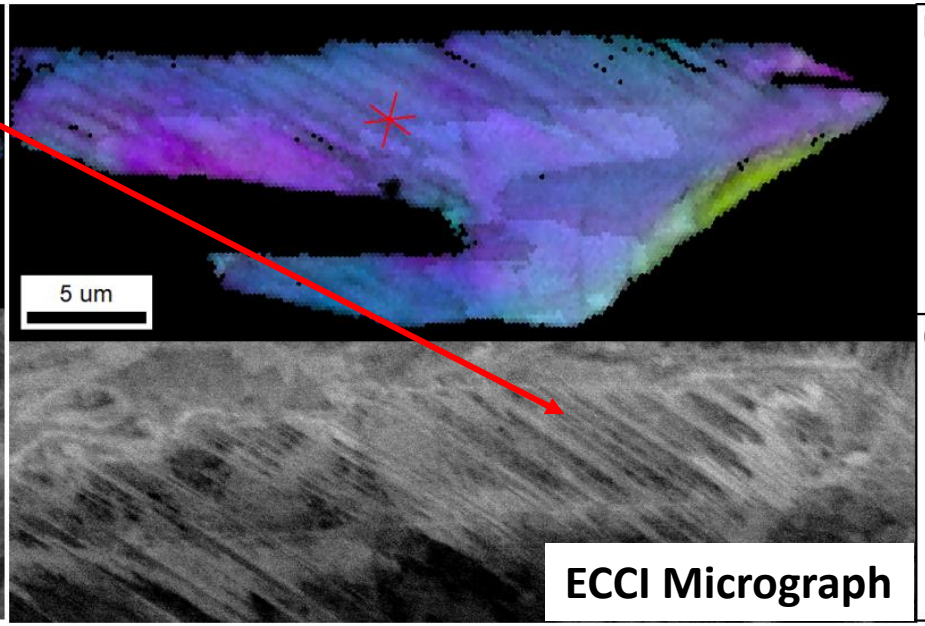
Multiple slip traces

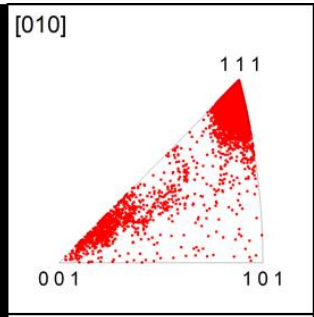


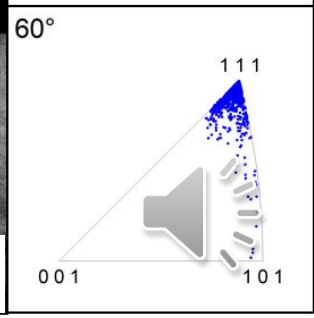


IPF-X after 30% strain with (111) plane traces,
Bundles of nano and intersecting twins as observed from ECCI





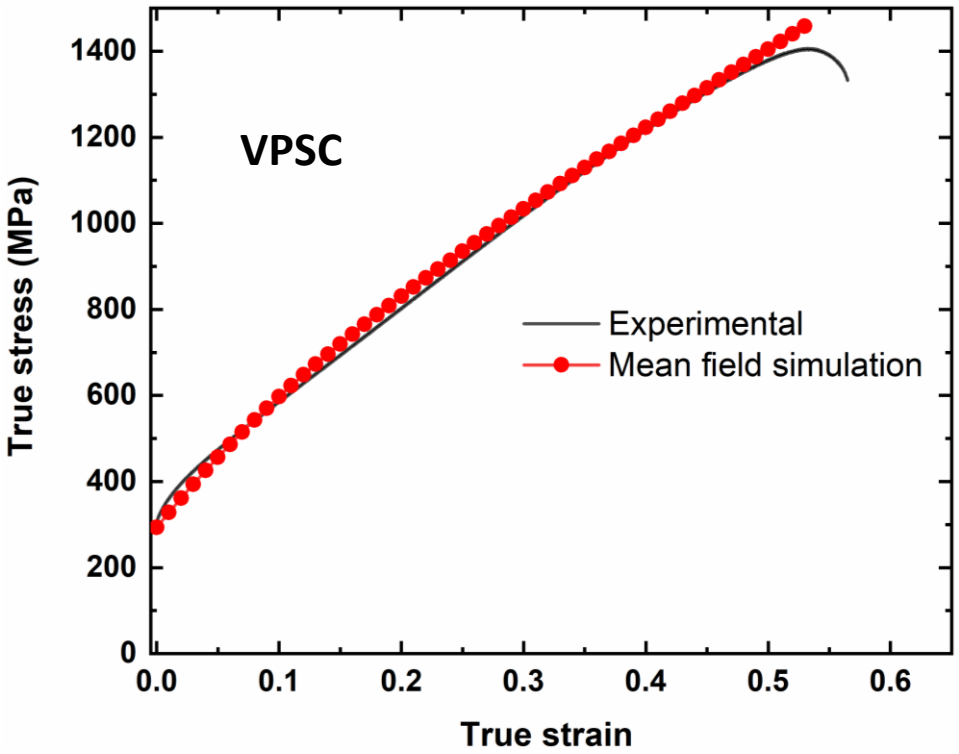


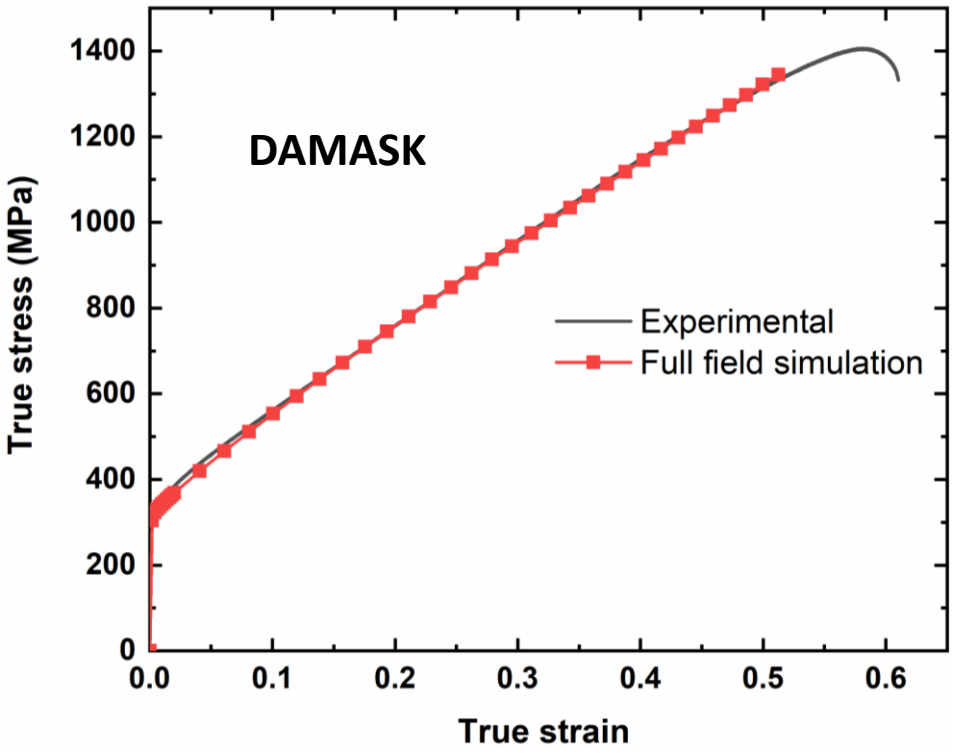


Mean &Full field crystal plasticity simulations

Results & Discussion

- ***Stress strain response prediction***



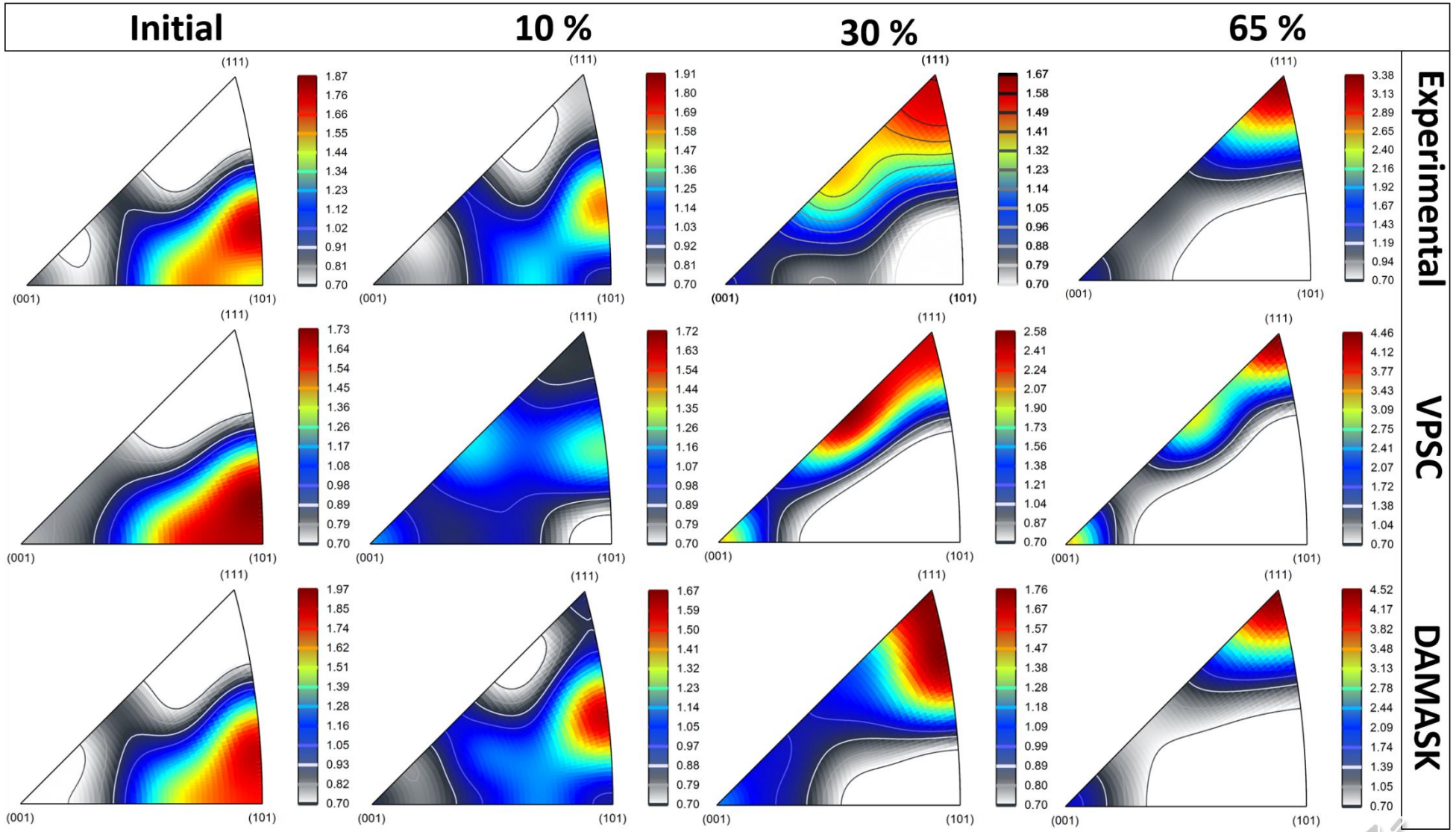


- **Good correlation between experimental and simulated outputs**

Mean &Full field crystal plasticity simulations

Results & Discussion

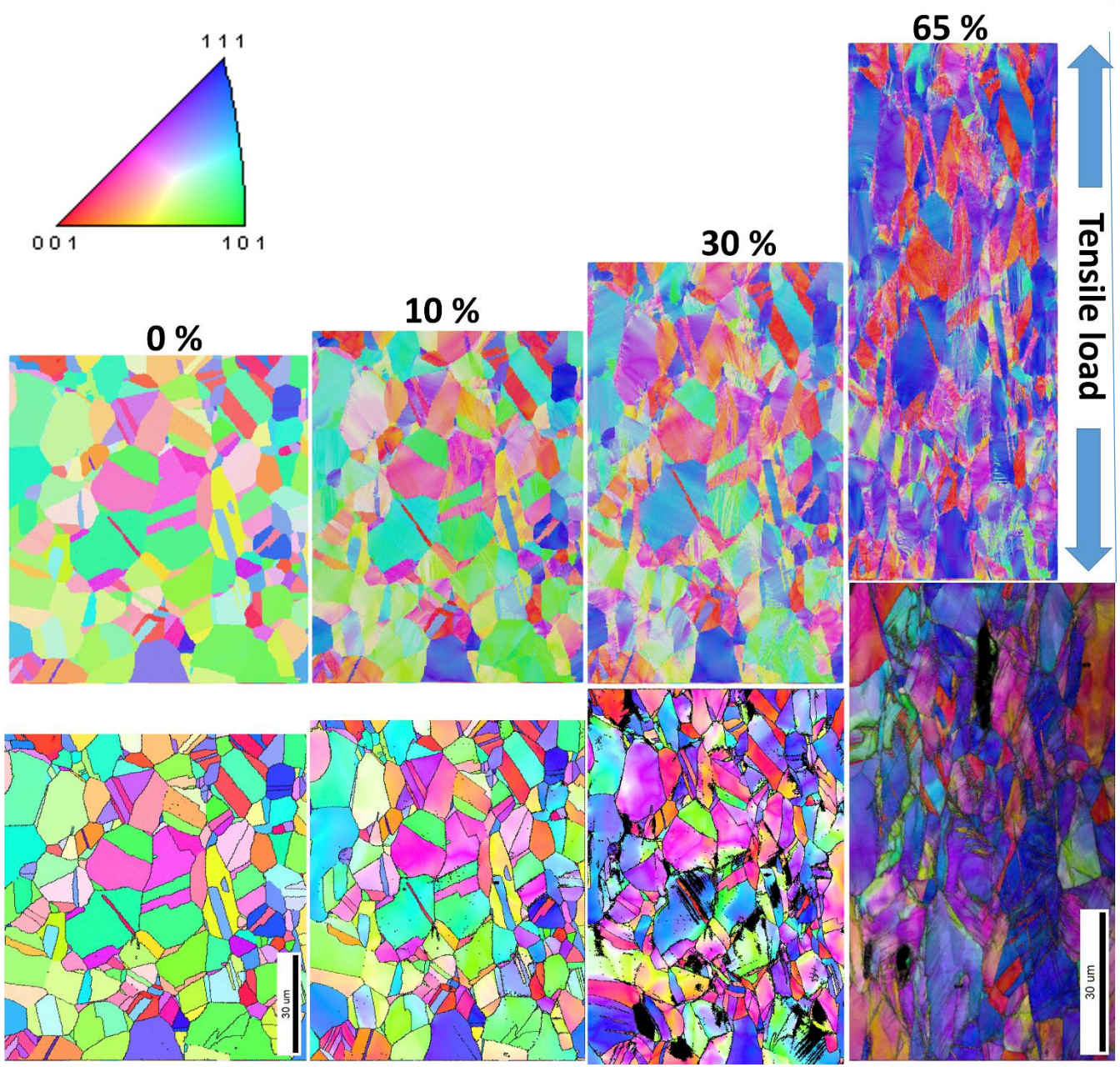
- *Texture evolution prediction*



- **Exellent texture evolution prediction**

Full field crystal plasticity simulations

Results & Discussion



- Excellent grain to grain correlation
- Excellent Intragranular Misorientation prediction
- Further correlations of orientations with stress and strain accommodation, slip and twin system activities are being carried out

Summary

- Silicon doping increased the gamma phase stability
- TRIP effect got suppressed rather TWIP effect was observed with bundles of nano twins imparting superior ductility and strength.
- Grains having <111> parallel to tensile direction deformation by more than one slip system and show twinning. Other orientations primarily deformed by slip as observed from slip traces.
- In situ experiment coupled with full field crystal plasticity simulations offers a high throughput procedure to reduce further experiments and predict microstructure sensitive and micro-mechanism guided deformation and damage behaviour of complex concentrated alloys.

Acknowledgement

- Texture – Microstructure – Stress laboratory, IIT Kanpur
- Department of Materials Science and Engineering, IIT Kanpur