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Lab for Multiscale Interfaces Design in Solids (MINDS)

Nebraska Engineering

Strength and Ductility of Fe-amorphous SiOC composites

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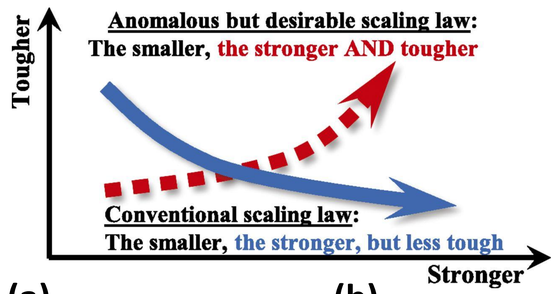
Metals can be fabricated to reach ultra-high strength, but usually at expense of a drastic loss of ductility. In this work, we introduced hard amorphous SiOC phase into soft nanocrystalline Fe. The mechanical evaluation results show the Fe-SiOC composite achieve high strength while retaining reasonable plasticity. The plasticity of the composite comes from a body-centered cubic (bcc) to face-centered cubic (fcc) phase transformation.

Background

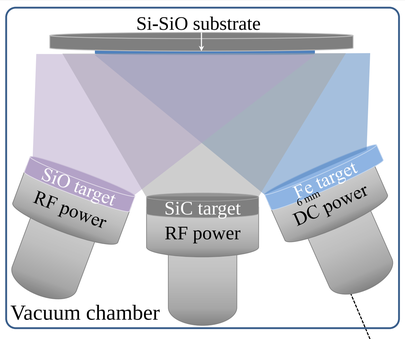


(a)

(b)

(a) Stress-strain curve of nanocrystalline Fe shows strength-ductility tradeoff in this system. (b) Several shear bands are observed after mechanical loading.[1]

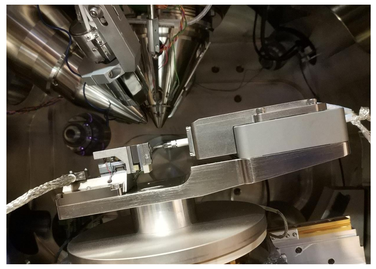
Synthesis of Fe-SiOC composite



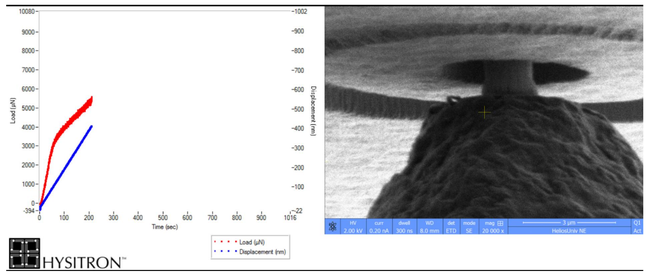
To synthesize Fe-SiOC, Fe, SiO_2 and SiC were co-sputtered.

Mechanical Evaluation

(a)



(b)

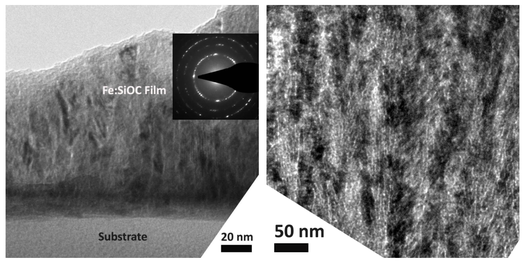


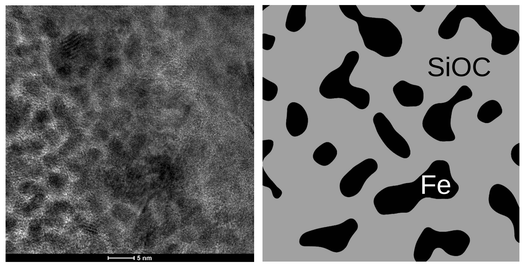
(a) In-situ nanomechanical testing system. (b) A snapshot of nanomechanical testing interface.

Advantages:

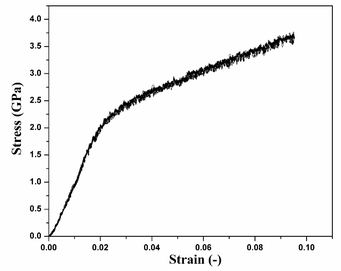
- **Quantitative nanomechanical testing while simultaneously imaging deformation process throughout the test.**
- **Establish accurate correlation deformation mechanism with applied stress.**

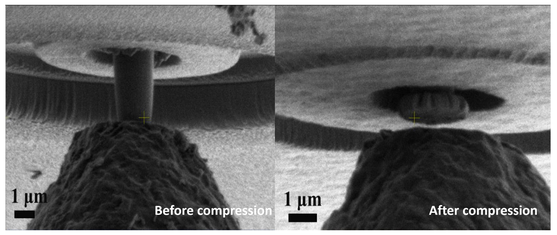
Microstructure



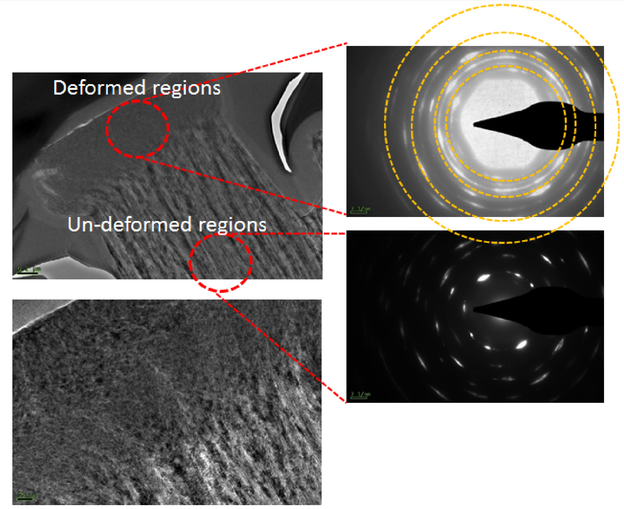


Stress-strain curve

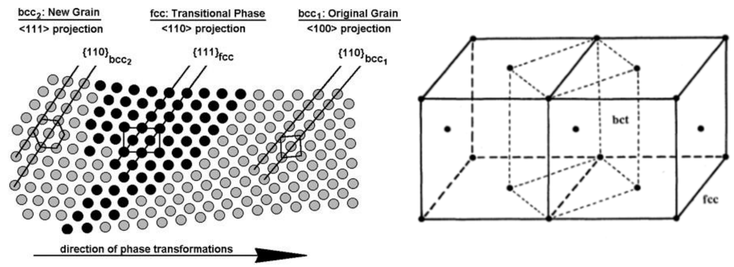




Microstructure



Thermodynamics and kinetics



Gibbs free energy differences of the interfaces between γ- and α-Fe grains with amorphous SiOC could provide the driving force.[2]

Conclusion:

- Strength and ductility synergy is achieved in Fe-amorphous SiOC composites.
- The stress-induced phase transformation represents a new deformation mode of nanocrystalline Fe giving rise to plasticity.
- The mechanism for bcc-fcc phase transformation warrants further examination.

[1] Jia, D., K. T. Ramesh, and E. Ma. "Effects of nanocrystalline and ultrafine grain sizes on constitutive behavior and shear bands in iron." Acta materialia 51.12 (2003): 3495-3509.

[2] Ivanisenko, Yu, et al. "Shear-induced α→ γ transformation in nanoscale Fe–C composite." Acta Materialia 54.6 (2006): 1659-1669.