DESIGN OF THE SUSTAINABLE METALLIC MATERIALS:

NEW OPPORTUNITIES IN RESEARCH AND MATERIAL SCIENCE EDUCATION

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1966 – 2016

ODTÜ METU

Metalurji ve Malzeme Mühendisliği Bölümü | Metallurgical and Materials Engineering Department

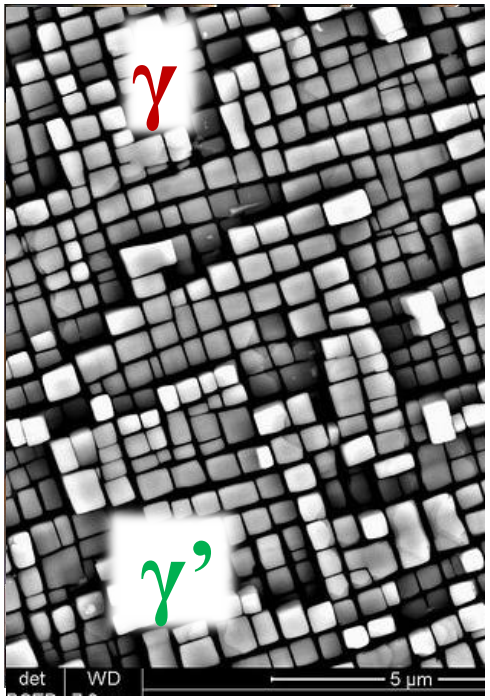
ODTÜ Metalurji ve Malzeme Mühendisliği Bölümü
50. Yıl Sempozyumu – 29.06.2016

Background

- Materials innovations are key in all technological advances...

Background-ii

- Multi-phase systems enable innovative property combinations…



FEI Company, R. Swadźba

Background-ii

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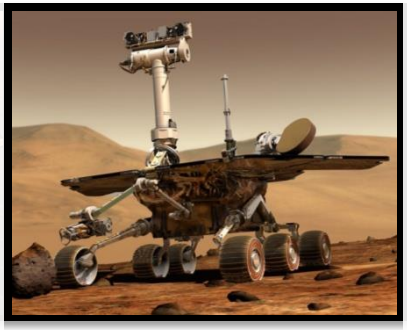

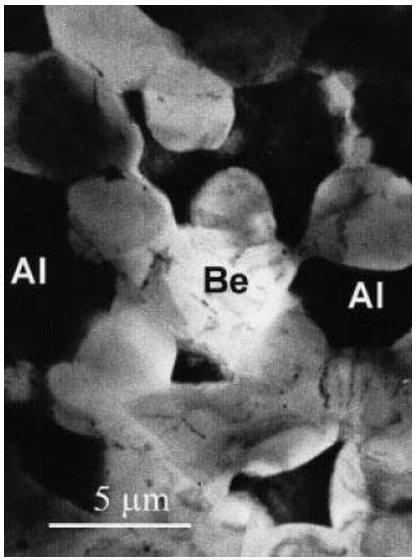

Song et al., MST, 2000

Background-ii

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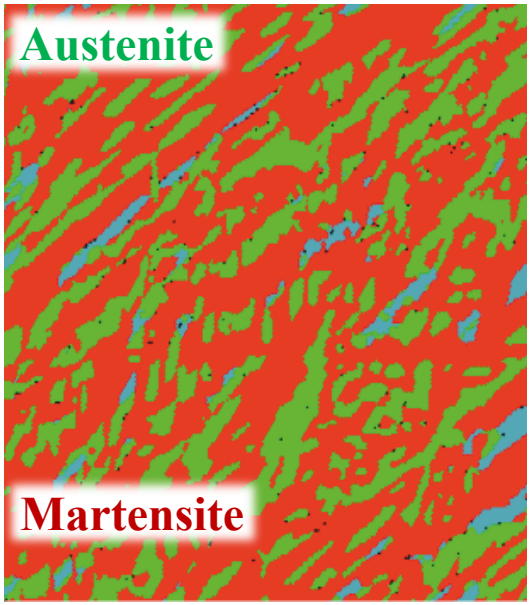

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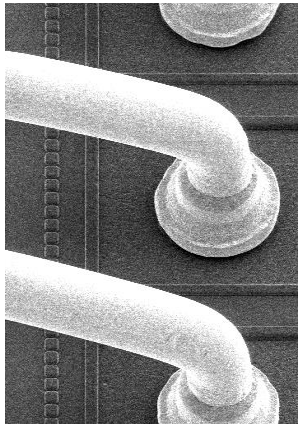
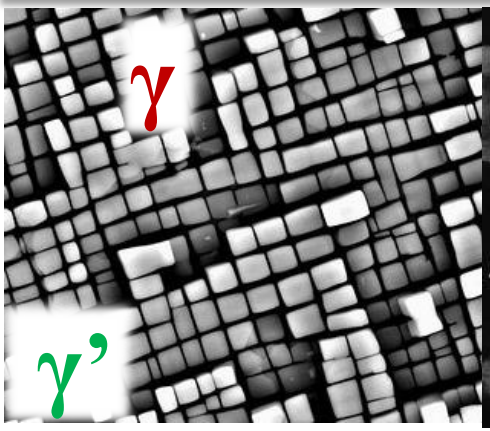
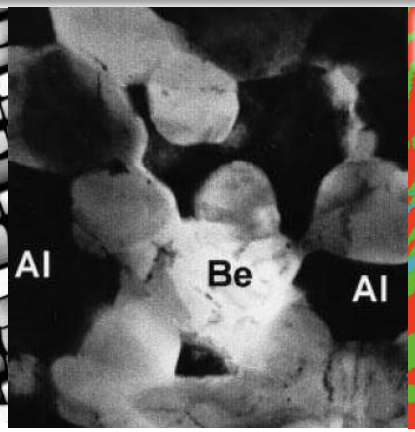
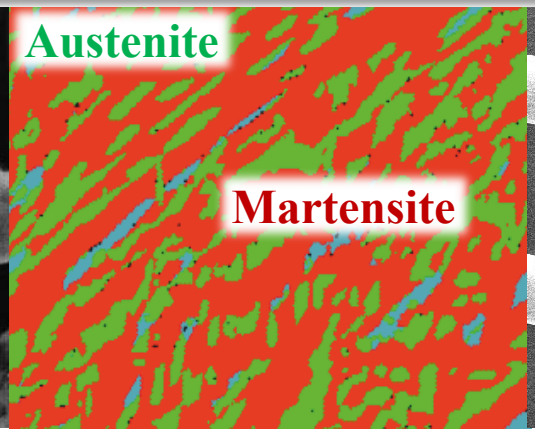


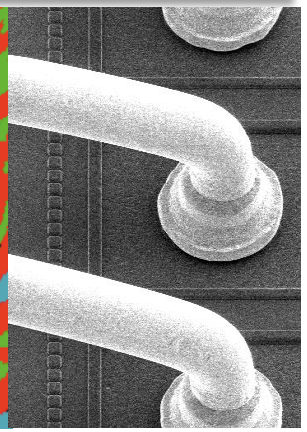
Background-iii

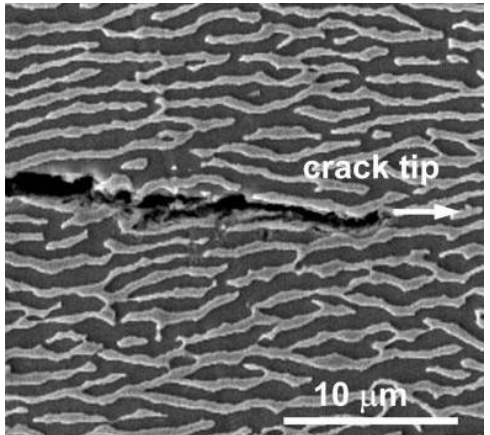
- Yet, multi-phase systems have several active damage mechanisms…

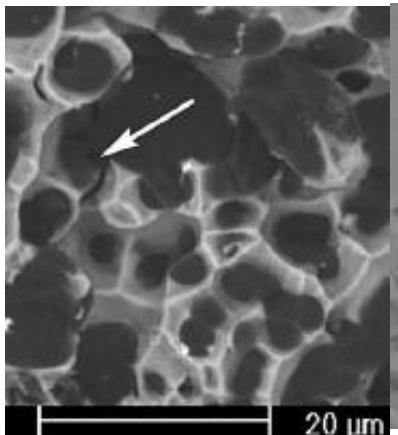


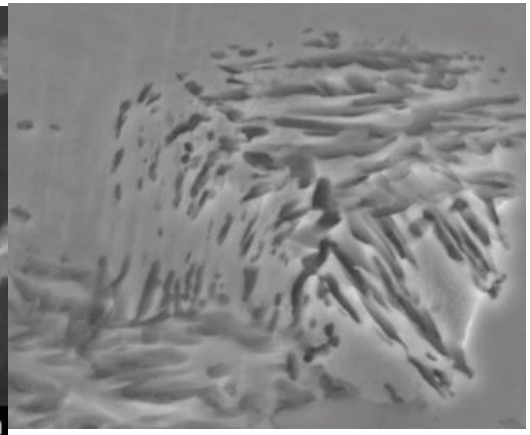


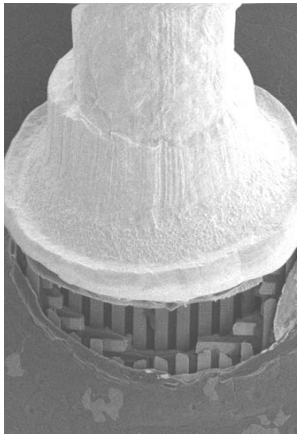




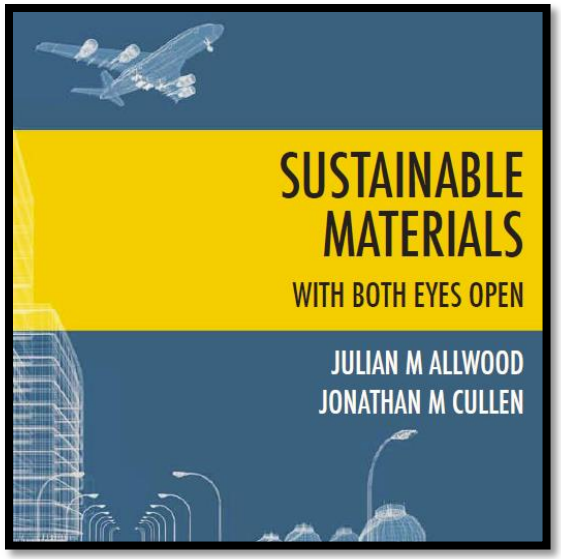


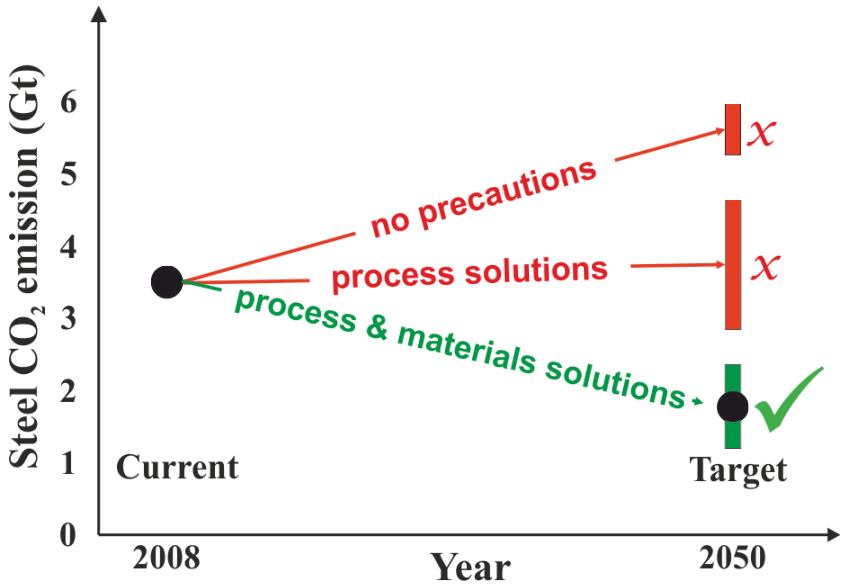




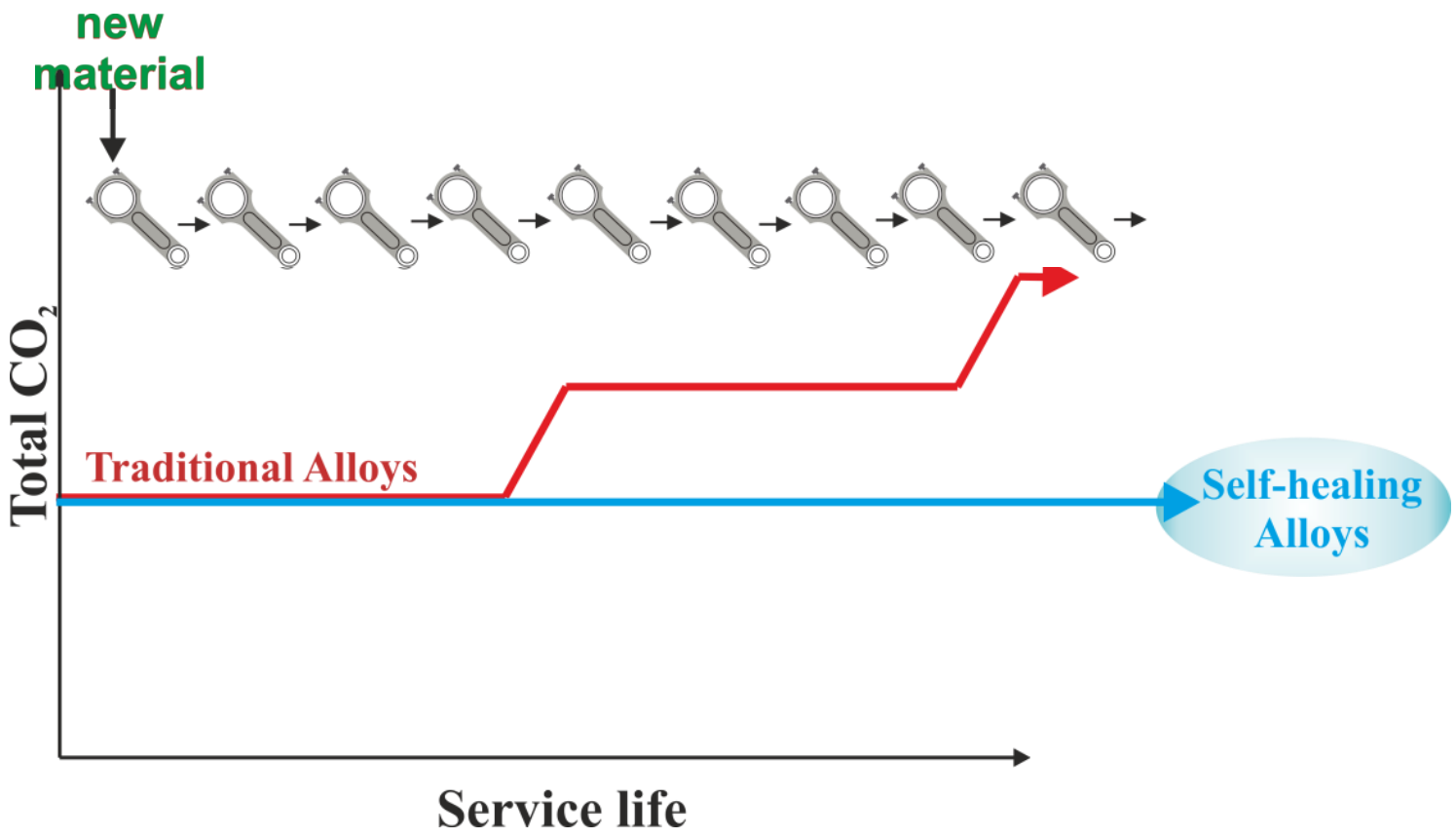


Challenge

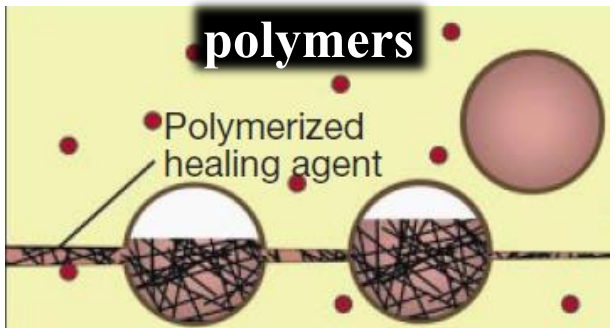

SUSTAINABLE
MATERIALS
WITH BOTH EYES OPEN
JULIAN M ALLWOOD
JONATHAN M CULLEN

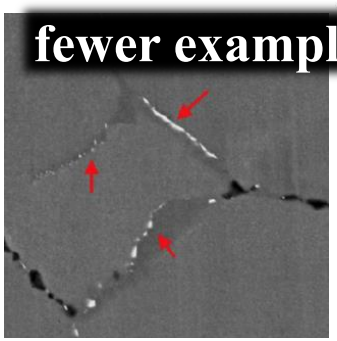

Steel CO_2 emission (Gt)
6
5
4
3
2
1
0
no precautions
process solutions
process & materials solutions
x
x
Current
Target
2008
Year
2050

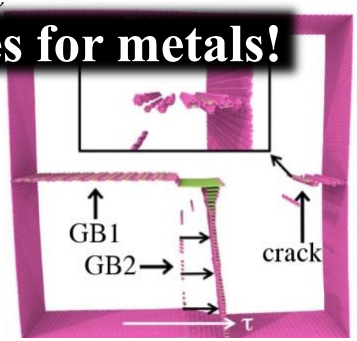
Solution

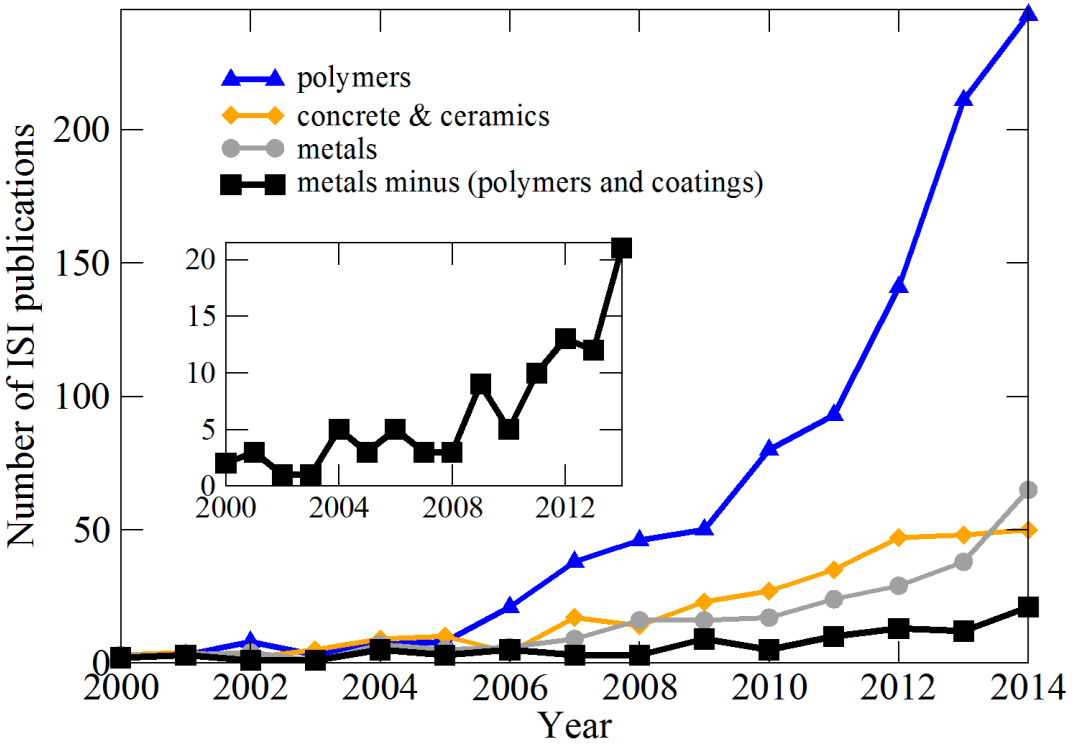

new material
Total CO_2
Traditional Alloys
Self-healing Alloys
Service life

Self-healing Polymers, Ceramics, Metals

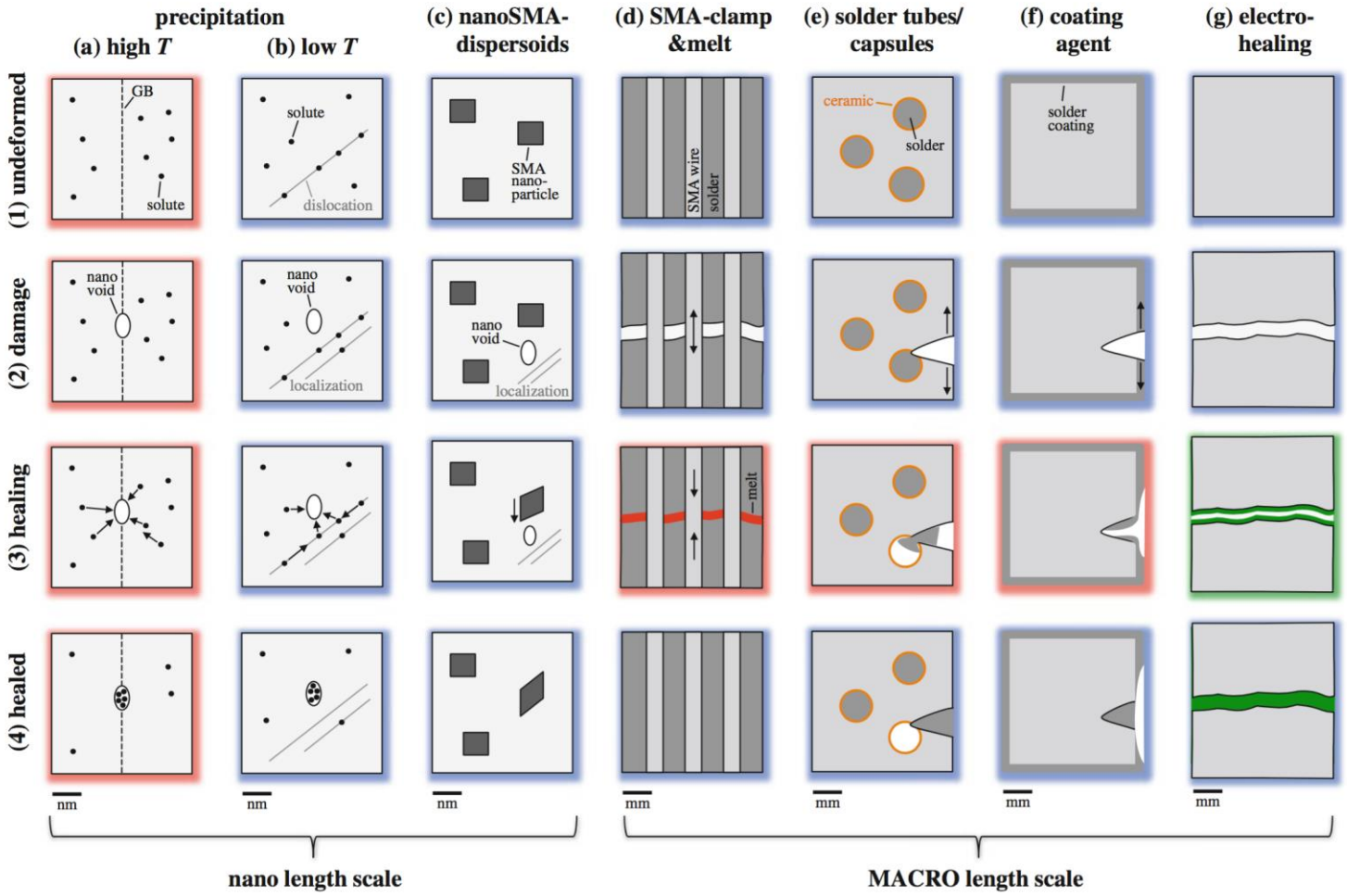








Self-healing metals: typically exotic systems!



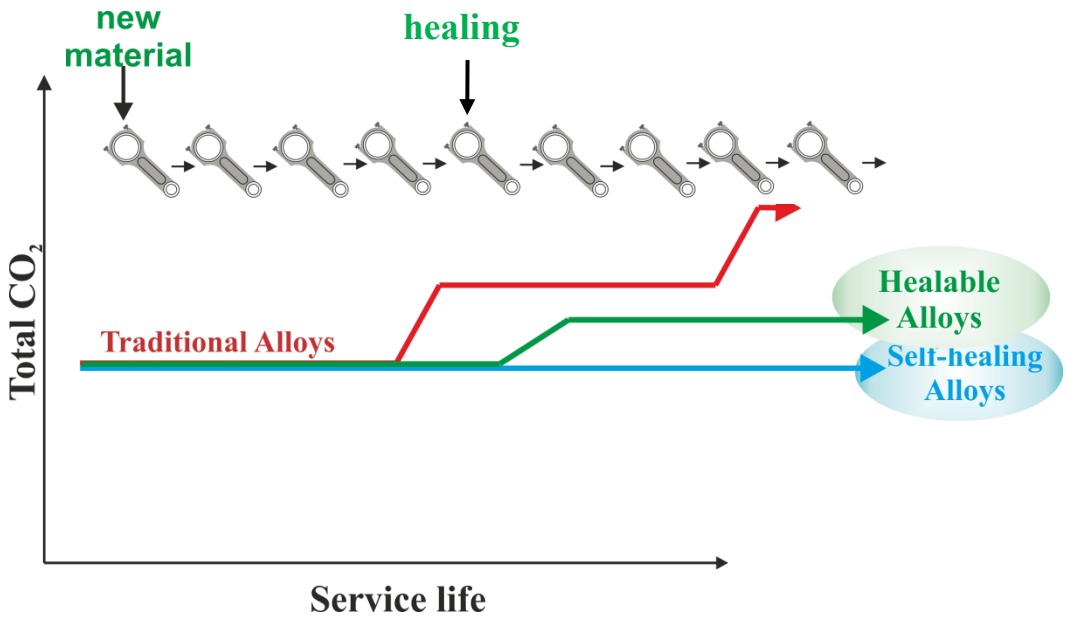
Grabowski and Tasan, Adv. Polym, Sci. (2016)

self-healing: "*autonomic closure of micro-cracks*"

- critisms
  - proposed mechanisms not generic (hence no real ecological solution)
  - not all closed cracks are healed (probably closed crack remains weakest spot)
  - not all cracks are critical (most parts have up to 1vol.% damage upon forming)
  - performance benefits questionable (why not just pick a better alloy?)
- what would be ideal?
  - generic approach
  - 'healing' all critical damage incidents
  - with clear performance benefits

Solution-ii

- self-healing: "*autonomic closure of micro-cracks*"
- healing: "*non-autonomic retrieval of crack-arresting ability*"

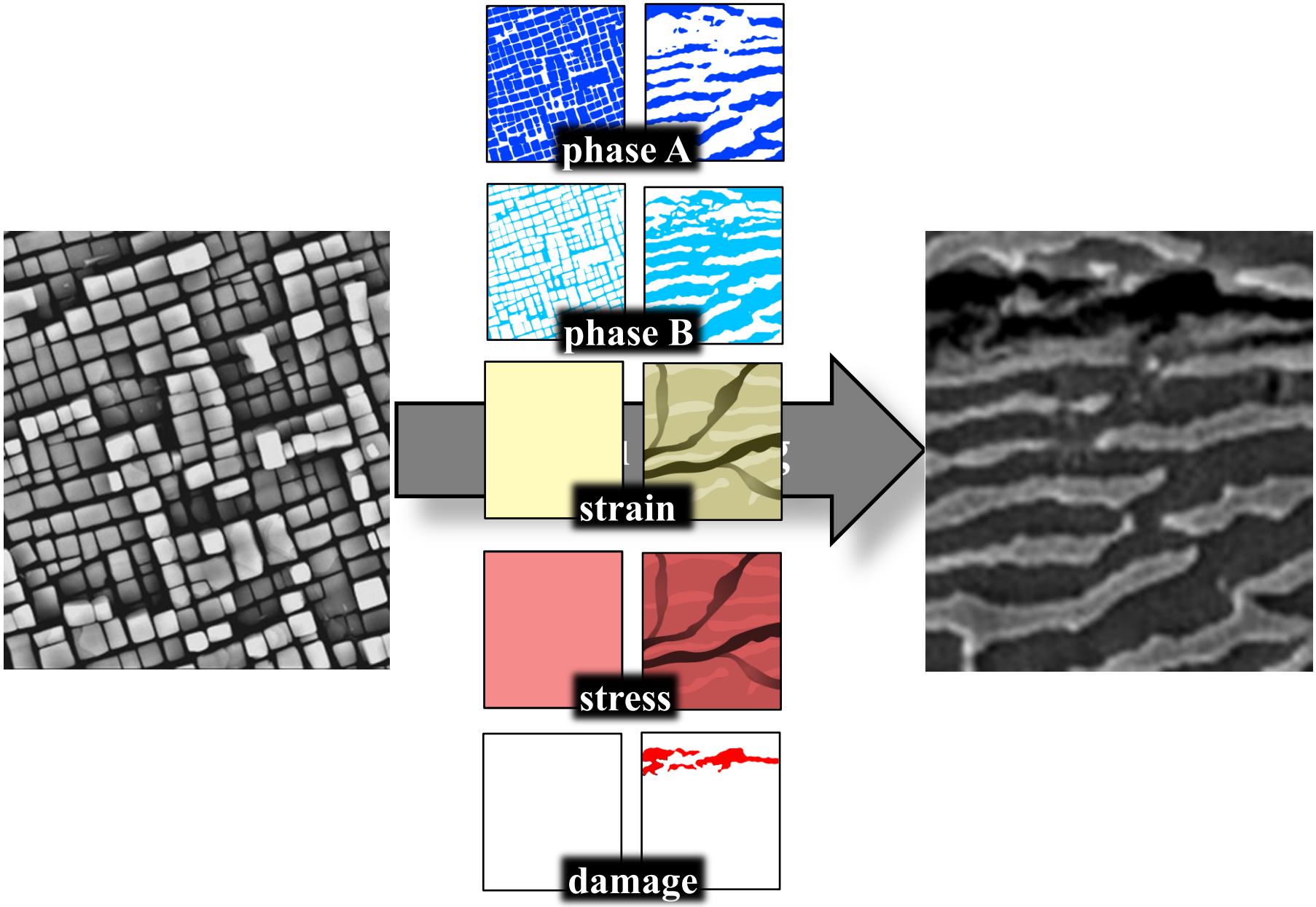


What is needed?

(a) Guidelines for damage-resistance

(b) Guidelines for healability

Toolbox: Multi-field mapping



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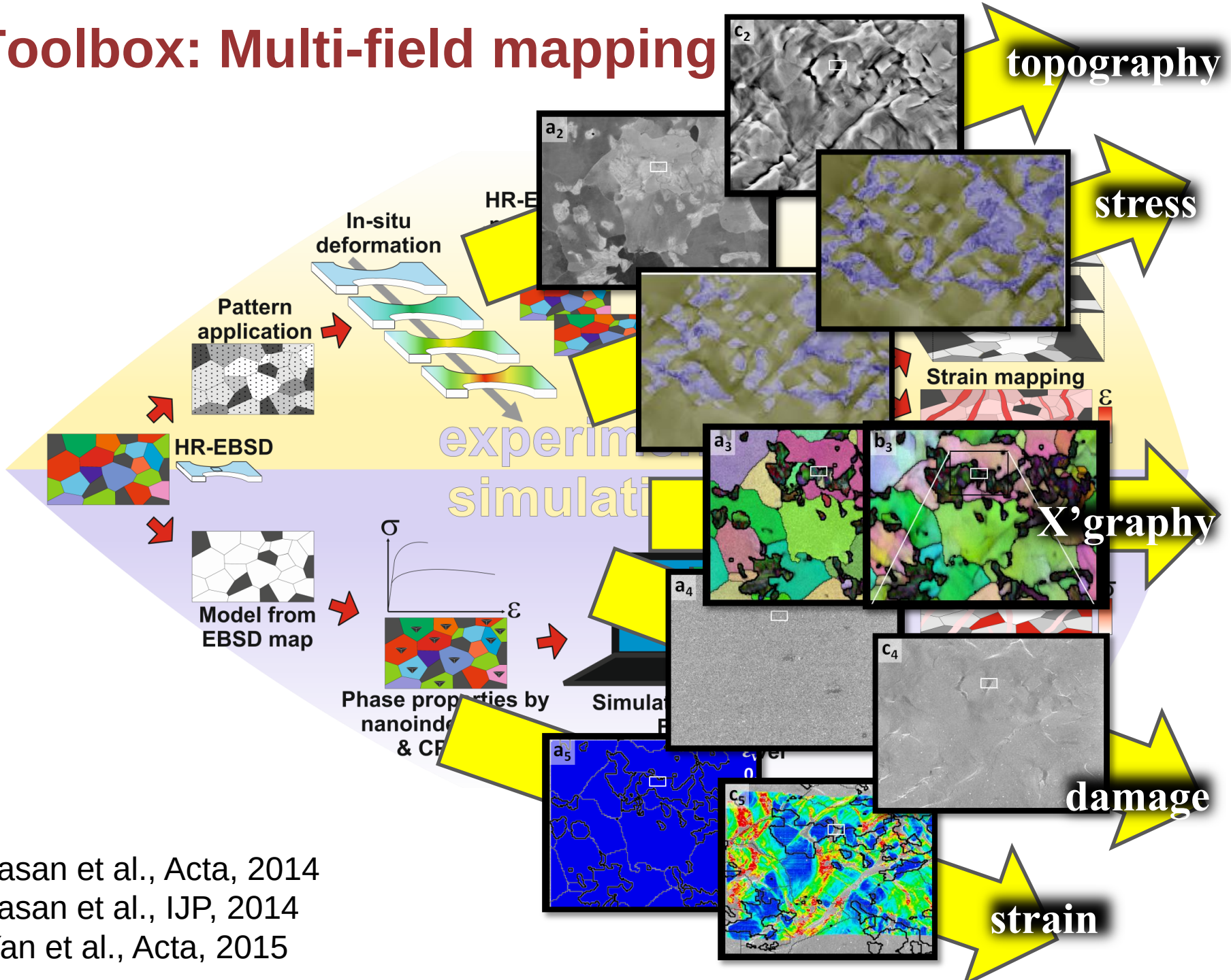
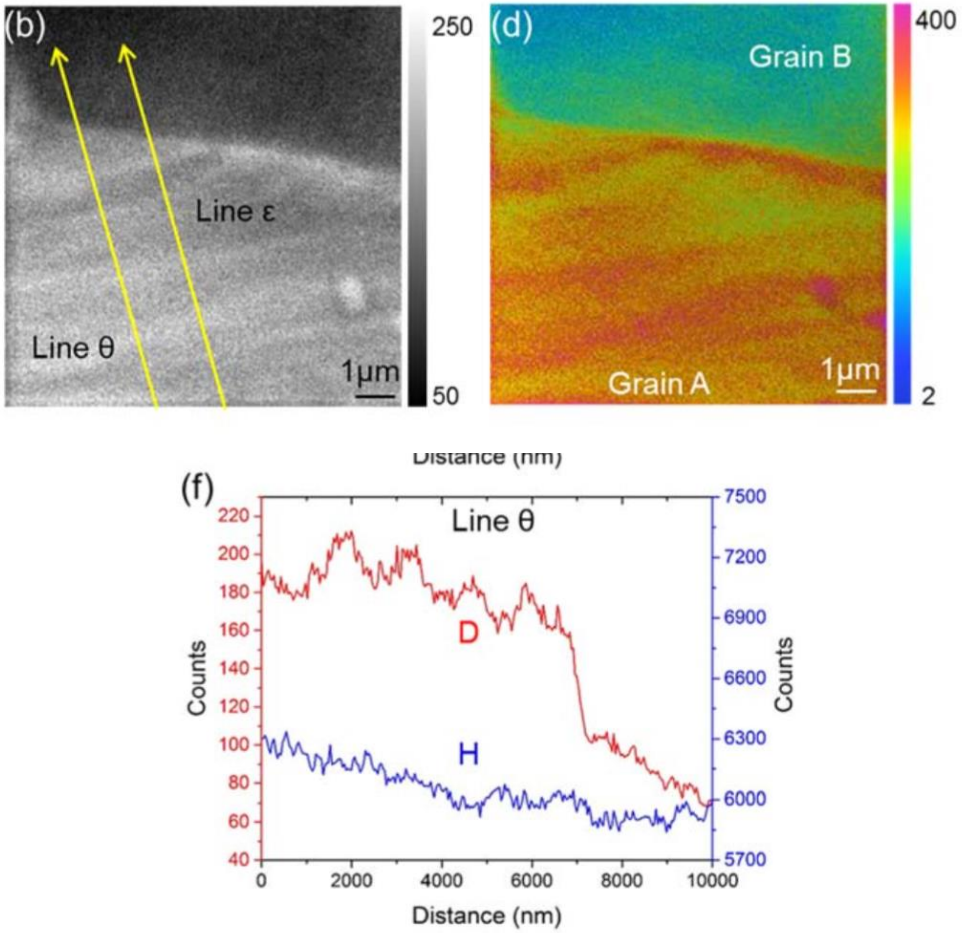


Tasan et al., Acta, 2014
Tasan et al., IJP, 2014
Yan et al., Acta, 2015

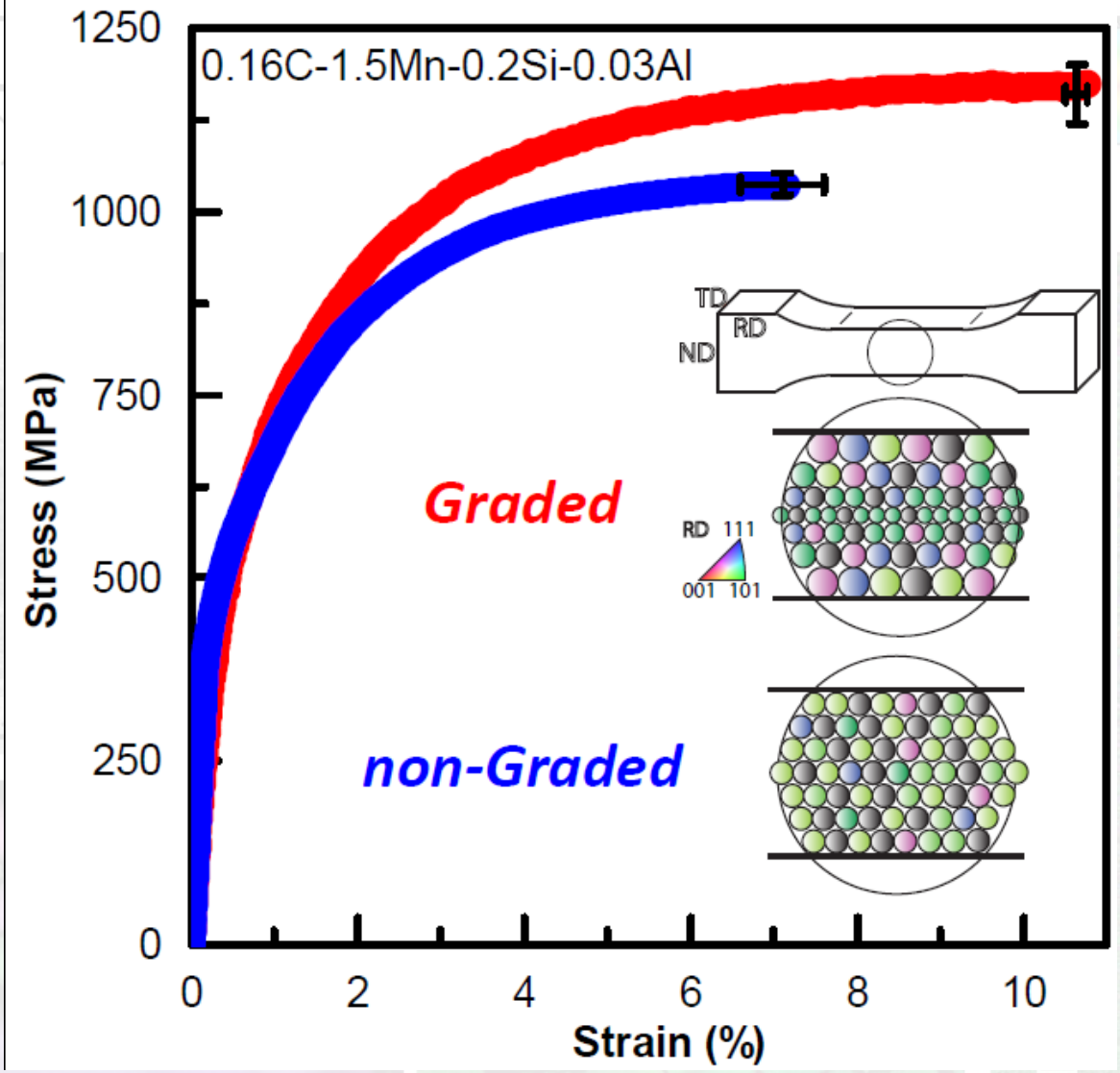
Hydrogen trapping & embrittlement



Hu et al., in review

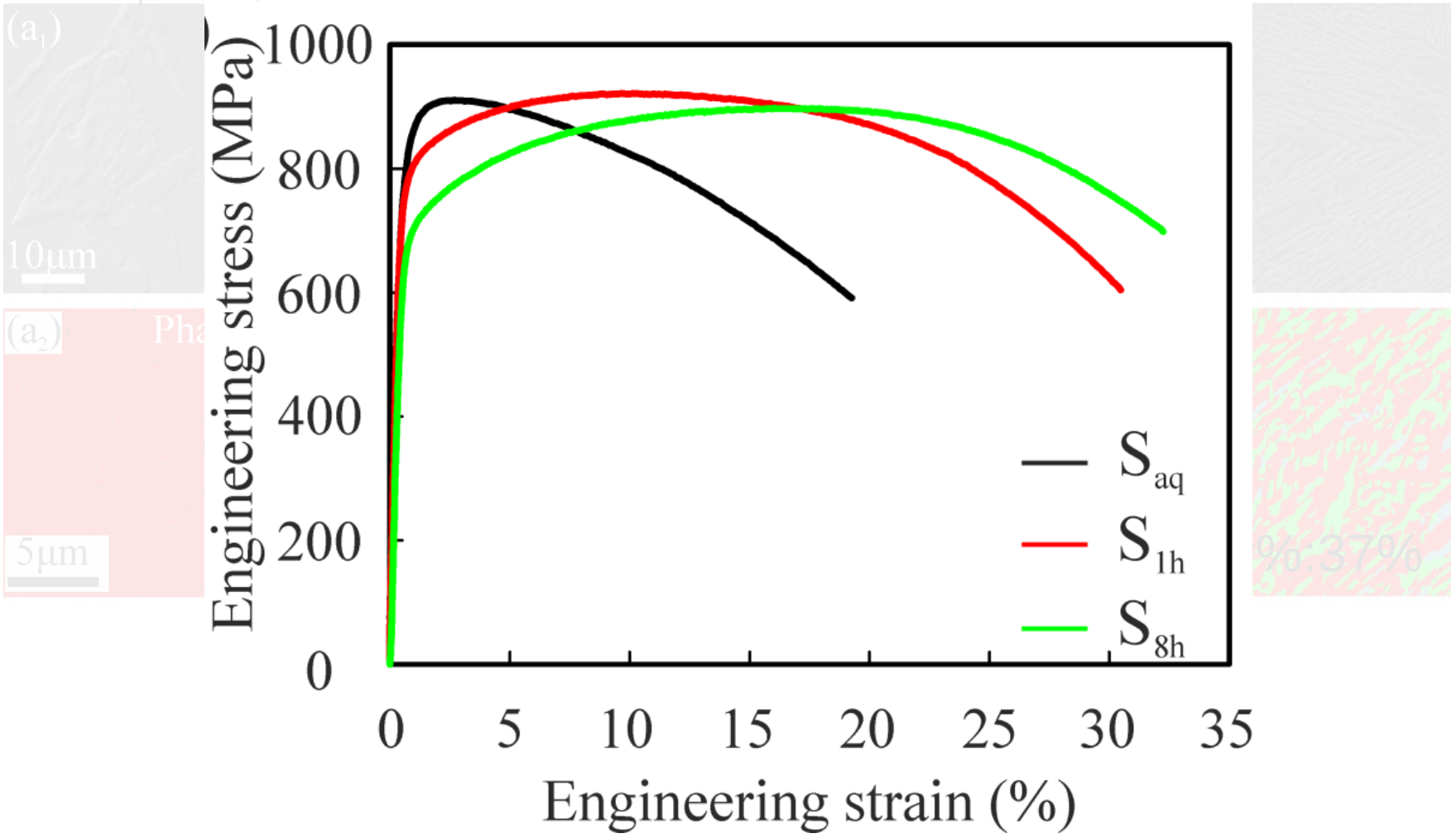
Koyama et al., Acta, 2014

Graded dual phase steel design



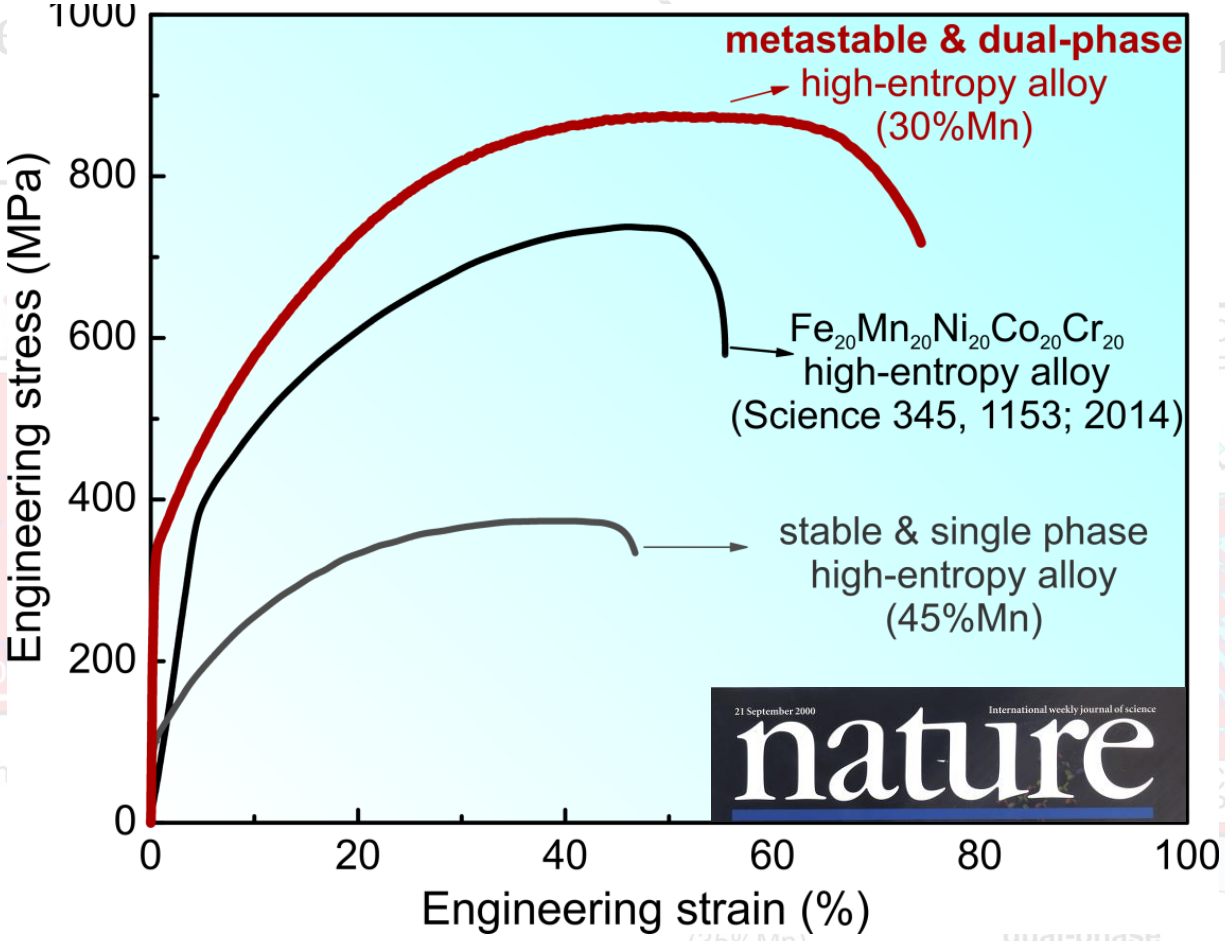
Yan et al., in review.

Design of ductile martensitic steels



Wang et al., Acta Mat (2014)
Wang et al., Acta Mat (2015)

Novel, metastable, High entropy alloys



Li, Pradeep, Deng, Raabe, Tasan, Nature (2016)

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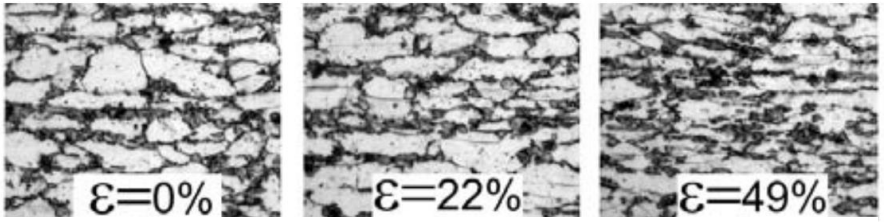
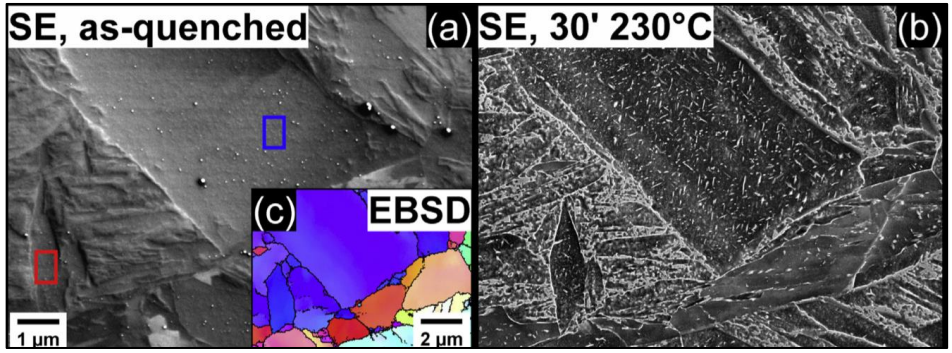
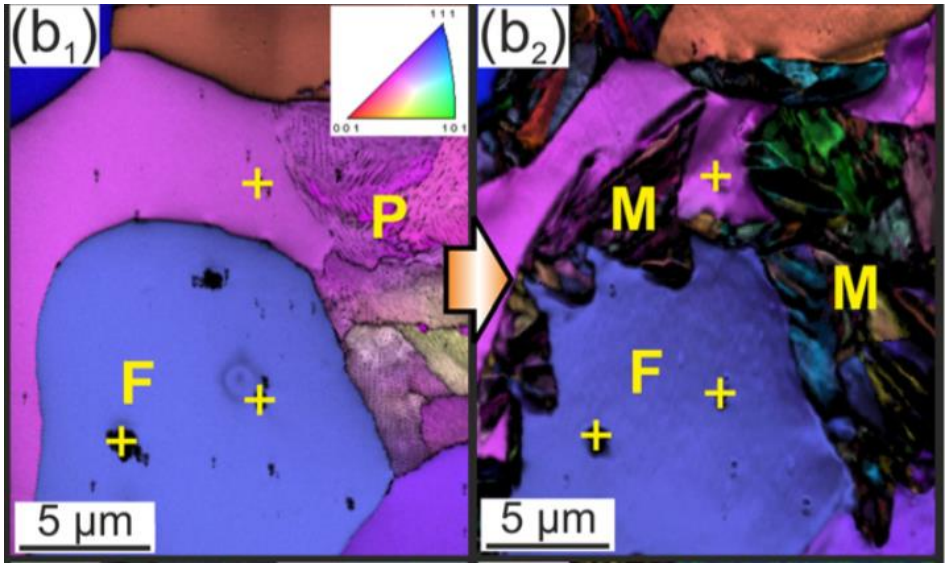
Strategy for Healability

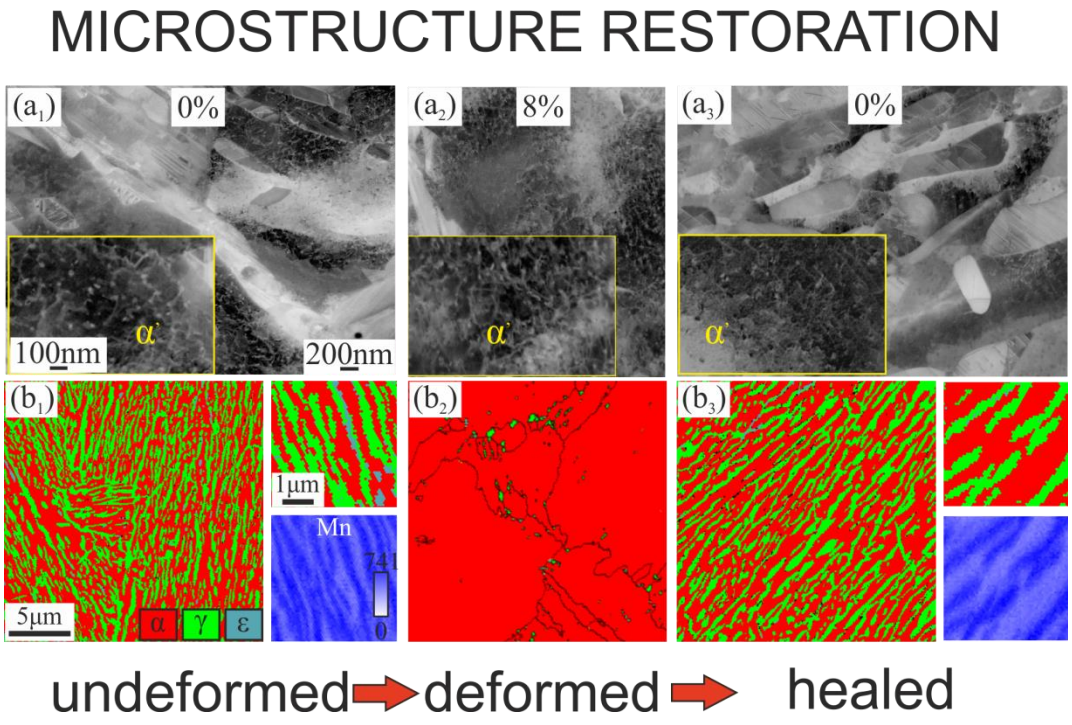




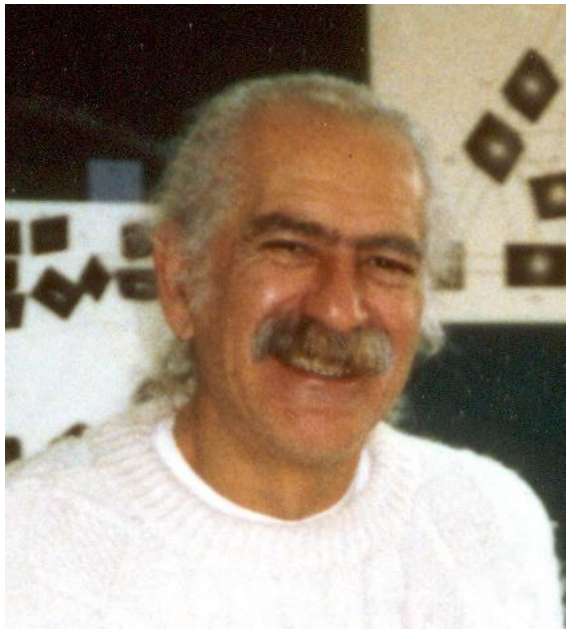


Tasan et al. Scripta Materialia (2010)
Zhang et al., Mater Char, 2016
Morsdorf et al., Acta, 2015

Strategy for Healability-ii



Conclusions

- Innovations in structural materials are still desperately needed.
- Yet, environmental concerns are serious, and they require action.
- We develop and employ multi-field mapping tools…
- … in order to design damage-resistant & healable alloys
- Several new opportunities & challenges: exciting times ahead!

Sevgi ve saygiyla…