Nanostructuring of 100 thousand tons

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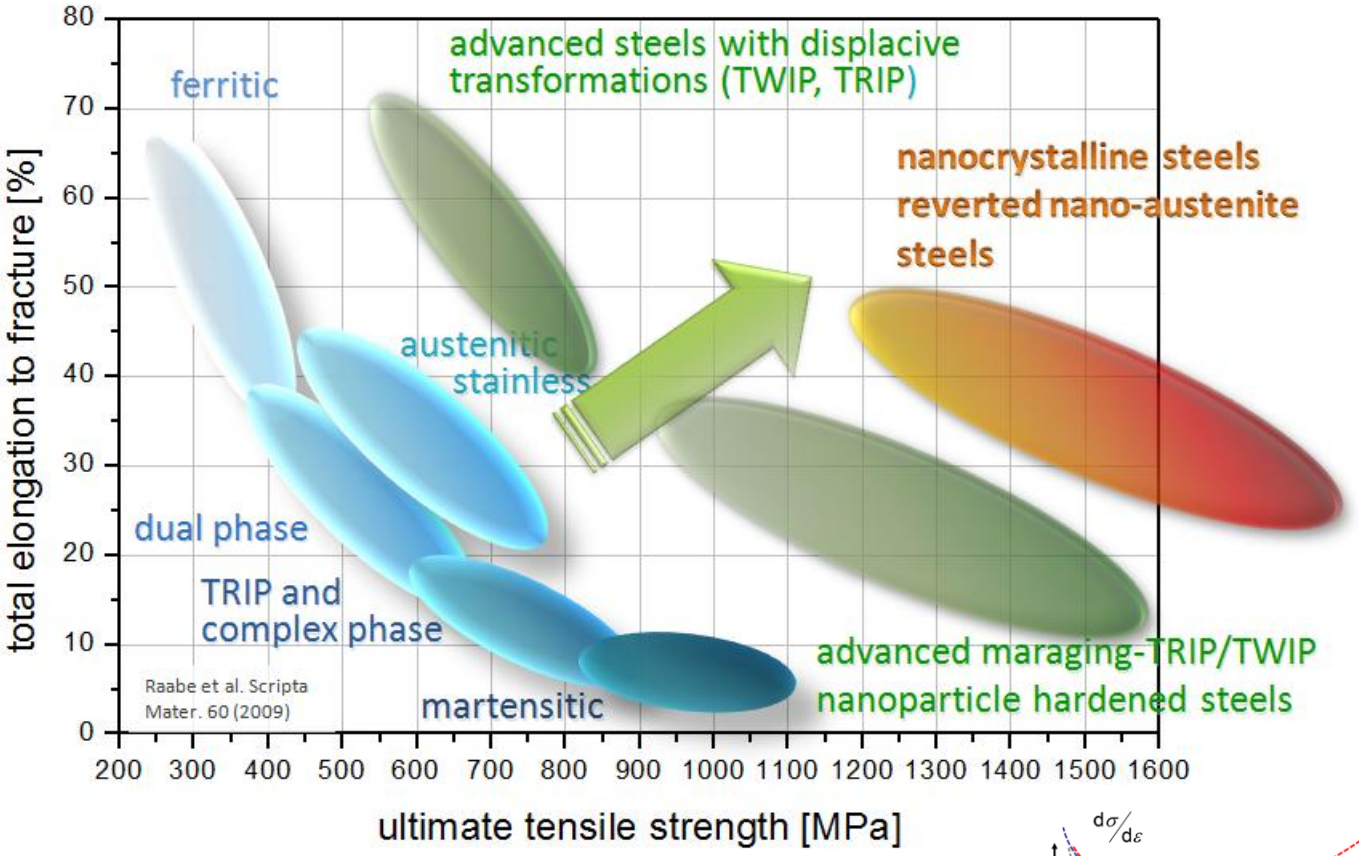
SHORTENED VERSION

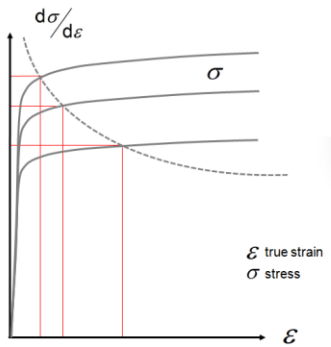
From atomistic understanding towards designing new materials



current status

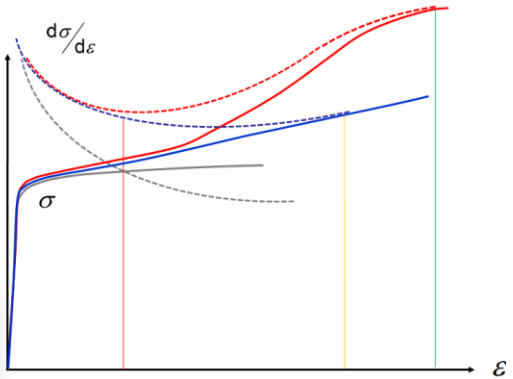
recent results

speculation



Inverse strength-ductility relation

Design strain hardening only where needed



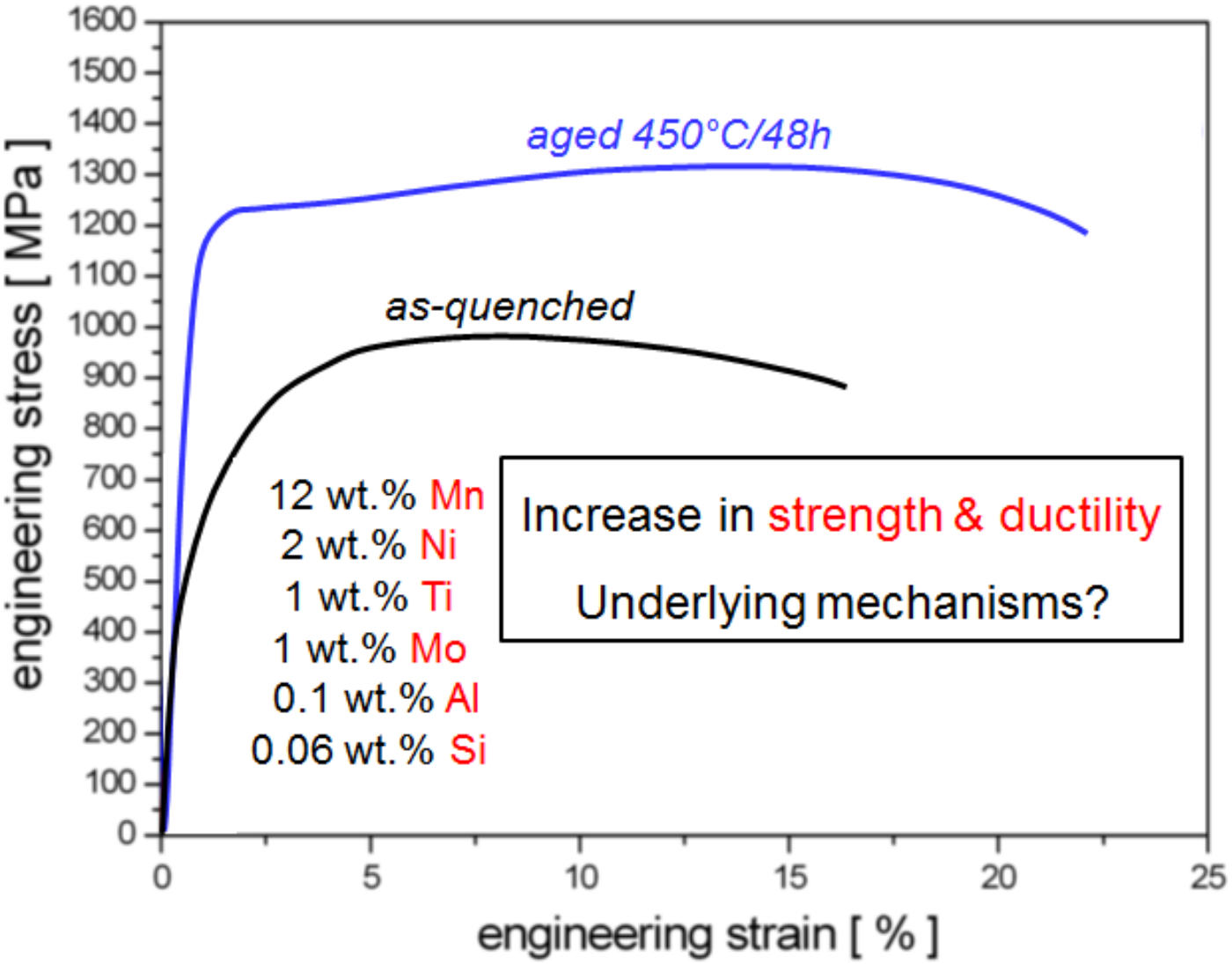
Self-organized nanostructuring via lattice defect decoration and selective phase transformation: nano-particles and nano-TRIP

Motivation for nanostructuring alloys via self-organization:

Properties of alloys change profoundly at nanoscale (mech. properties)

Self organization essential for nanostructuring large quantities under real-world process conditions:
e.g.
Fe: 1.4 Billion t/a
Al: 24 Million t/a
Ti: 150 Thousand t/a

Hierarchy of maraging TRIP / TWIP steels



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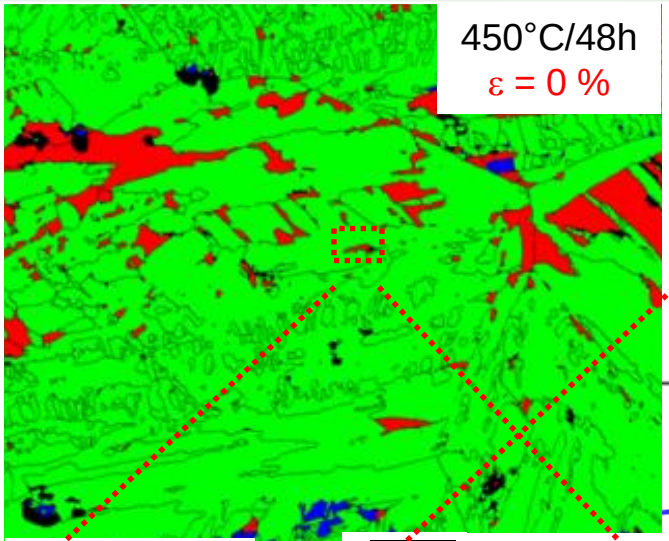

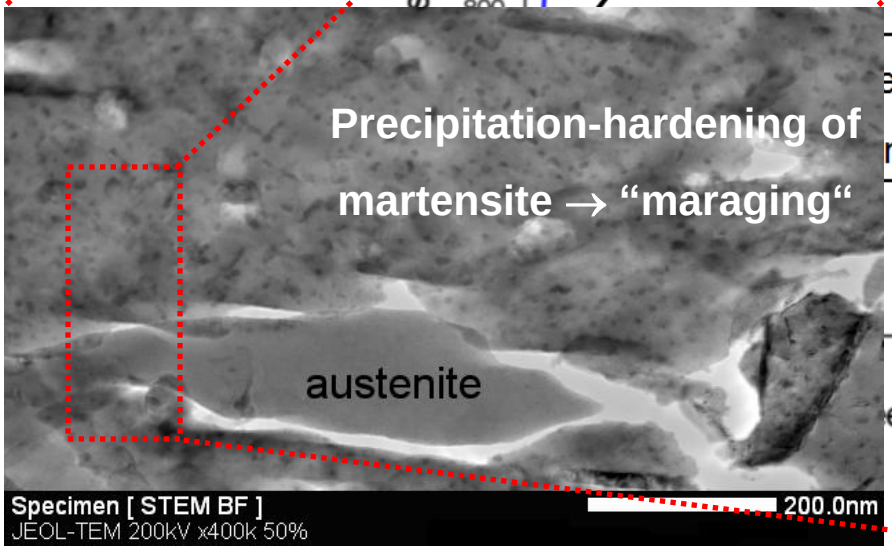

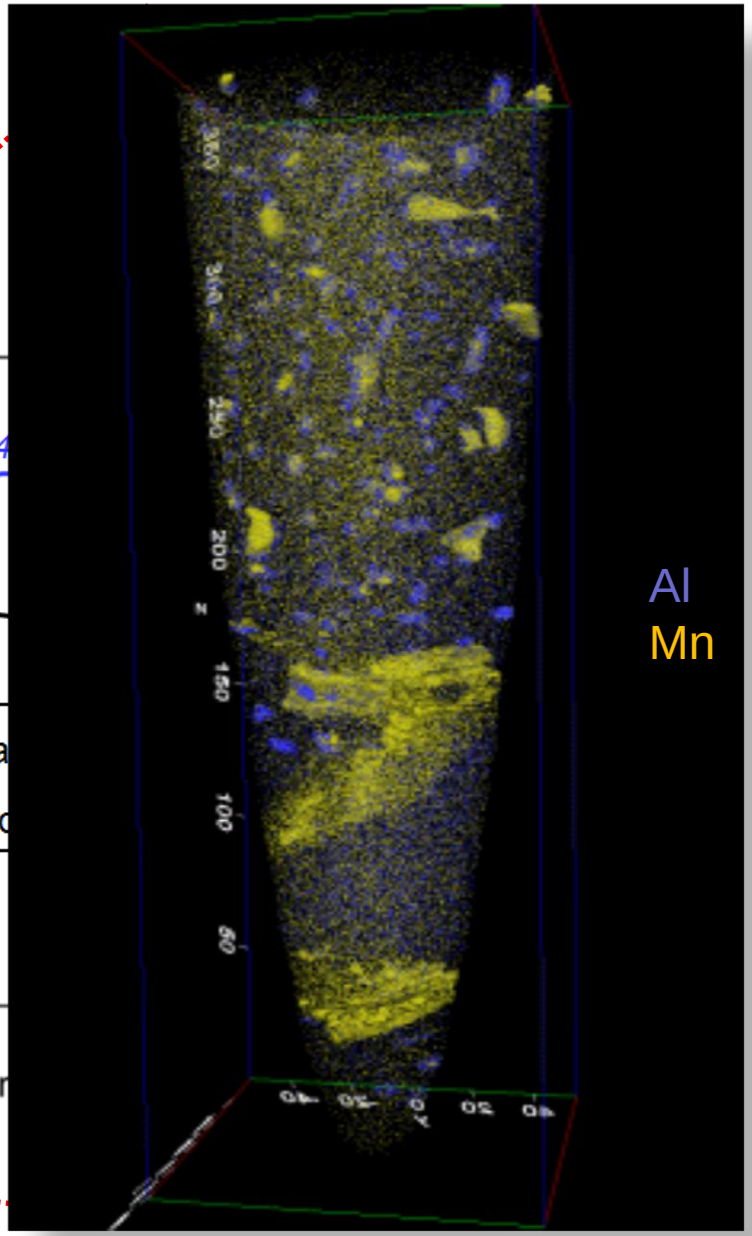

martensite

austenite

martensite

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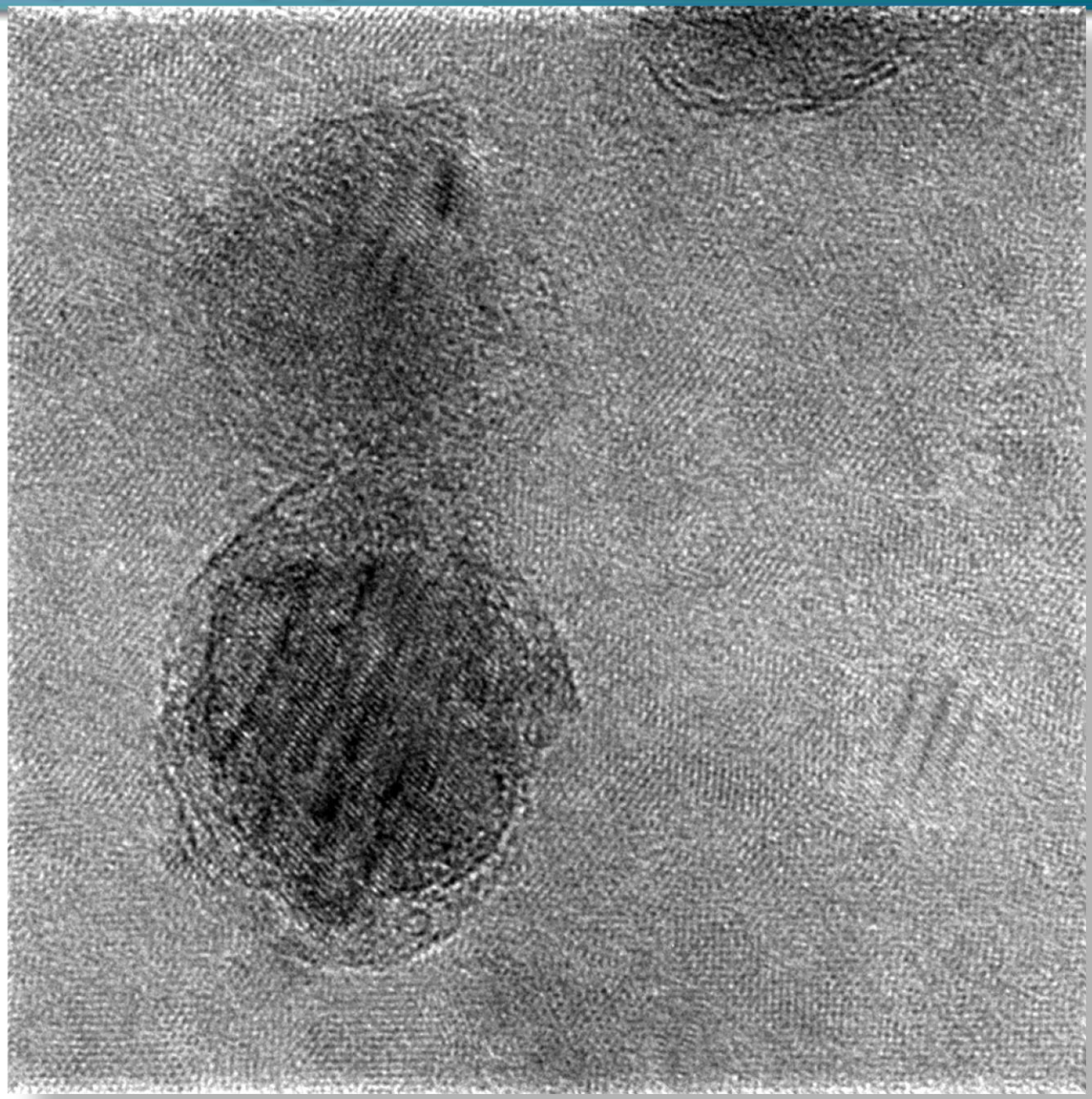
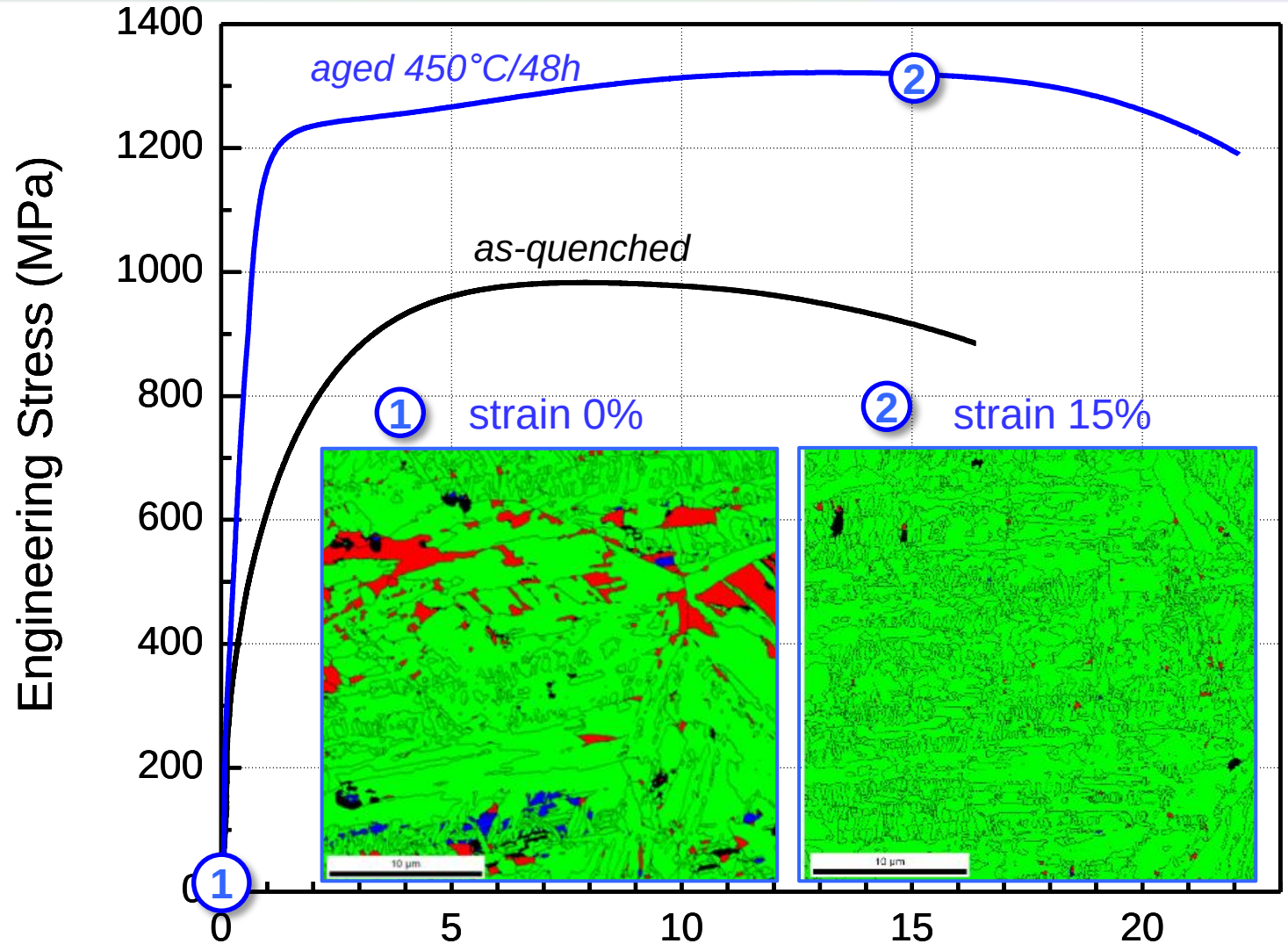


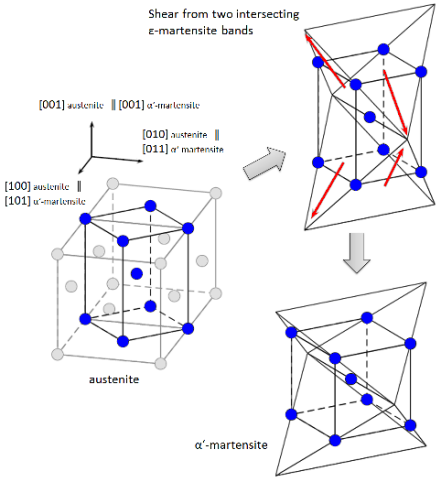
Dmitrieva et al., Acta Mater, 59 (2011)

Effect of aging on ductility



Precipitation hardening

increase of γ austenite fraction during aging

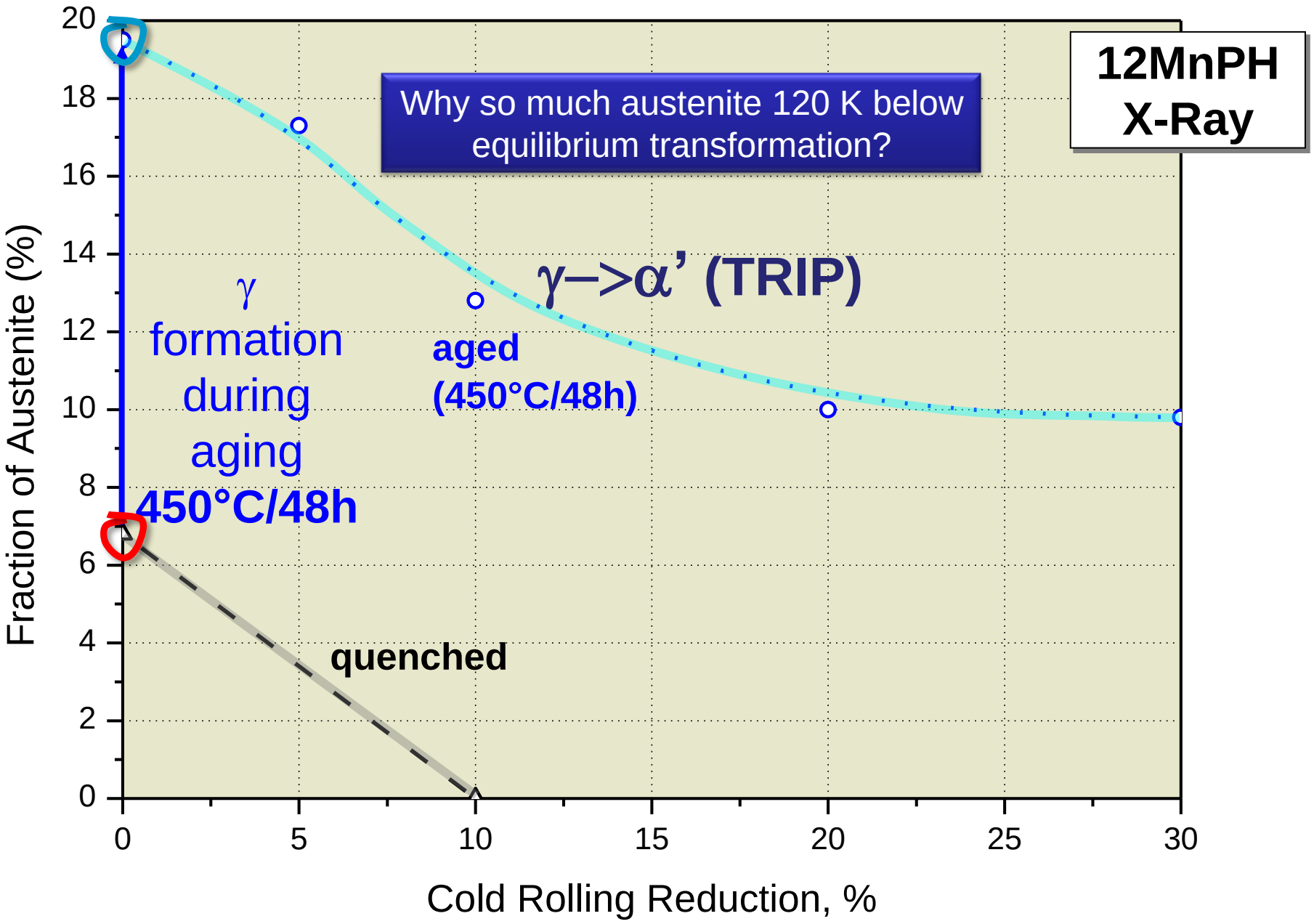


α-Fe (Martensite)

γ-Fe (Austenite), vol. fraction 15-20%

C	Ni	Mo	Ti	Al	Mn	Fe
0.01	2.0	1.0	1.0	0.15	12	bal.

Effect of cold rolling after aging



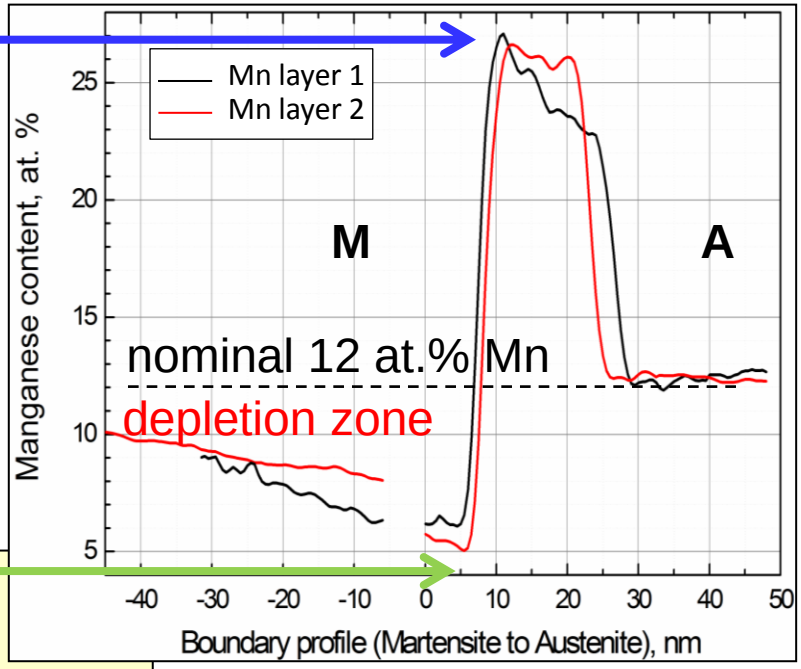
Aging-induced austenite reversion

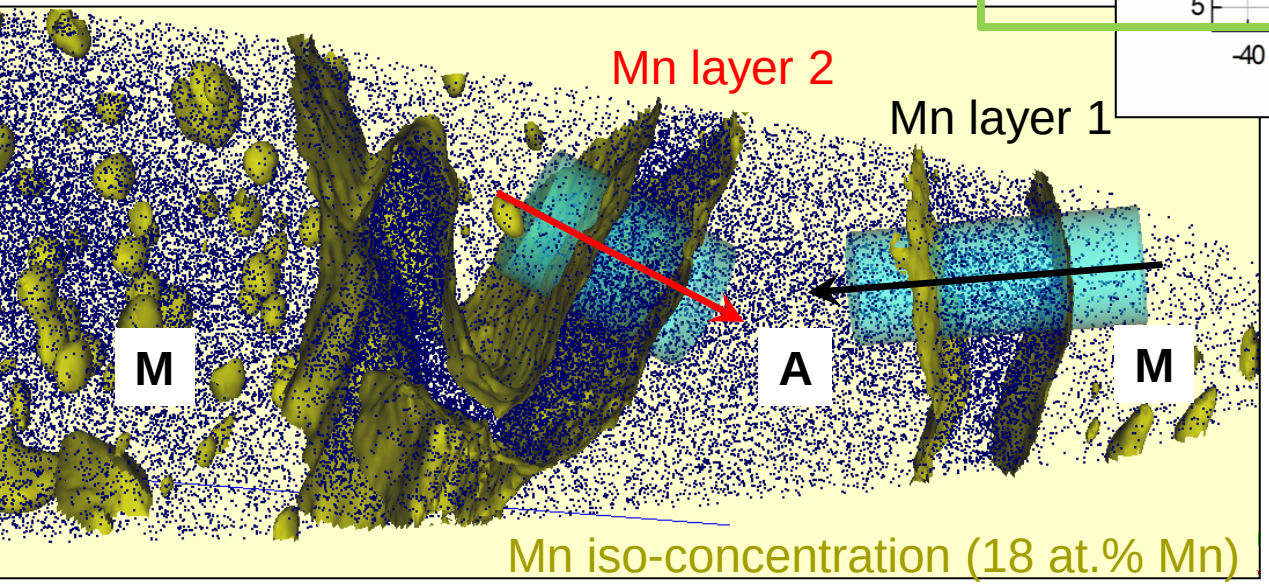
Thermo-Calc ⇒

equilibrium Mn-conc.:

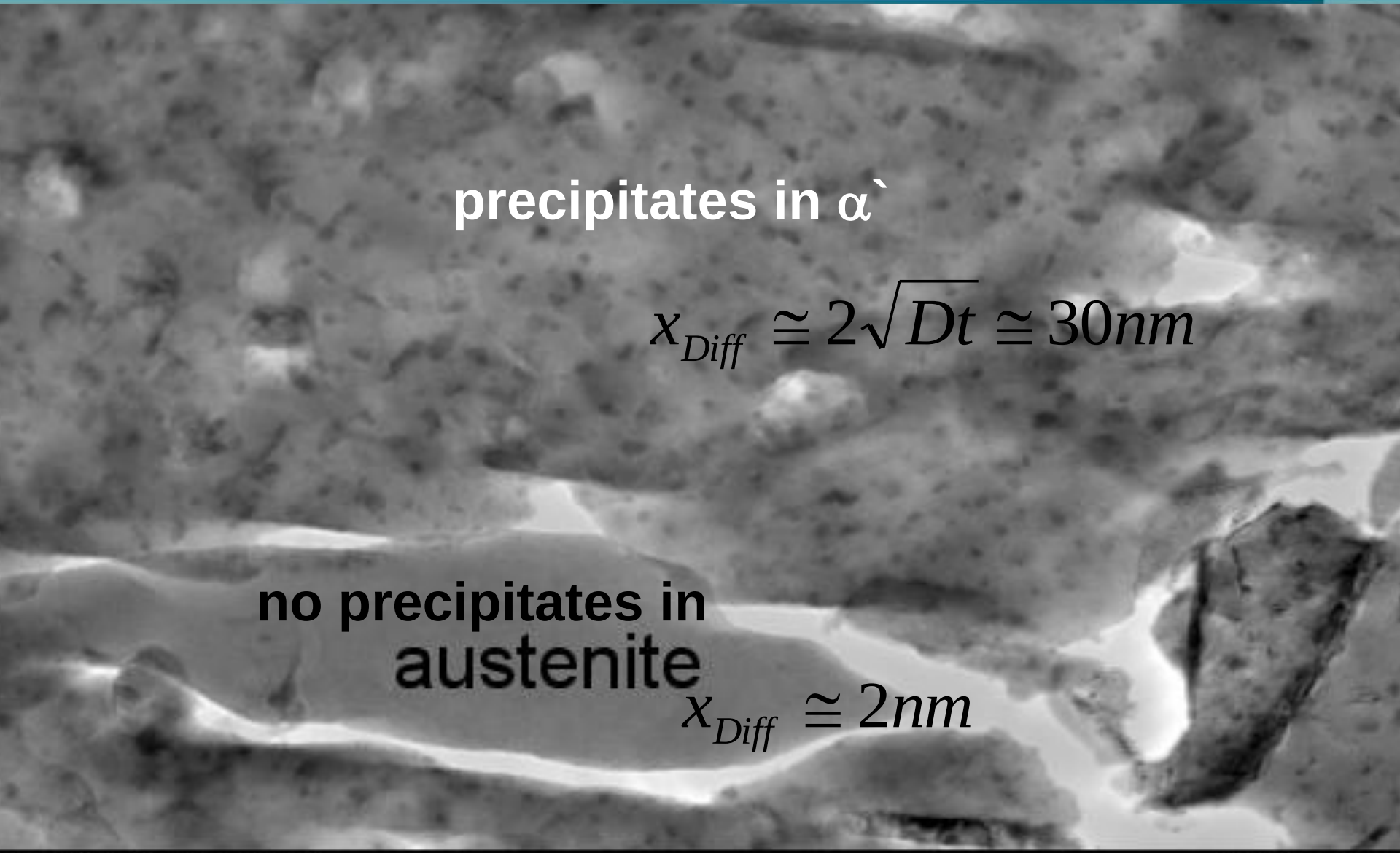
27 at. % Mn in austenite (A)

3 at. % Mn in ferrite (martensite) (M)





12%Mn alloy after aging (48h 450°C)



Aging-induced austenite reversion

Thermo-Cal

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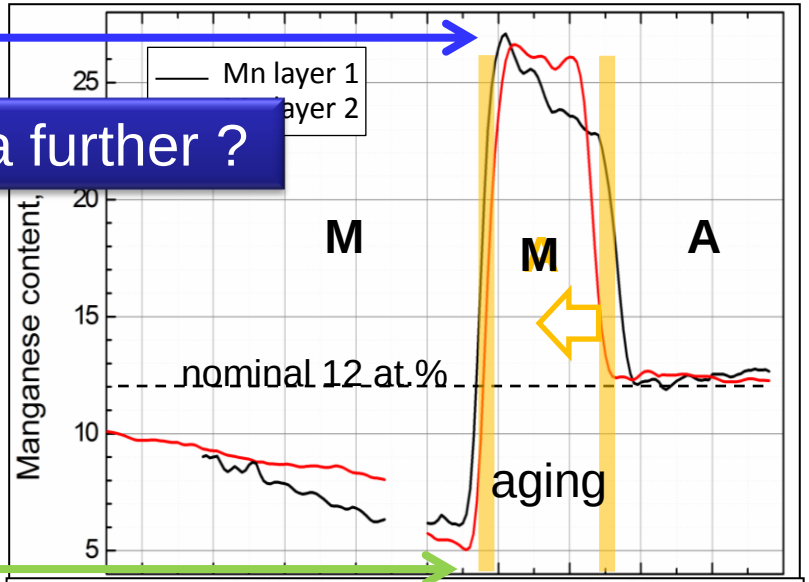
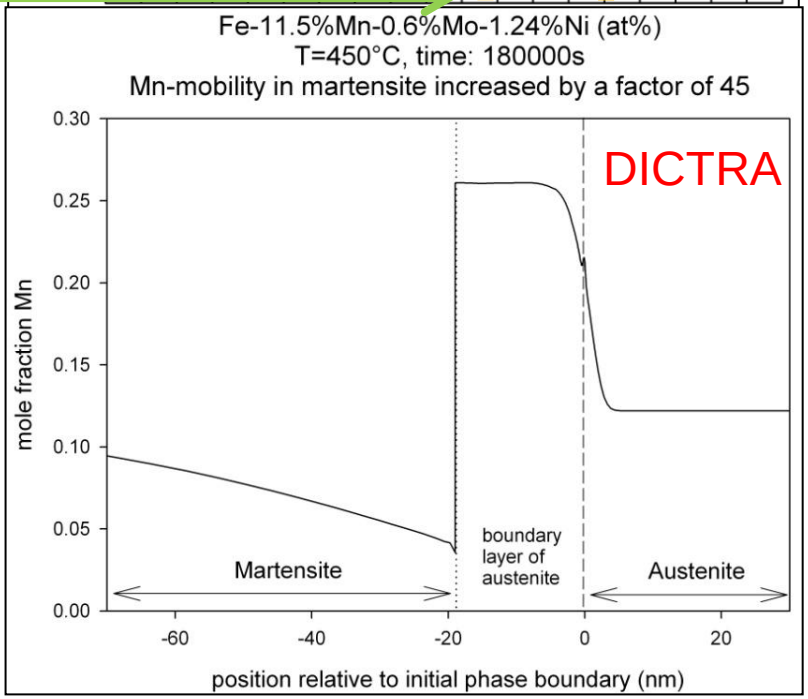
Can I push this idea further ?

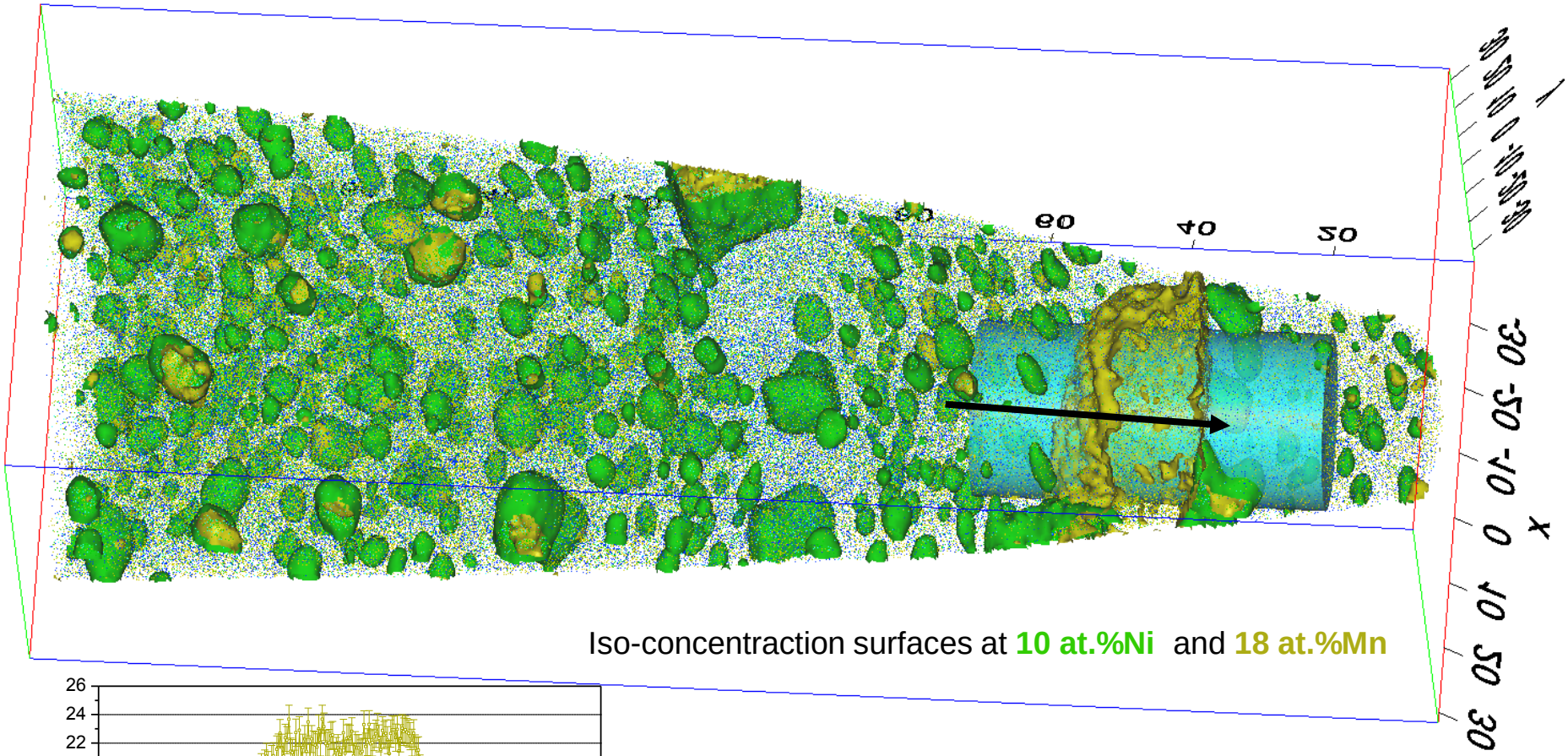


Excellent agreement between experiment & simulation !

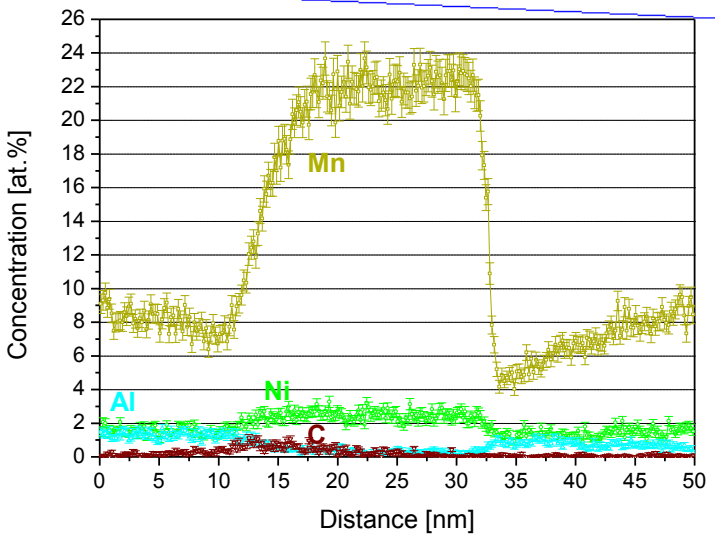
Kinetic freezing and associated austenite reversion !



Dmitrieva et al. Acta Mater 59 (2011)



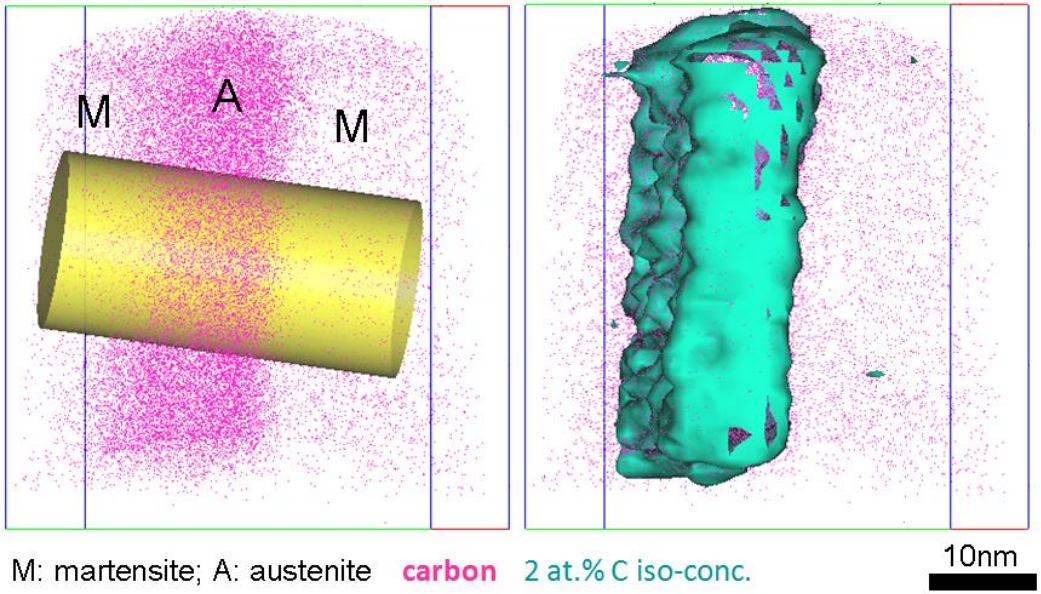
Iso-concentration surfaces at **10 at.%Ni** and **18 at.%Mn**

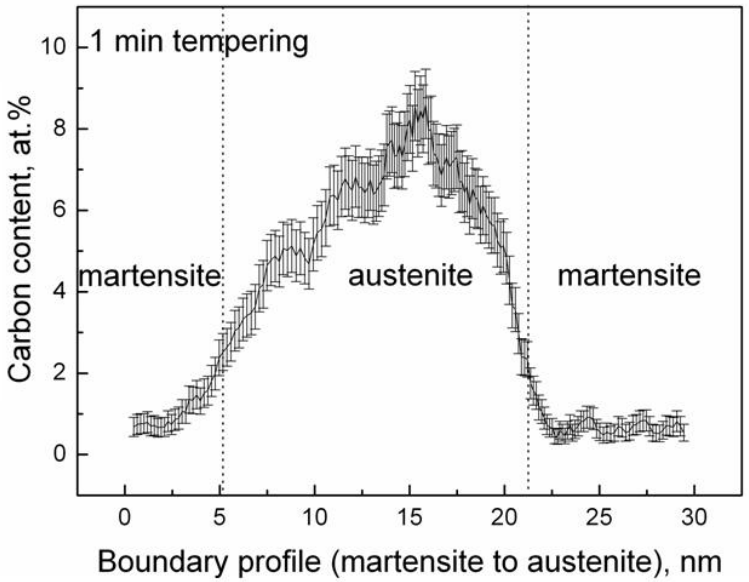


Equilibrium segregation on g.b. and associated austenite reversion !

Martensite relaxation & aging & nanoscale austenite reversion

at 5.45 at.% C, austenite forms at 400°C





C has ‘/\’ shape in austenite layer: inheritance from austenite, Gibbs adsorption isotherm;
C on martensite grain boundaries

C has ‘V’ shape in austenite layer: austenite reversion through partitioning and kinetic freezing

Martensite relaxation & aging & nanoscale austenite reversion

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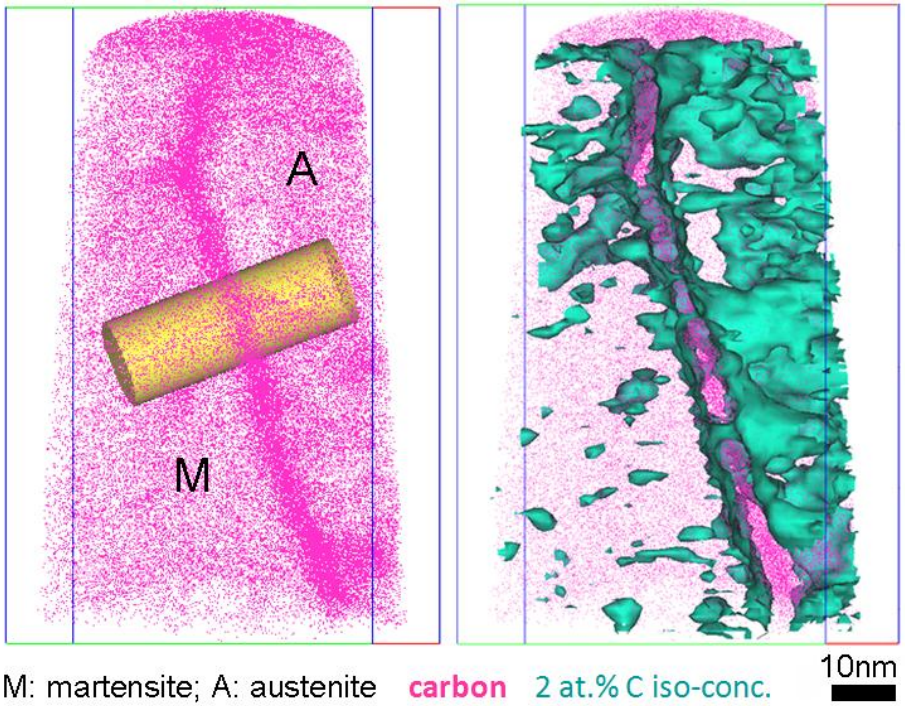

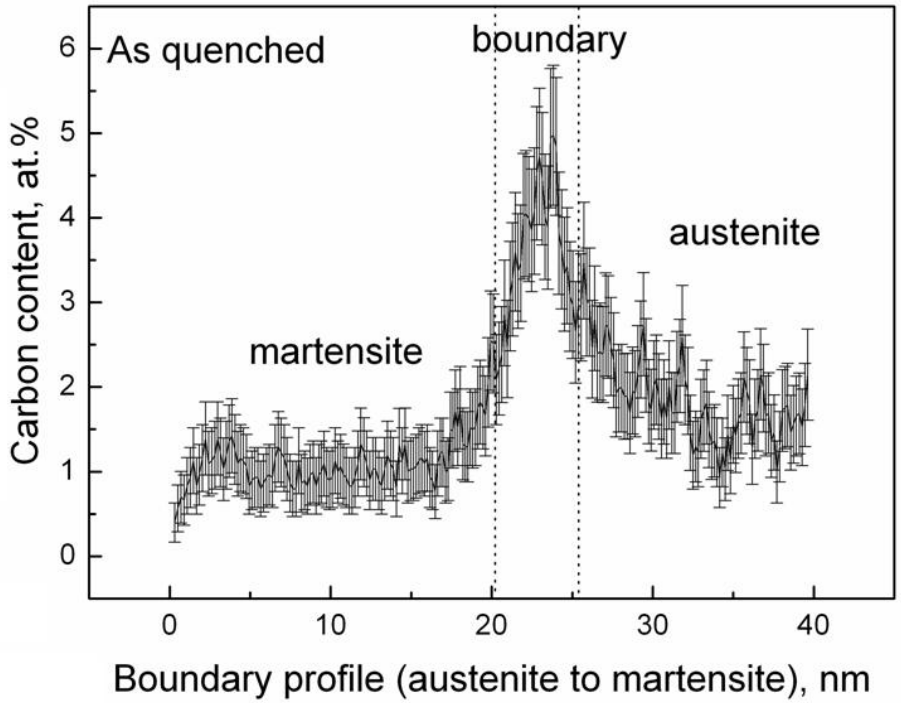

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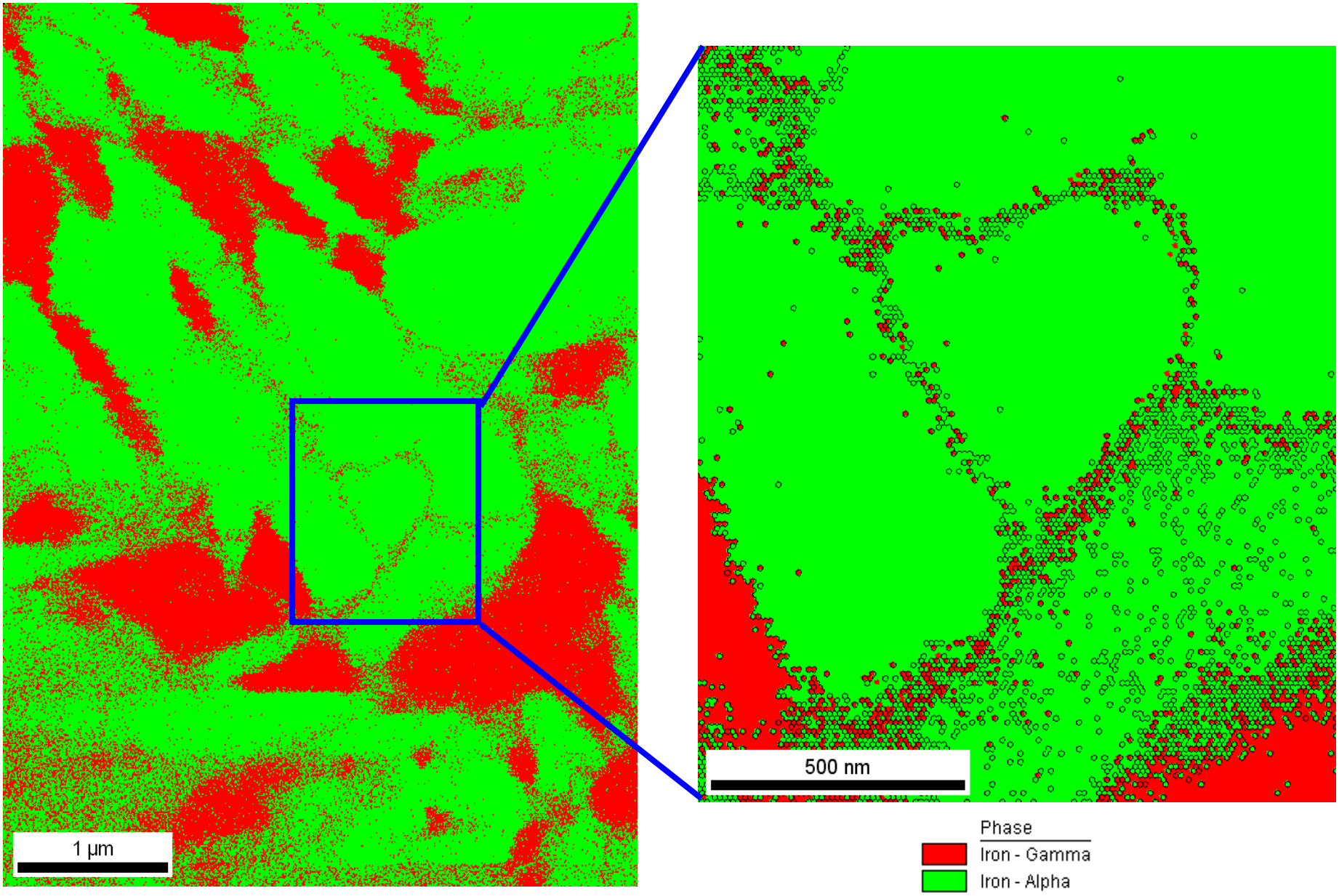
Self-repair steels