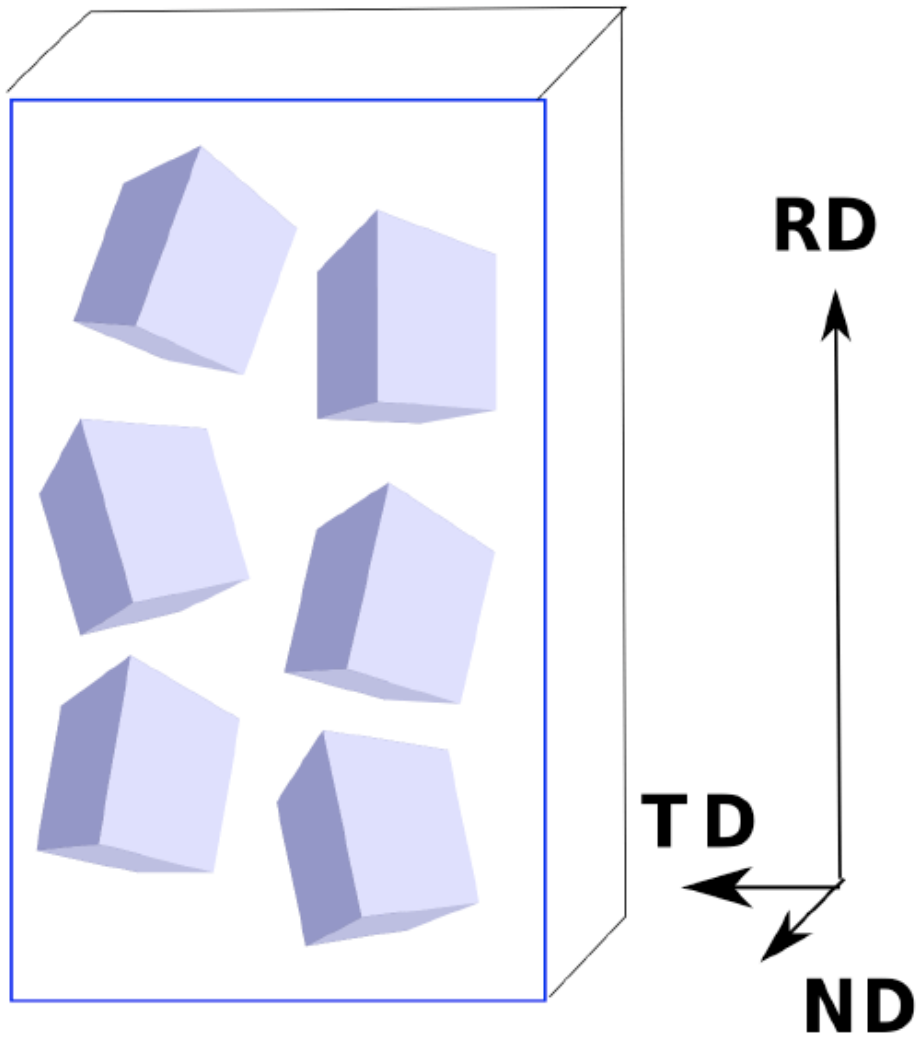
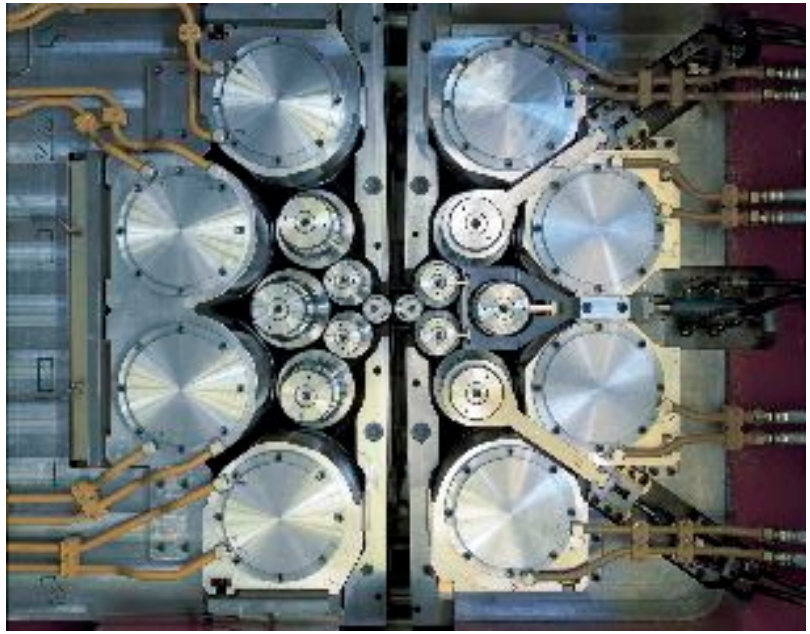
Problems in the Calculation of Transformation Texture

www.msm.cam.ac.uk/phase-trans

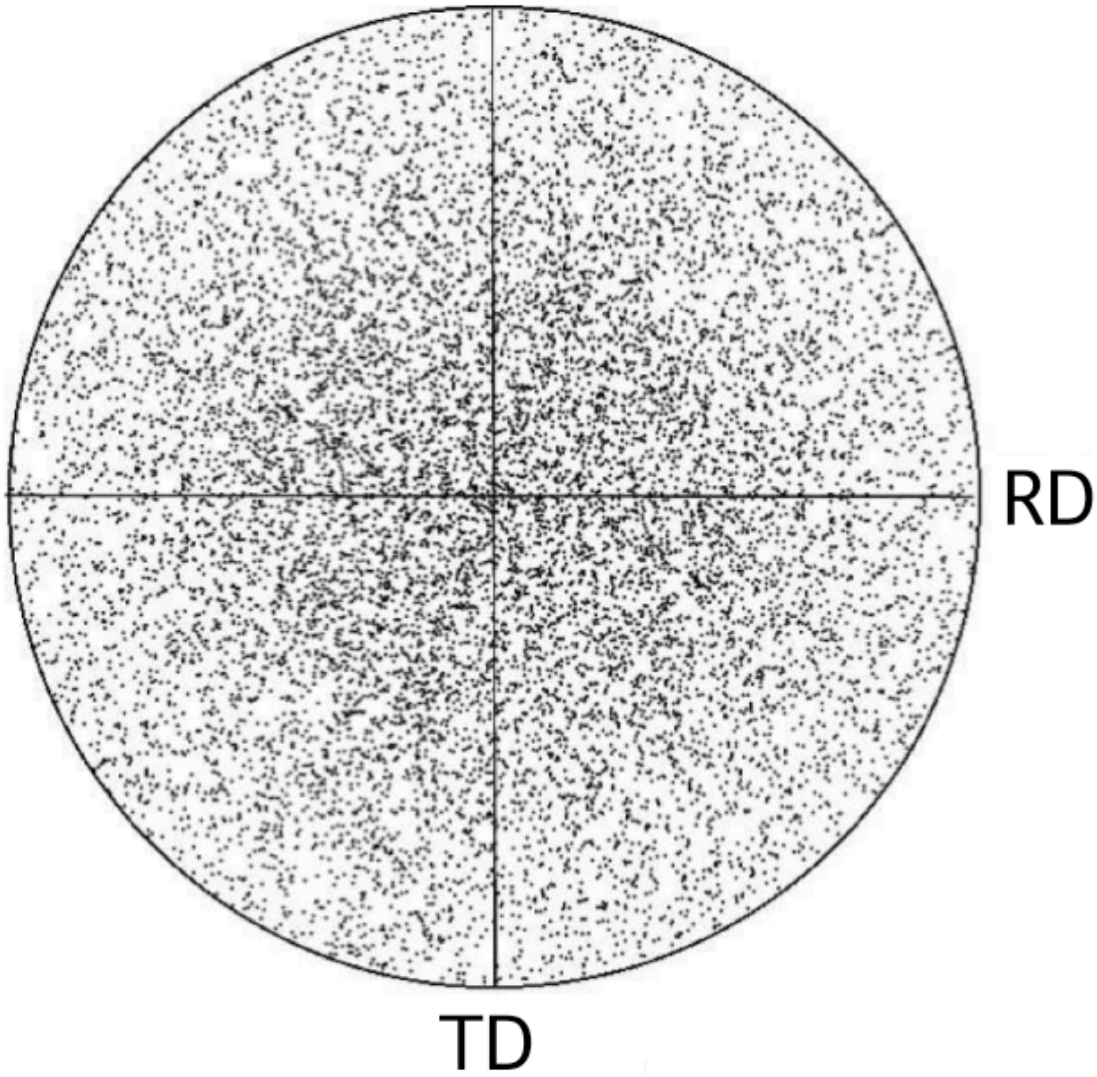
POSTECH
GIFT
Graduate Institute of Ferrous Technology

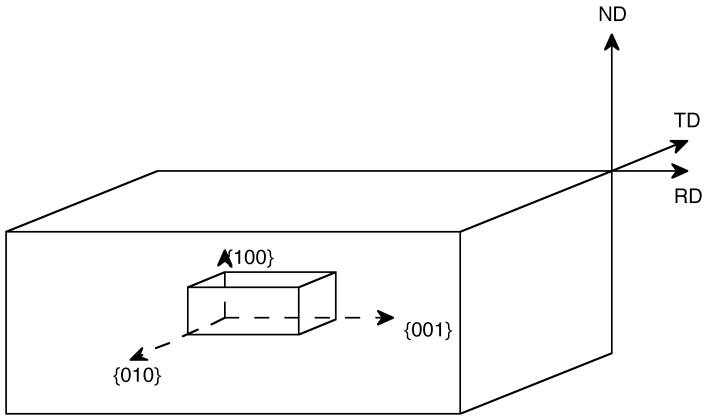
UNIVERSITY OF CAMBRIDGE

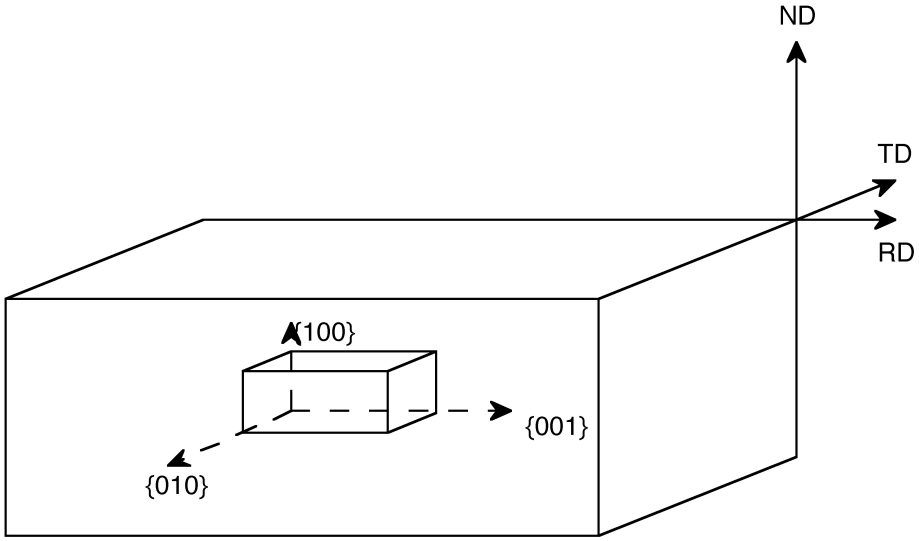

RD
TD
ND

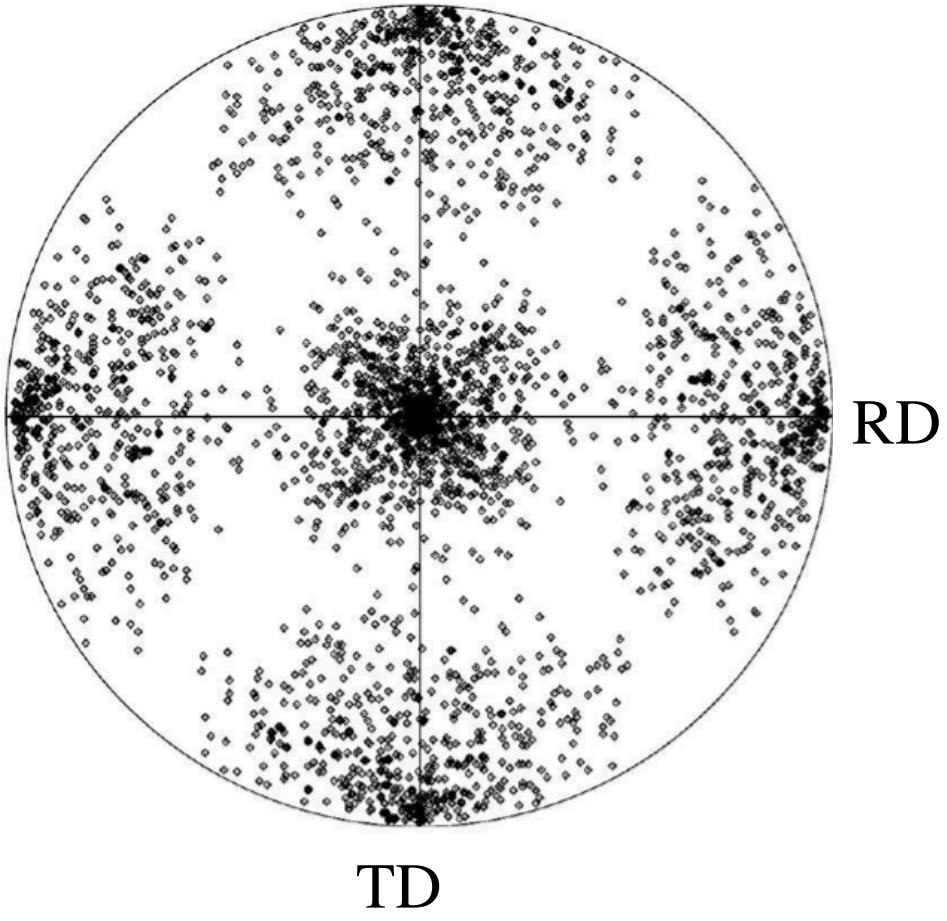


100 pole figure plotted relative to sample axes





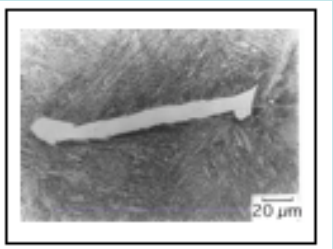




100 pole figure showing “cube” texture

RECONSTRUCTIVE

Diffusion of all atoms during nucleation and growth.
Sluggish below about 850 K.

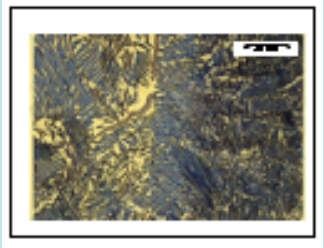


ALLOTRIOMORPHIC FERRITE

IDIOMORPHIC FERRITE

MASSIVE FERRITE

No change in bulk composition.



PEARLITE

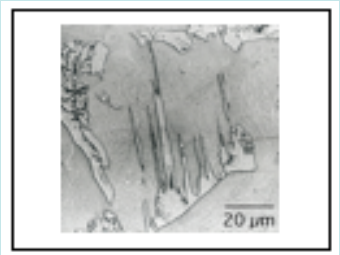
Cooperative growth of ferrite & cementite.

DISPLACIVE

Invariant-plane strain shape deformation with large shear component.
No iron or substitutional solute diffusion.
Thin plate shape.

WIDMANSTÄTTEN FERRITE

Carbon diffusion during paraequilibrium nucleation & growth.



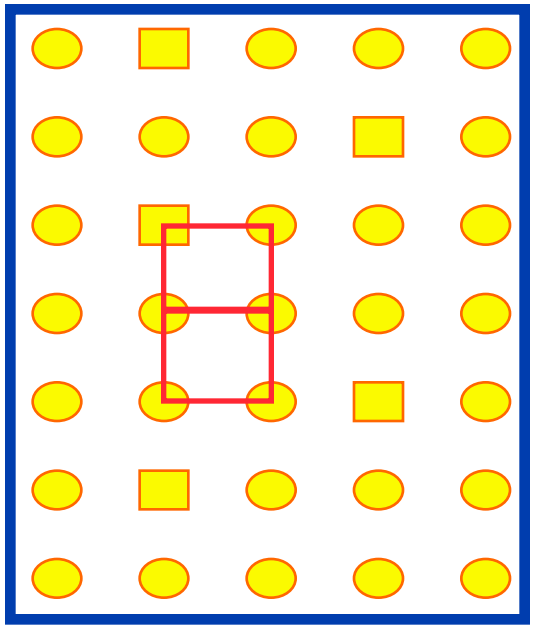
BAINITE & ACICULAR FERRITE

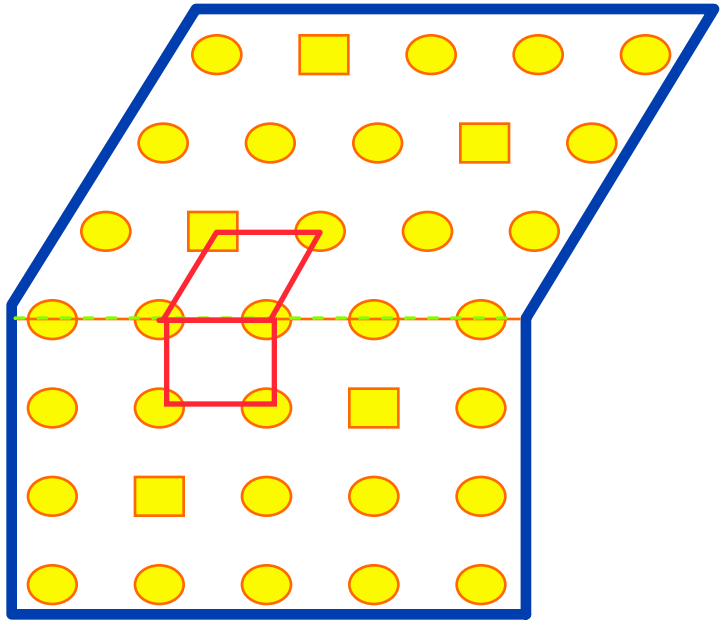
Carbon diffusion during paraequilibrium nucleation. No diffusion during growth.

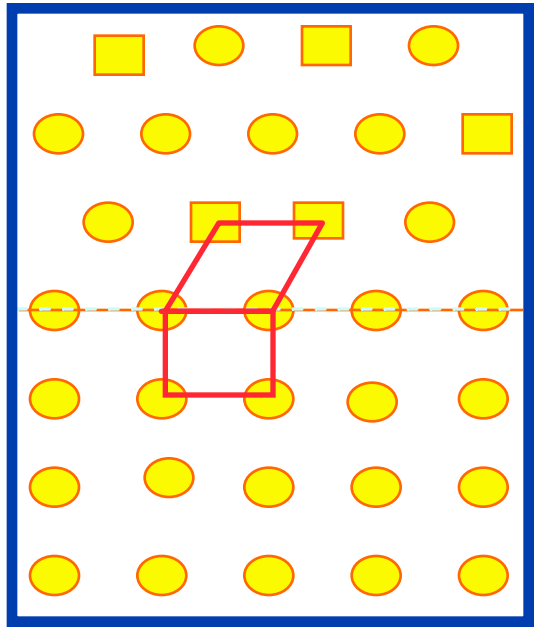
MARTENSITE

Diffusionless nucleation & growth.

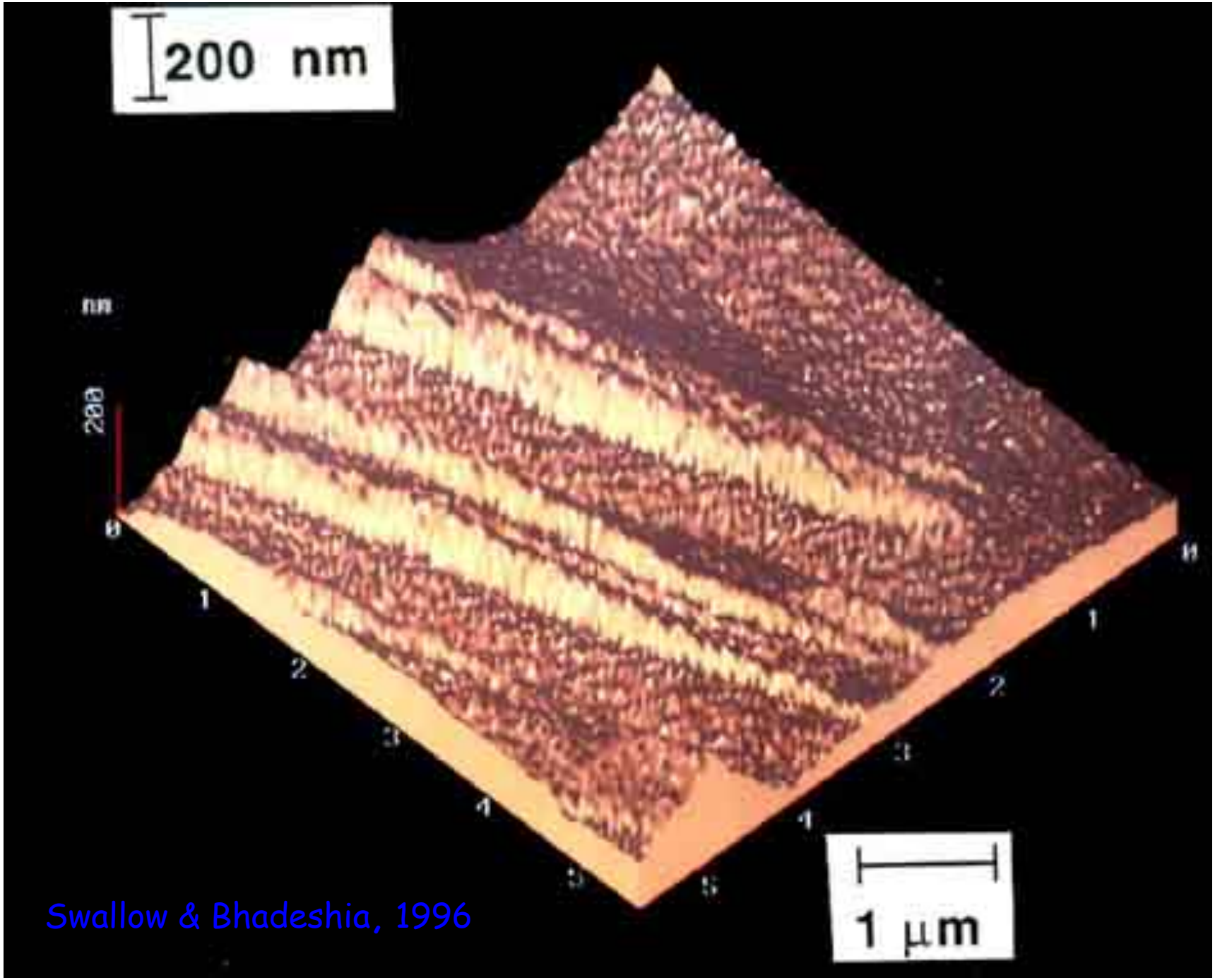
DISPLACIVE







RECONSTRUCTIVE

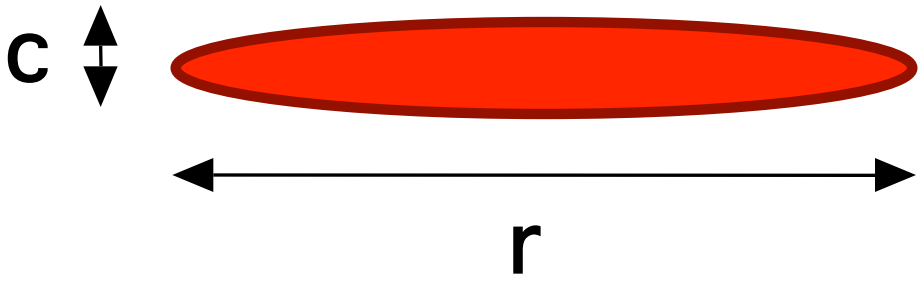


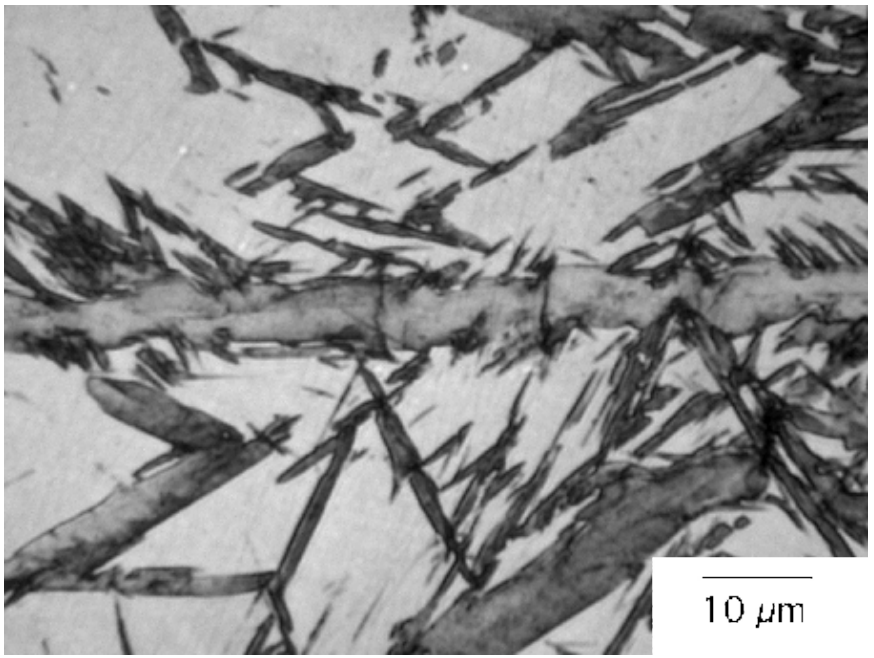
Swallow & Bhadeshia, 1996

habit plane

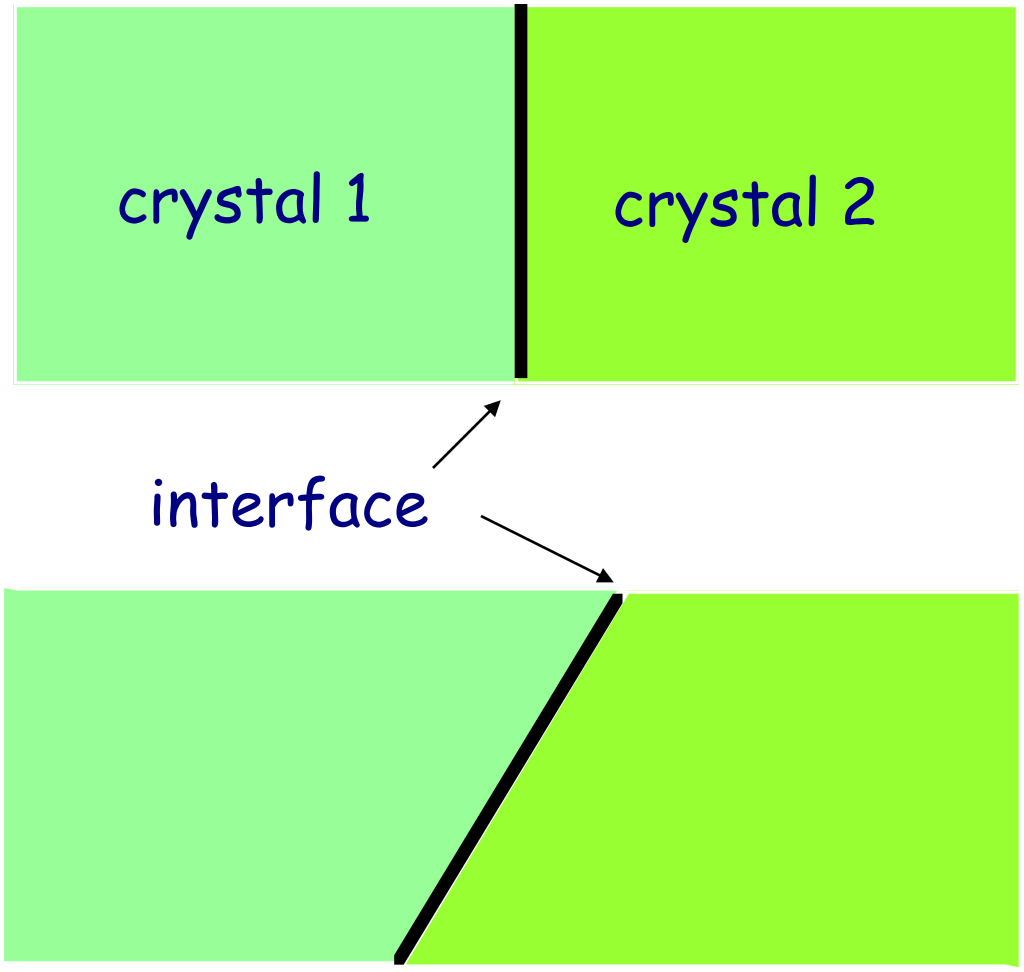
orientation relationship

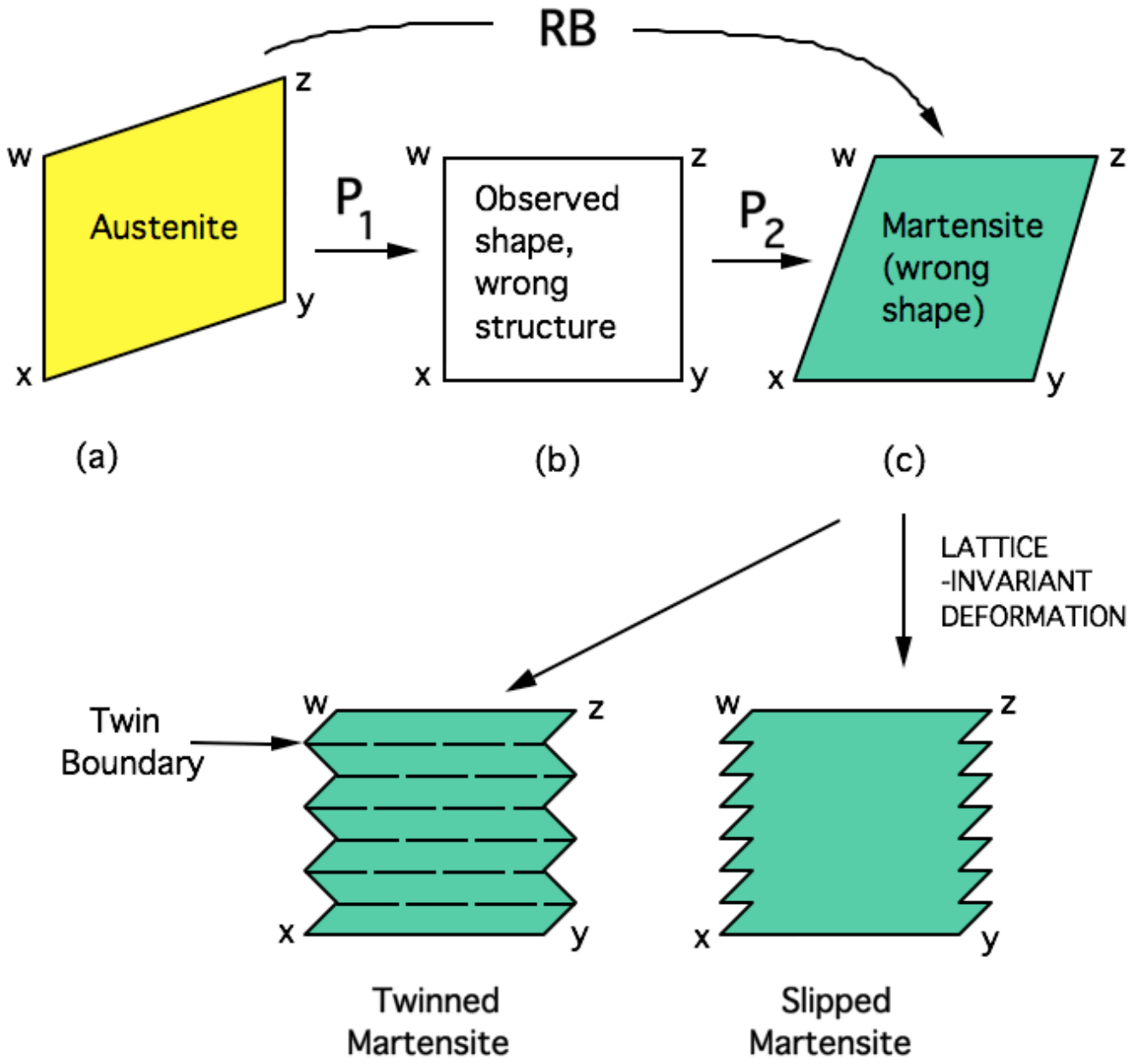
deformation





Degrees of freedom





Correct macroscopic shape, correct structure

Habit plane $\mathbf{p}_\gamma$

$$\begin{pmatrix} -0.168640 \\ -0.760394 \\ -0.627185 \end{pmatrix}$$

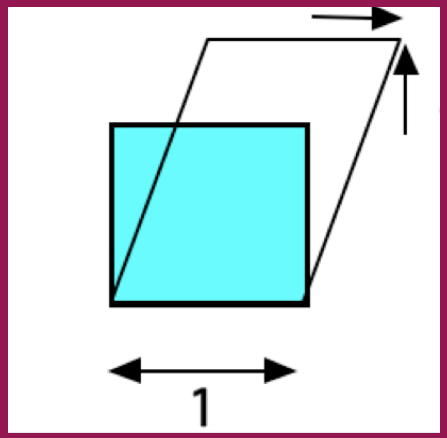
Orientation (γ J α)

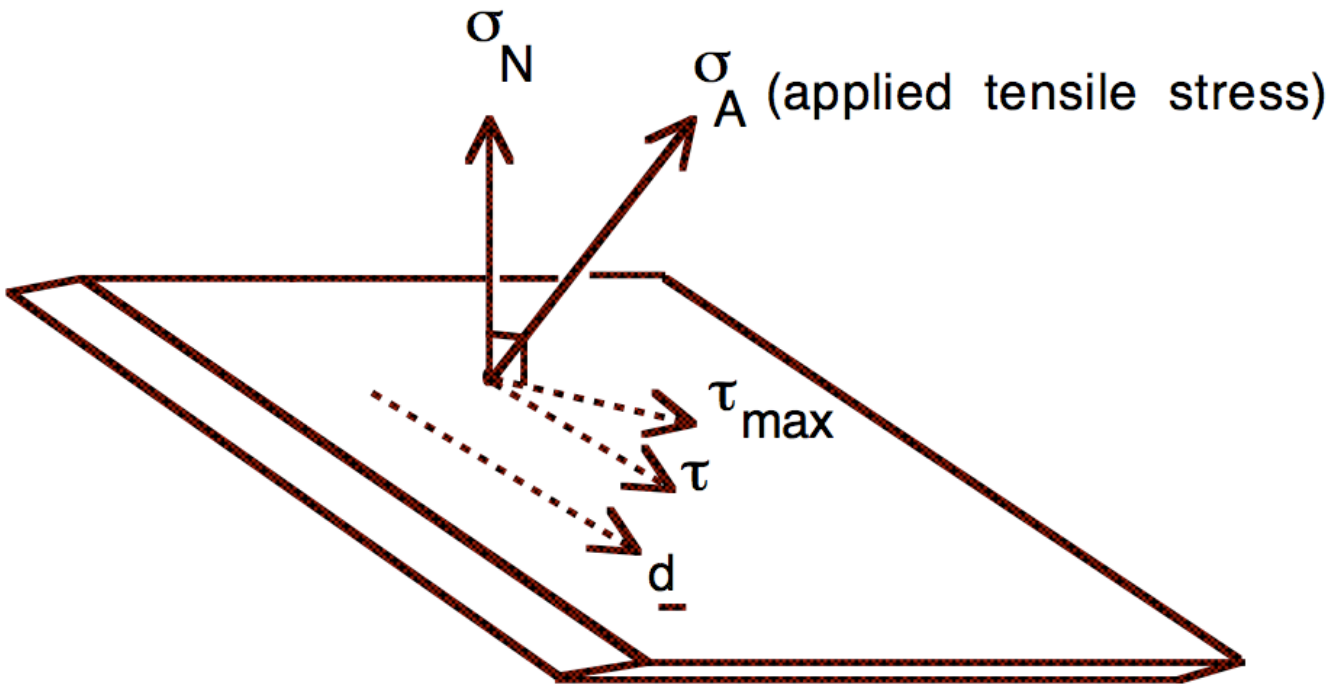
$$\begin{pmatrix} 0.575191 & 0.542067 & 0.097283 \\ -0.550660 & 0.568276 & 0.089338 \\ -0.008610 & -0.131800 & 0.785302 \end{pmatrix}$$

$$[\bar{1}\ 0\ 1]_\gamma || [-0.920611\ -1.062637\ 1.084959]_{\alpha'}$$
$$(1\ 1\ 1)_\gamma || (0.015921\ 0.978543\ 0.971923)_{\alpha'}$$

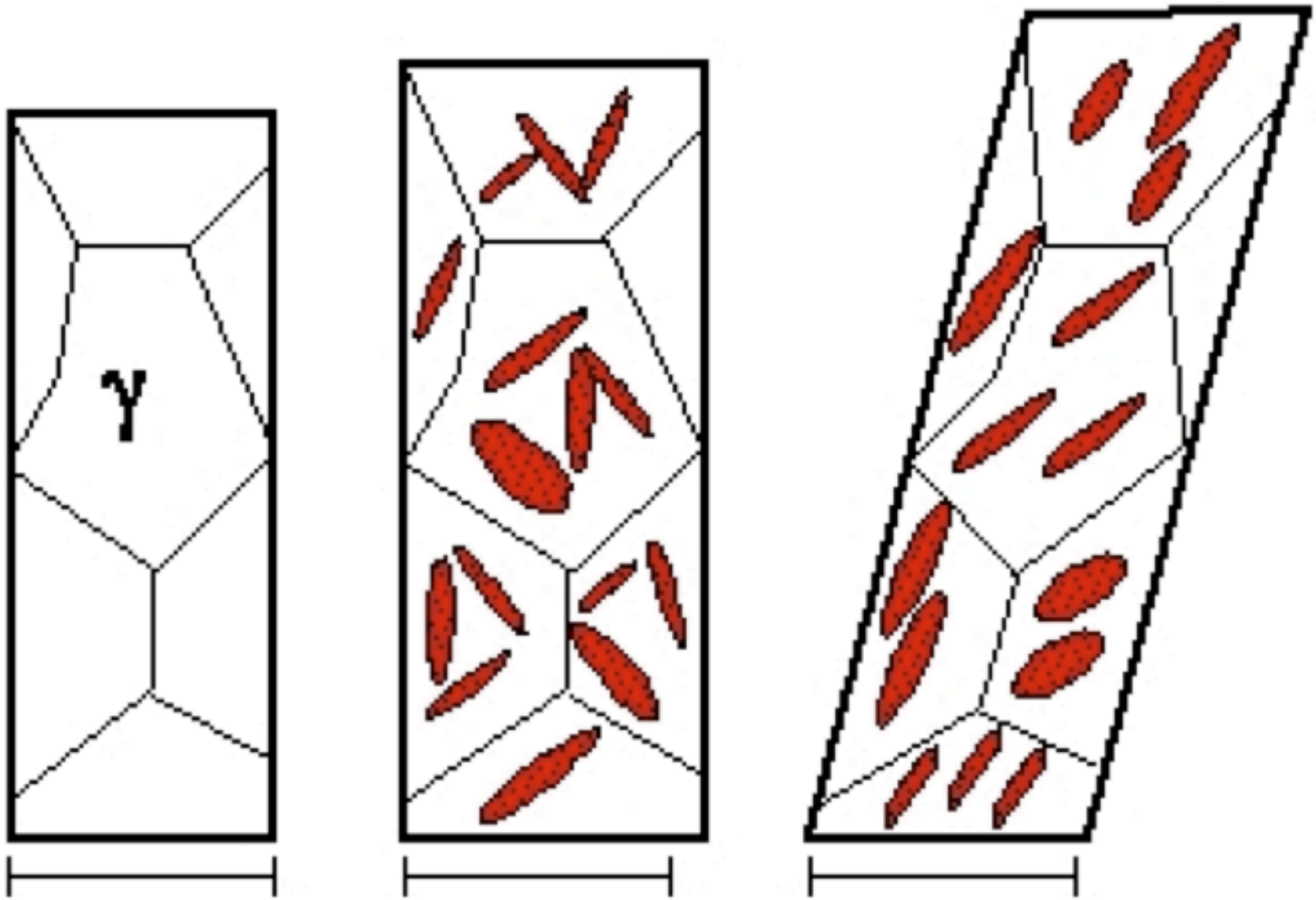
Shape change (γ P γ)

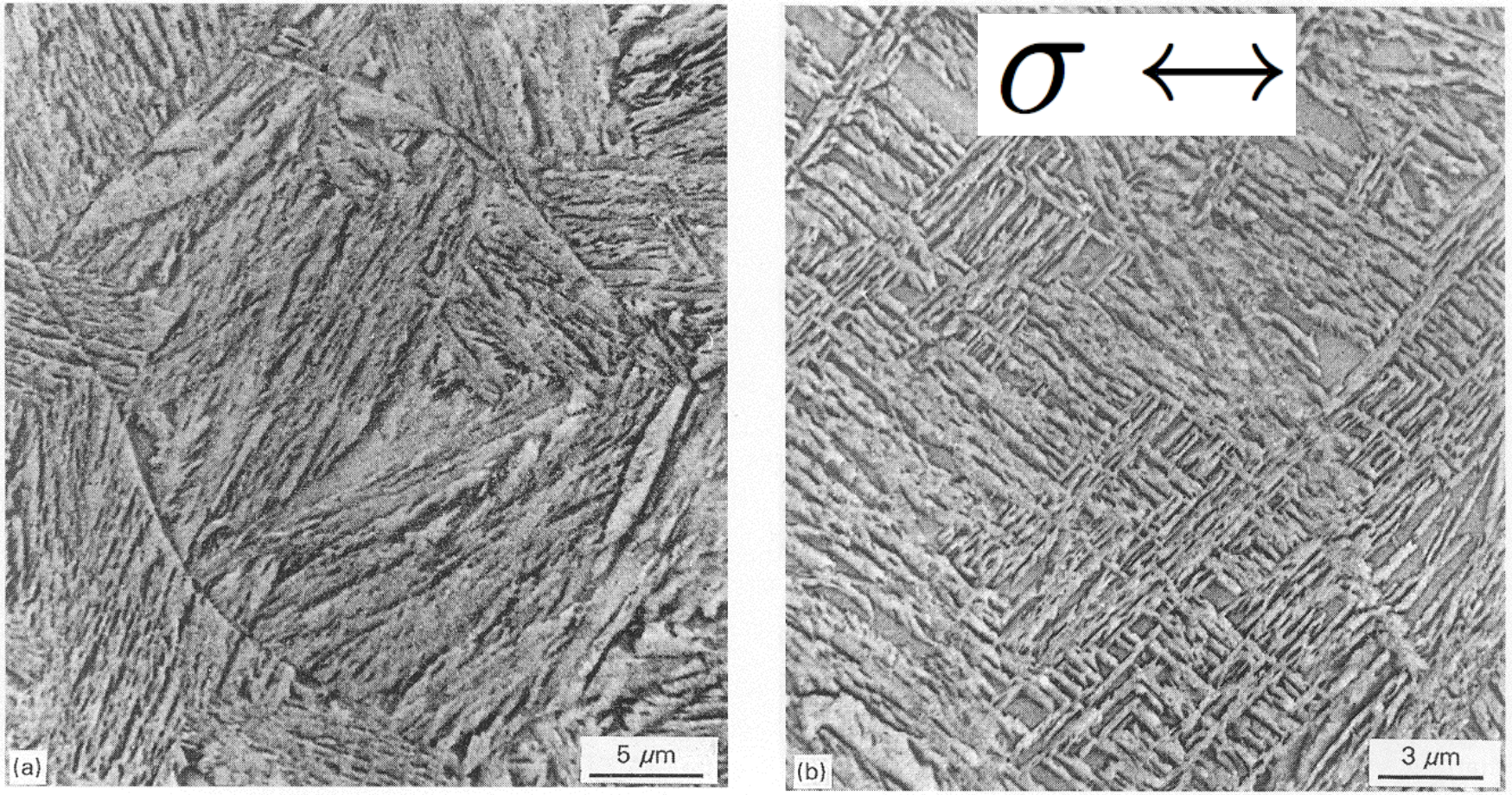
$$\begin{pmatrix} 0.992654 & -0.033124 & -0.027321 \\ 0.026378 & 1.118936 & 0.098100 \\ -0.027321 & -0.123190 & 0.898391 \end{pmatrix}$$





$$\Delta G_{MECH} = \tau s + \sigma_N \delta$$

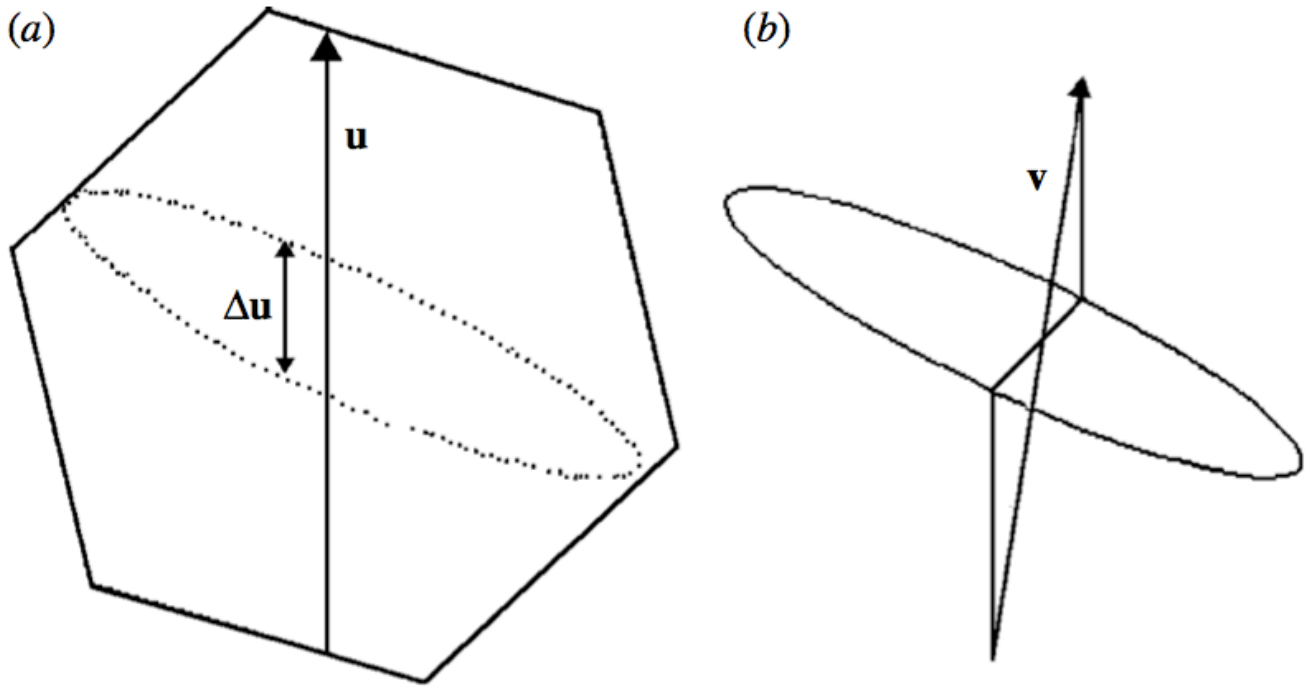

γ



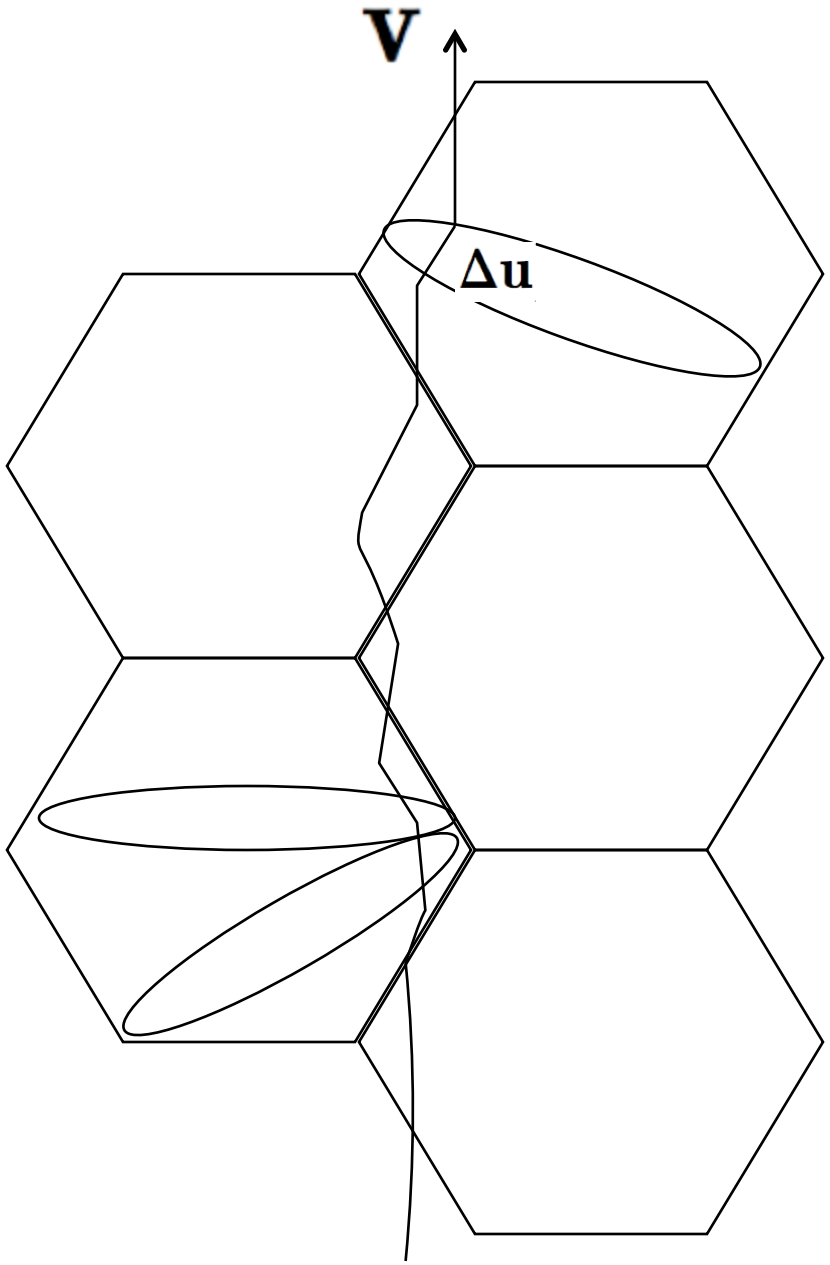
Lower bainite, transformed with and without stress

Chang et al., 1996

$$(\mathrm{F}\ \mathbf{P}\ \mathrm{F}) = \mathbf{I} + m[\mathrm{F}; \mathbf{d}](\mathbf{p}; \mathrm{F}^*)$$



$$\mathbf{v} = \mathbf{P}\Delta\mathbf{u} + (\mathbf{u} - \Delta\mathbf{u})$$

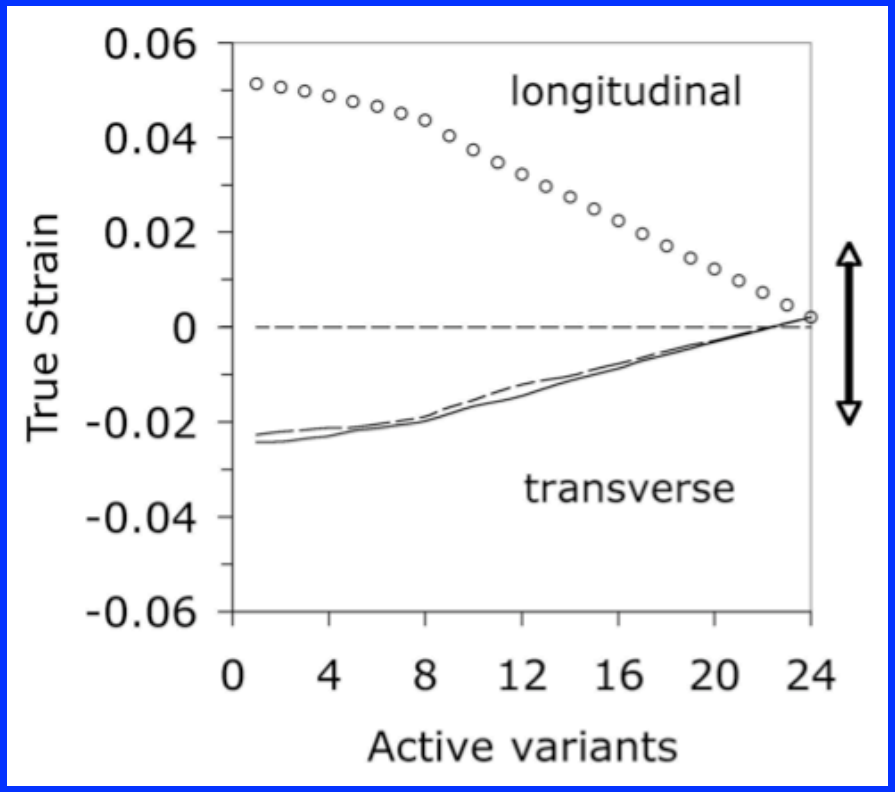


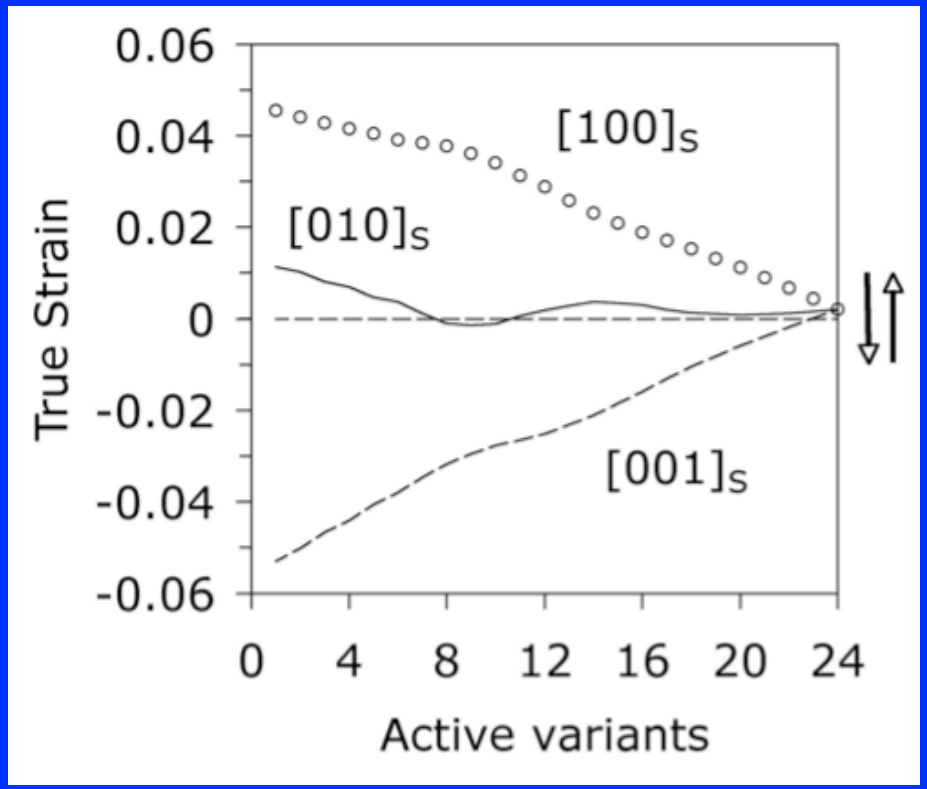
$$\ln\{|\mathbf{v}|/|\mathbf{u}|\}$$

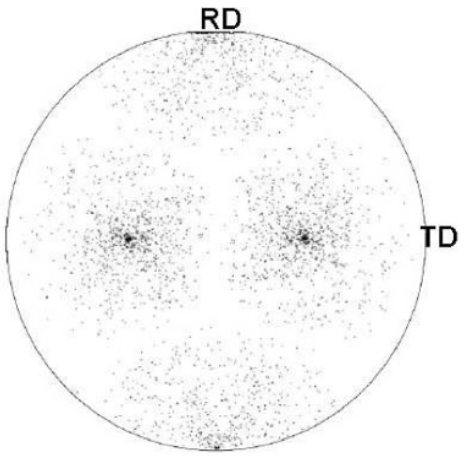
$$\mathbf{v} = \sum_{k=1}^{n} \sum_{j=1}^{24} \mathbf{P}_j^k \Delta \mathbf{u}_j^k + \left(\mathbf{u} - \sum_{k=1}^{n} \sum_{j=1}^{24} \Delta \mathbf{u}_j^k \right)$$

24 crystallographic variants

n austenite grains

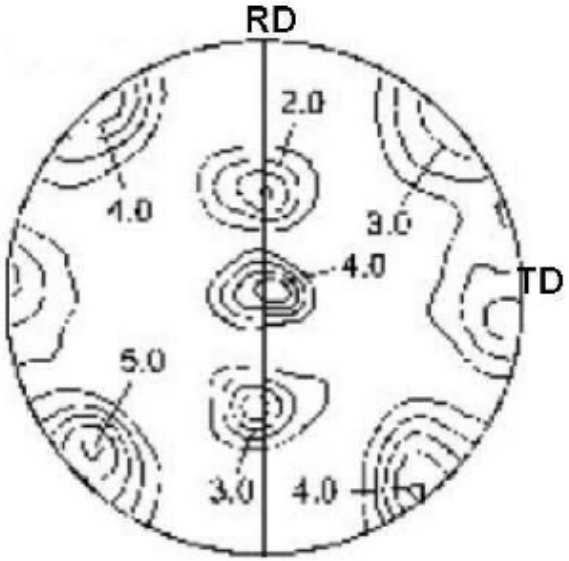

0.06
0.04
0.02
0
-0.02
-0.04
-0.06
True Strain
longitudinal
transverse
0
4
8
12
16
20
24
Active variants


0.06
0.04
0.02
0
-0.02
-0.04
-0.06
True Strain
[100]s
[010]s
[001]s
0
4
8
12
16
20
24
Active variants



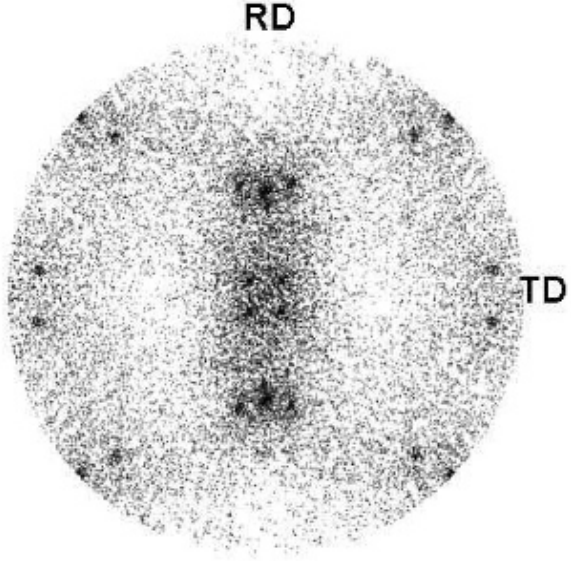
Goss

Experimental



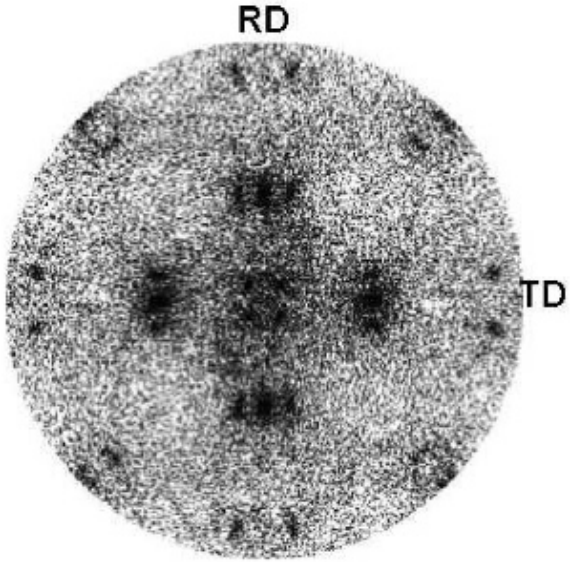
(a)

Calculated



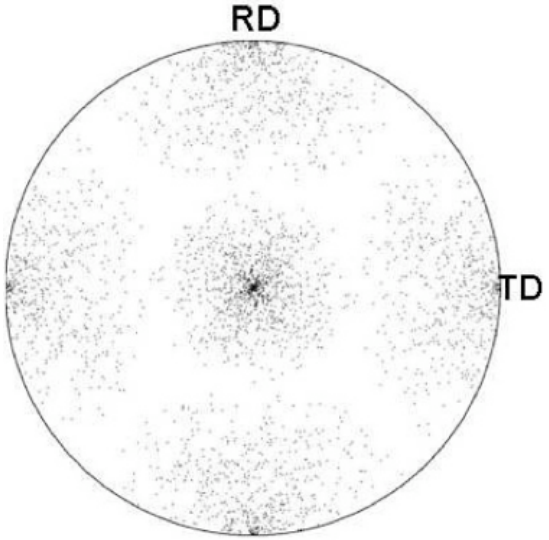
(b)

Calculated



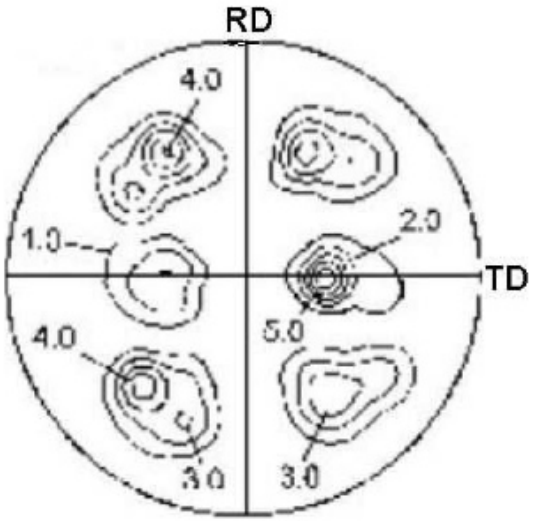
(c)

Kundu and Bhadeshia, Scripta Materialia 55 (2006) 779



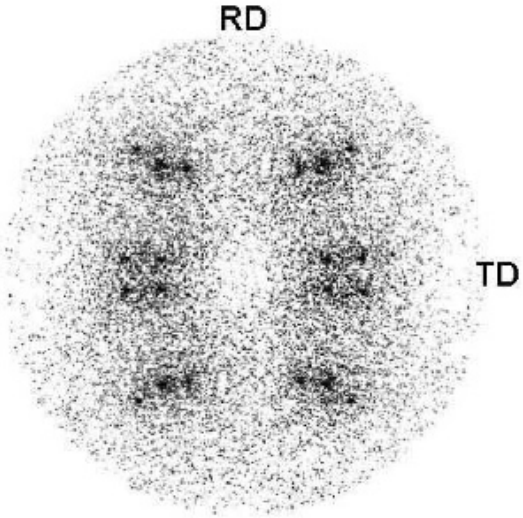
Cube

Experimental



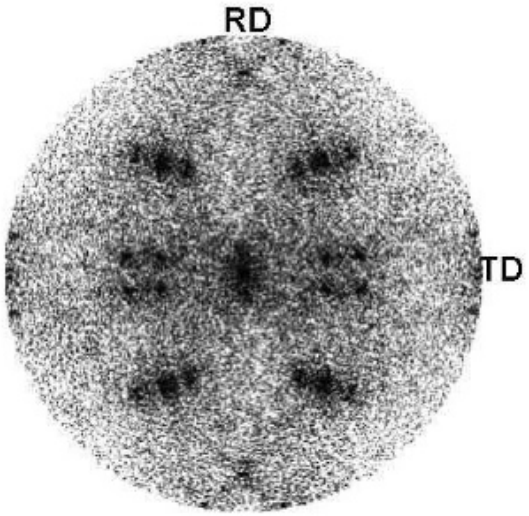
(a)

Calculated

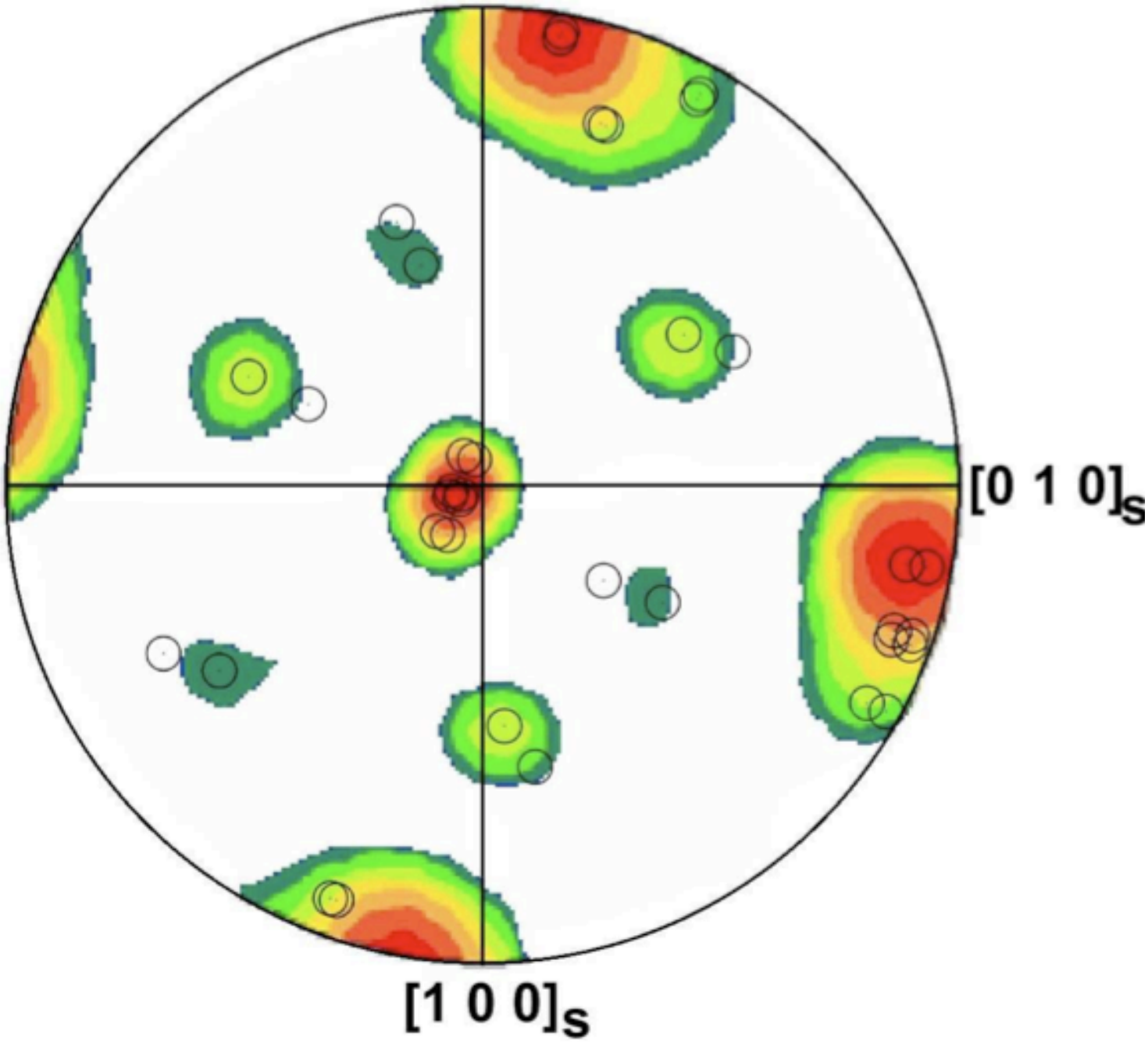


(b)

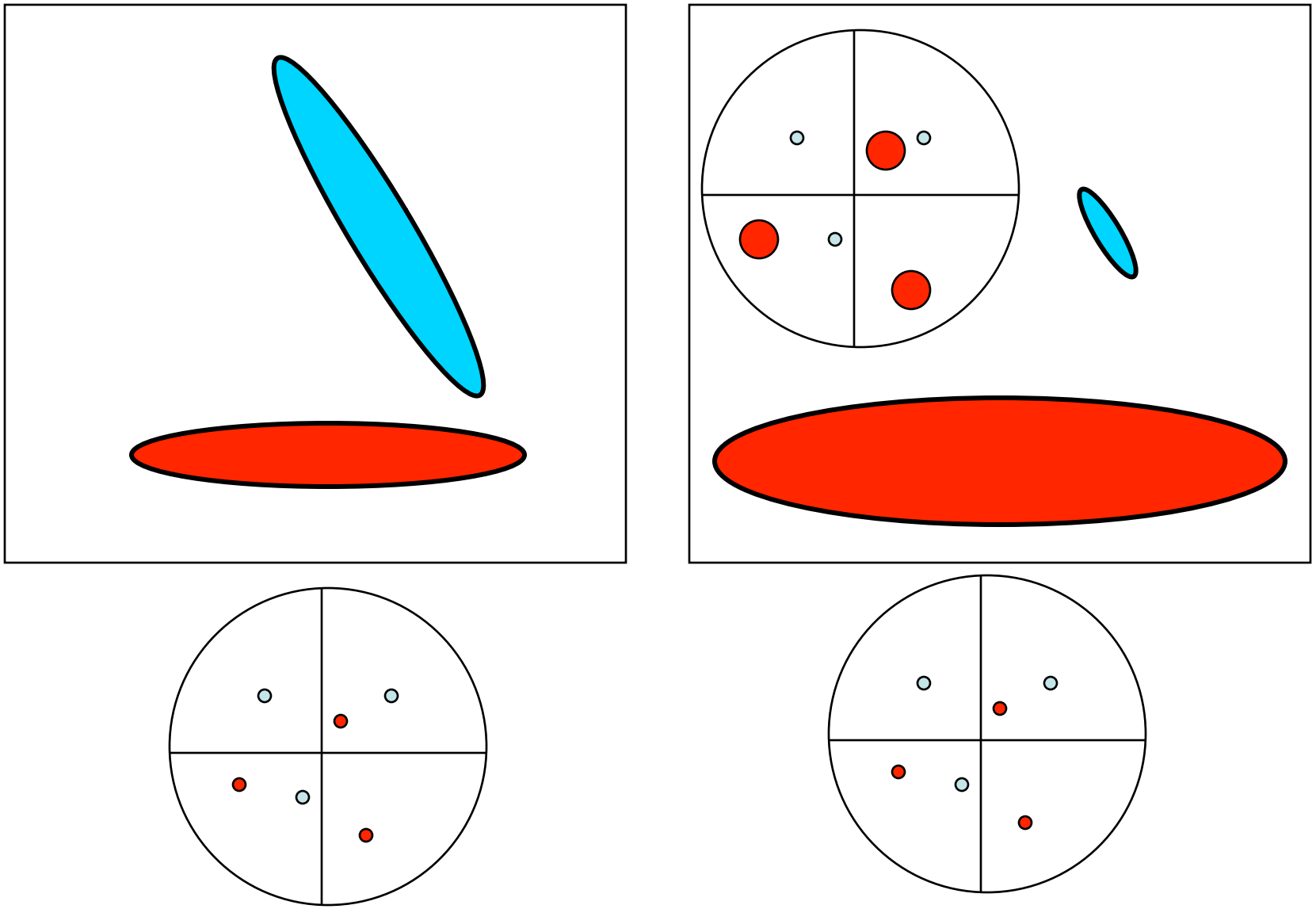
Calculated



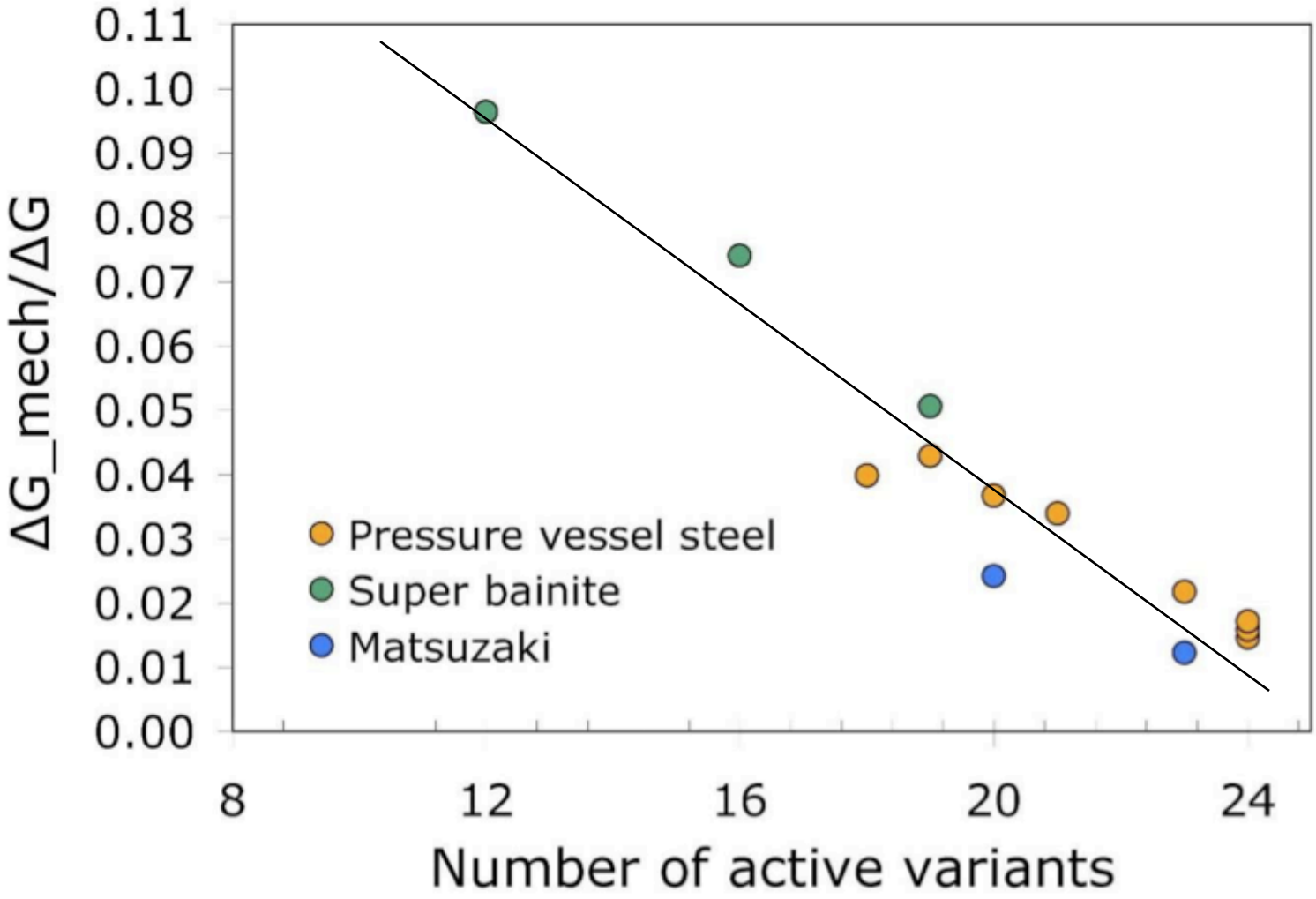
(c)


[0 1 0]S
[1 0 0]S

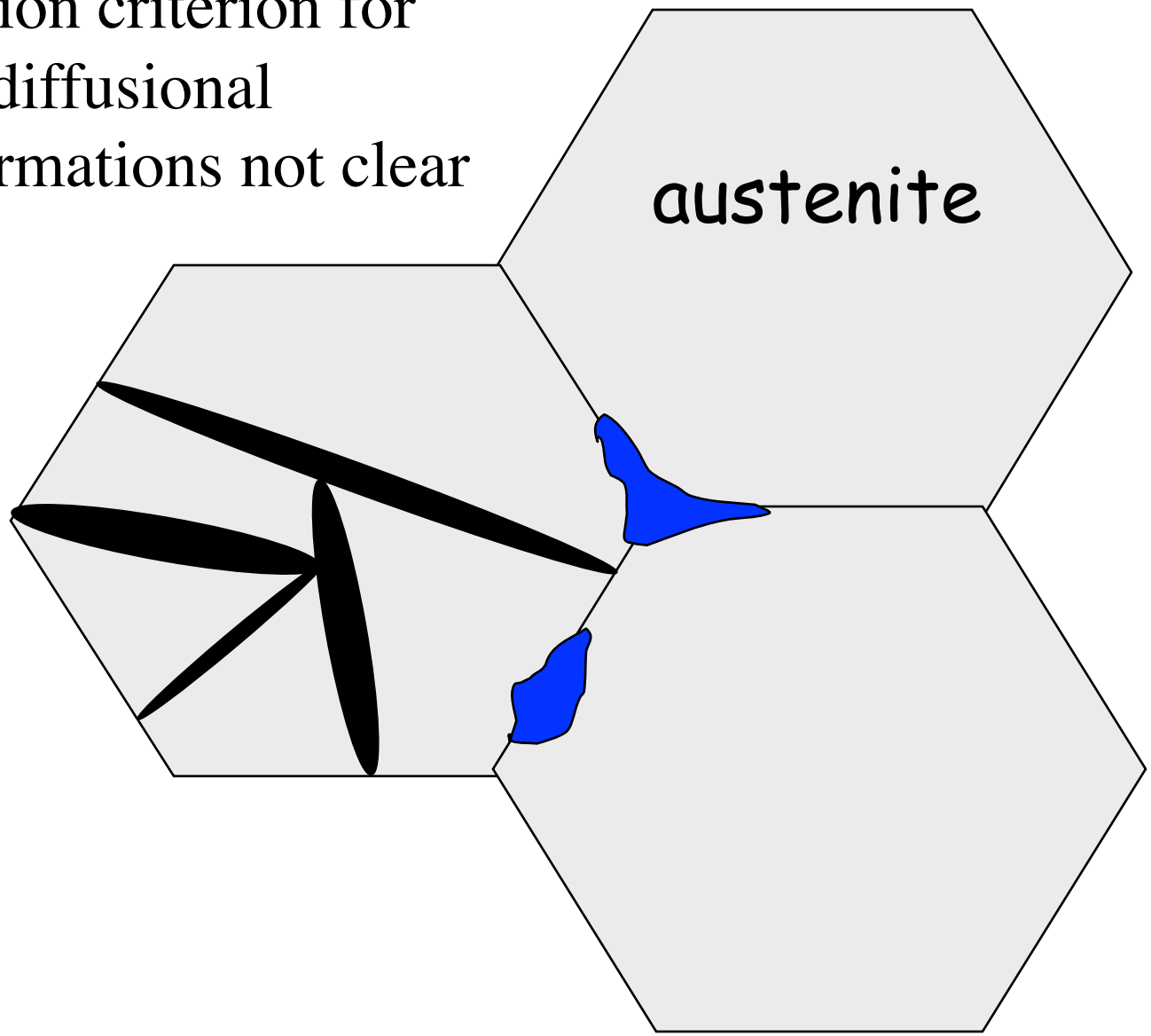
No method calculates INTENSITY,
only POSITIONS of poles

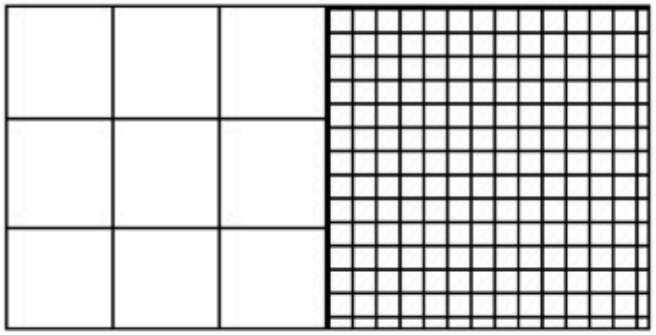


$$\Delta G = \Delta G_{CHEM} + \Delta G_{MECH}$$

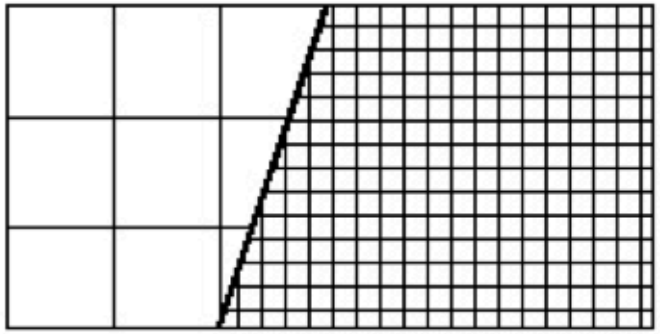


selection criterion for diffusional transformations not clear

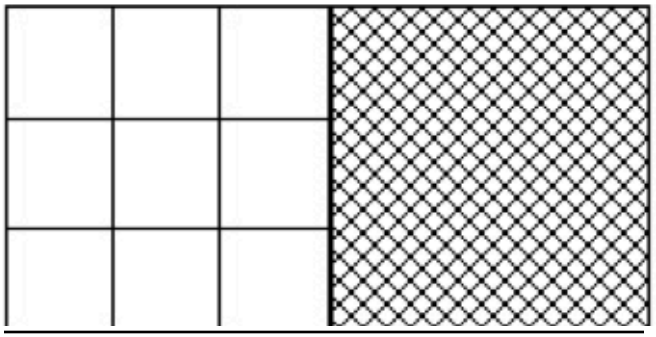




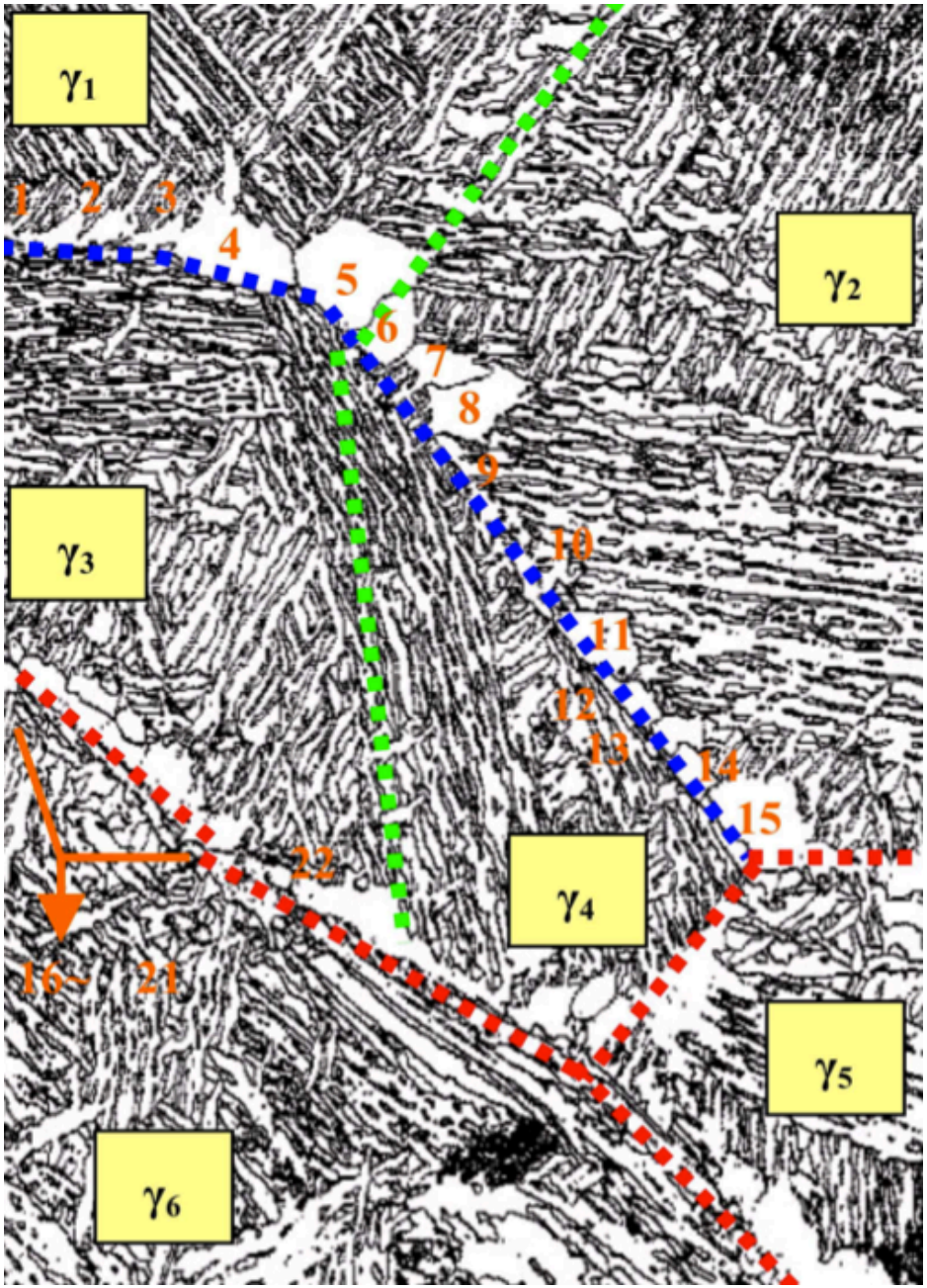
Reference
bicrystal



Orientations fixed,
interface plane altered



Orientation altered,
interface plane fixed



Contact with more than one austenite grain

Role of austenite grain boundary plane

Nucleation or growth dominated?

Number of variables very large (10 μm cube requires 10^{15} parameters)