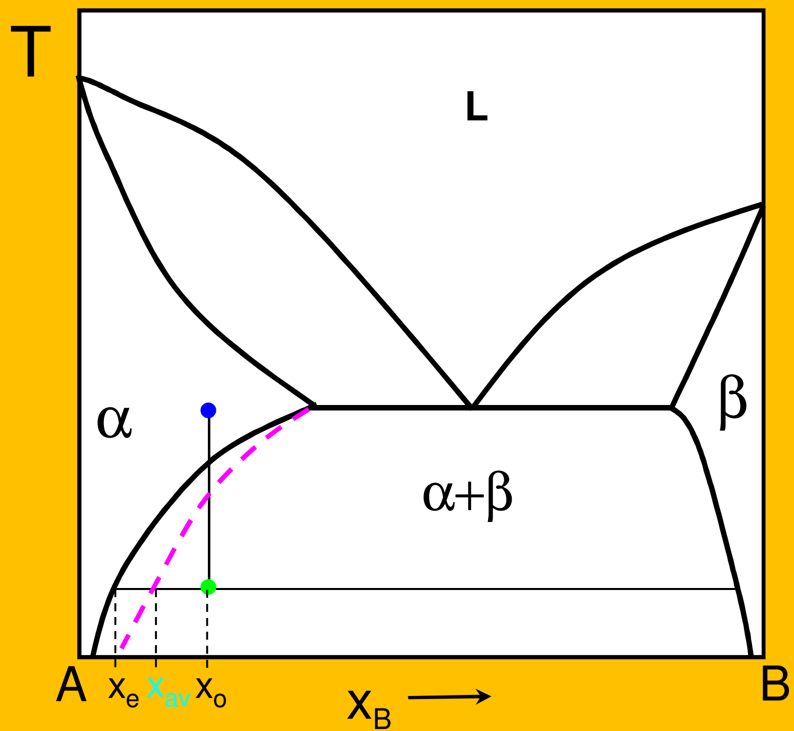
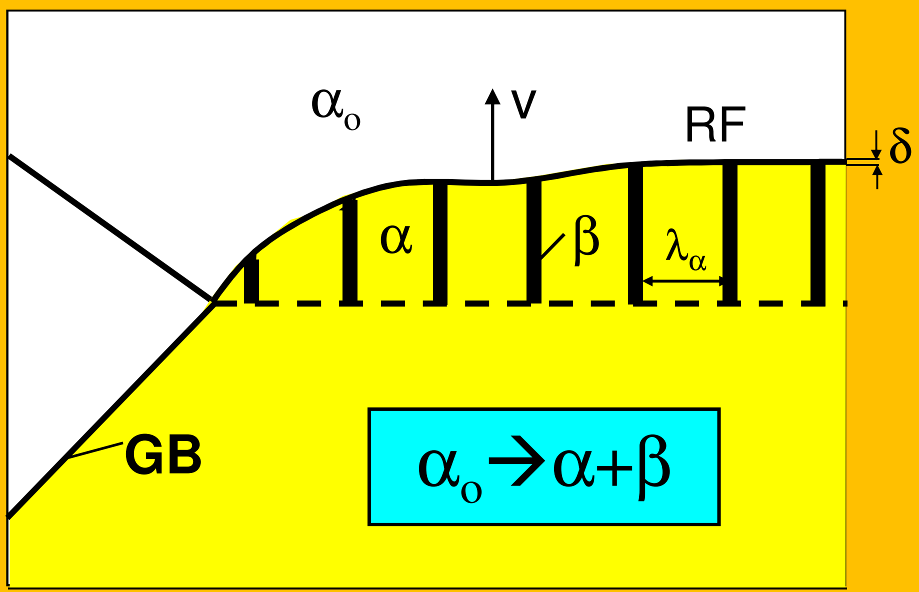
In-situ observations of moving interfaces during DP reaction

ATTENTION !!!

This part includes movies which are not active in the pdf access. Please contact Lecturer in the case you want to have the copies of movies.

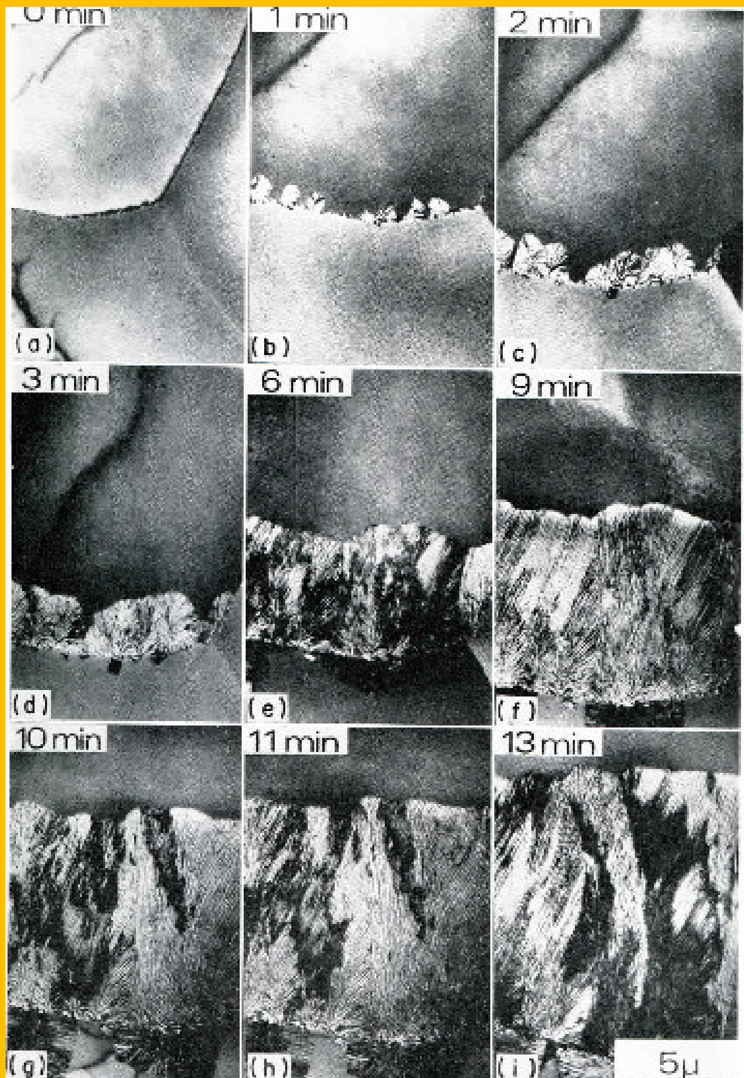




The solute redistribution occurs at the moving RF

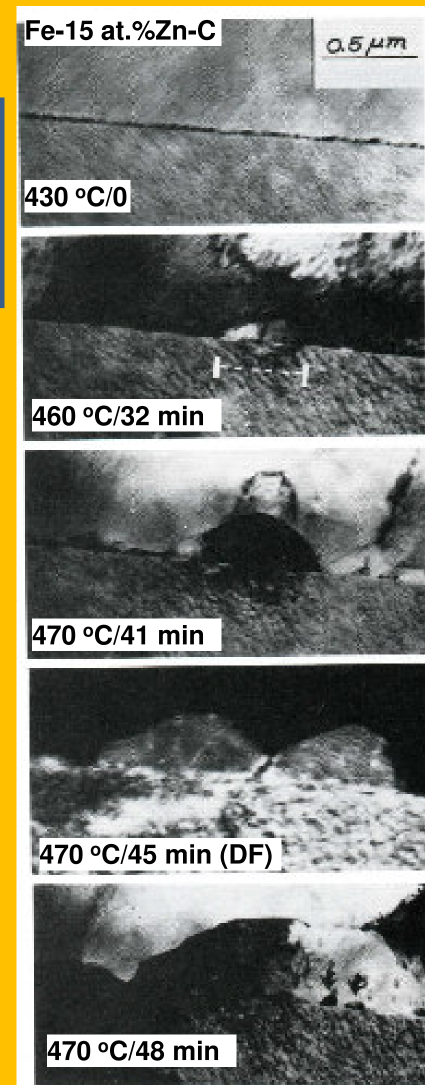
There exists an excess of solute atoms within the α lamella compared to the equilibrium state

Nucleation



Al-28 at. % Zn: 105 ^{o}C±15 ^{o}C

E.P. Butler, V. Ramaswamy, P.R. Swann, Acta Metall. 21 (1973-517-524.

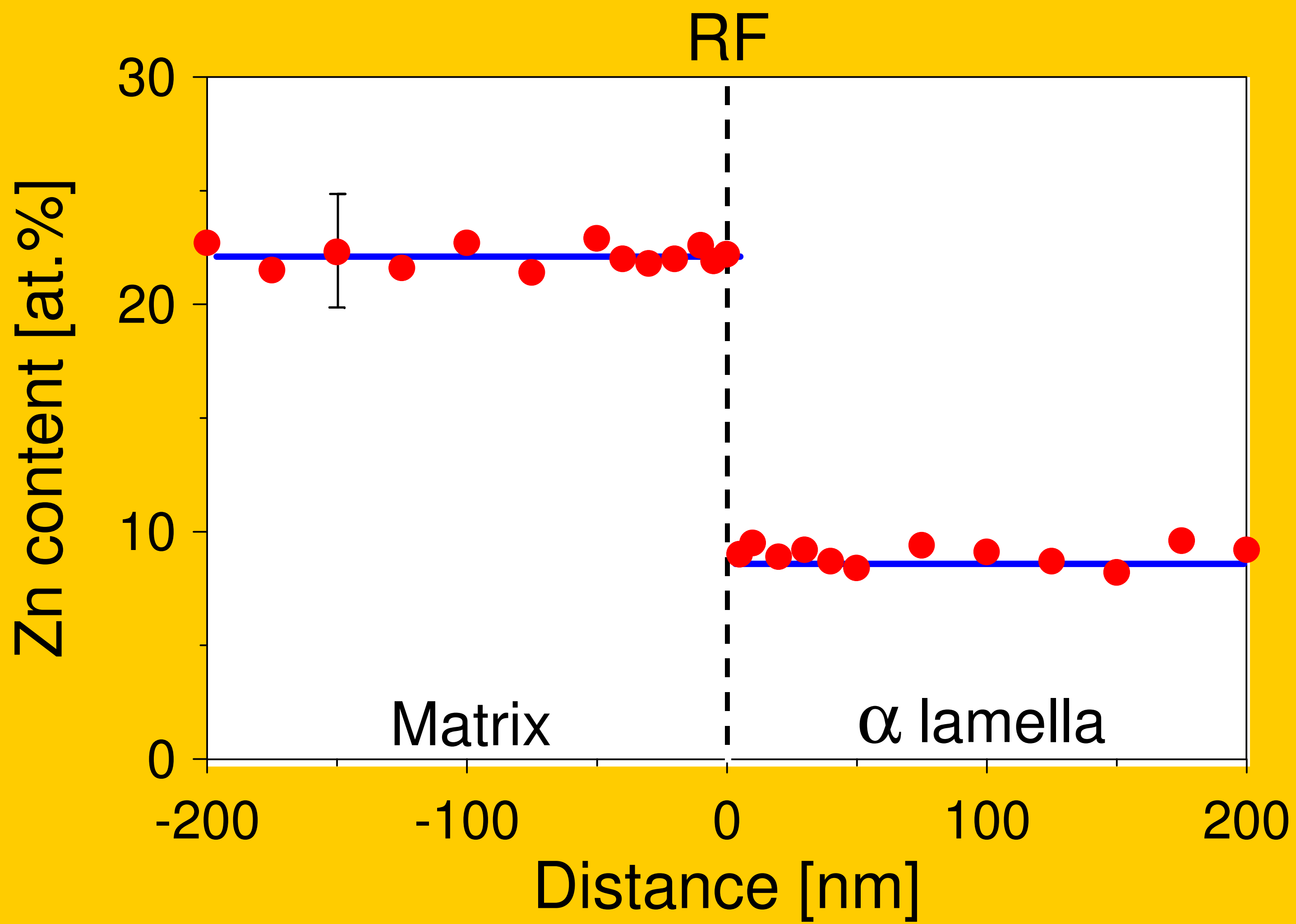


G.R. Purdy, N. Lange, in Decomposition of Alloys: the early stage, Proc. 2nd Acta-Scripta Metallurgica (P. Haasen, V. Gerold., R. Wagner, M.F. Ashby- eds.), Pergamon Press 1984, pp. 214-220

STEADY STATE GROWTH – REGULAR MORPHOLOGY

STEADY STATE GROWTH – REGULAR MORPHOLOGY

Solute Distribution Across Reaction Front

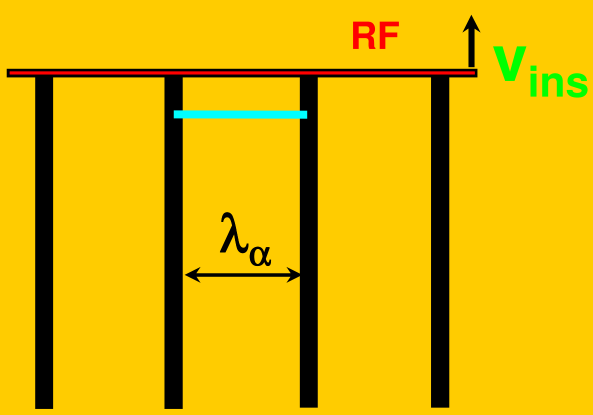


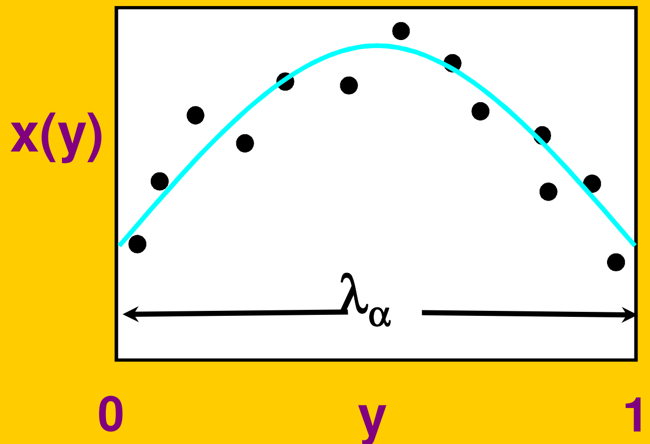
Solute concentration profile across the α lamella

$$x(y) = (x_e - x_o)\frac{\cosh\left[(y-0.5)\sqrt{C}\right]}{\cosh(\sqrt{C}/2)} + x_o$$

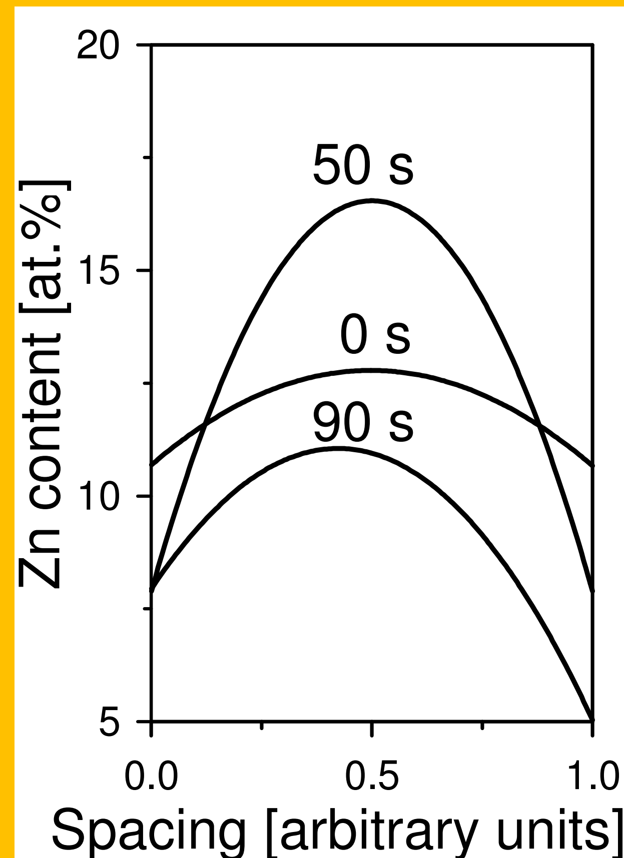
$$C = \frac{v_{ins}\lambda_\alpha^2}{s\delta D_b}$$

$$s = \frac{x_b}{x_o}$$





Shape changing

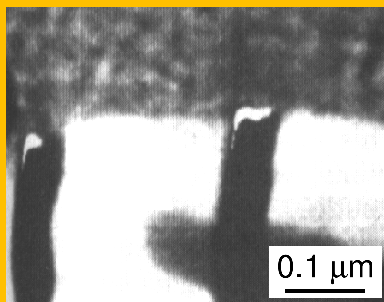


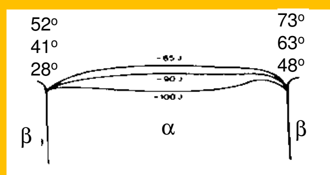
RF shape modelling (for known solute concentration profile in the α phase lamella

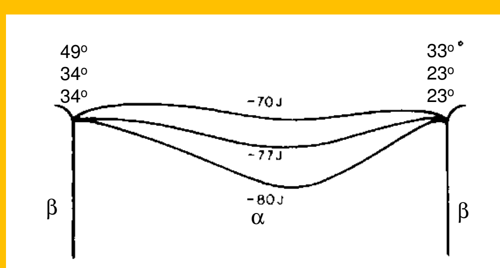
Al-22 at.% Zn aged at 403 K.

K. Tashiro and G.R. Purdy:

Metall. Transactions A20 (1989) 1593.







RF shape modelling (for known solute concentration profile in the α phase lamella

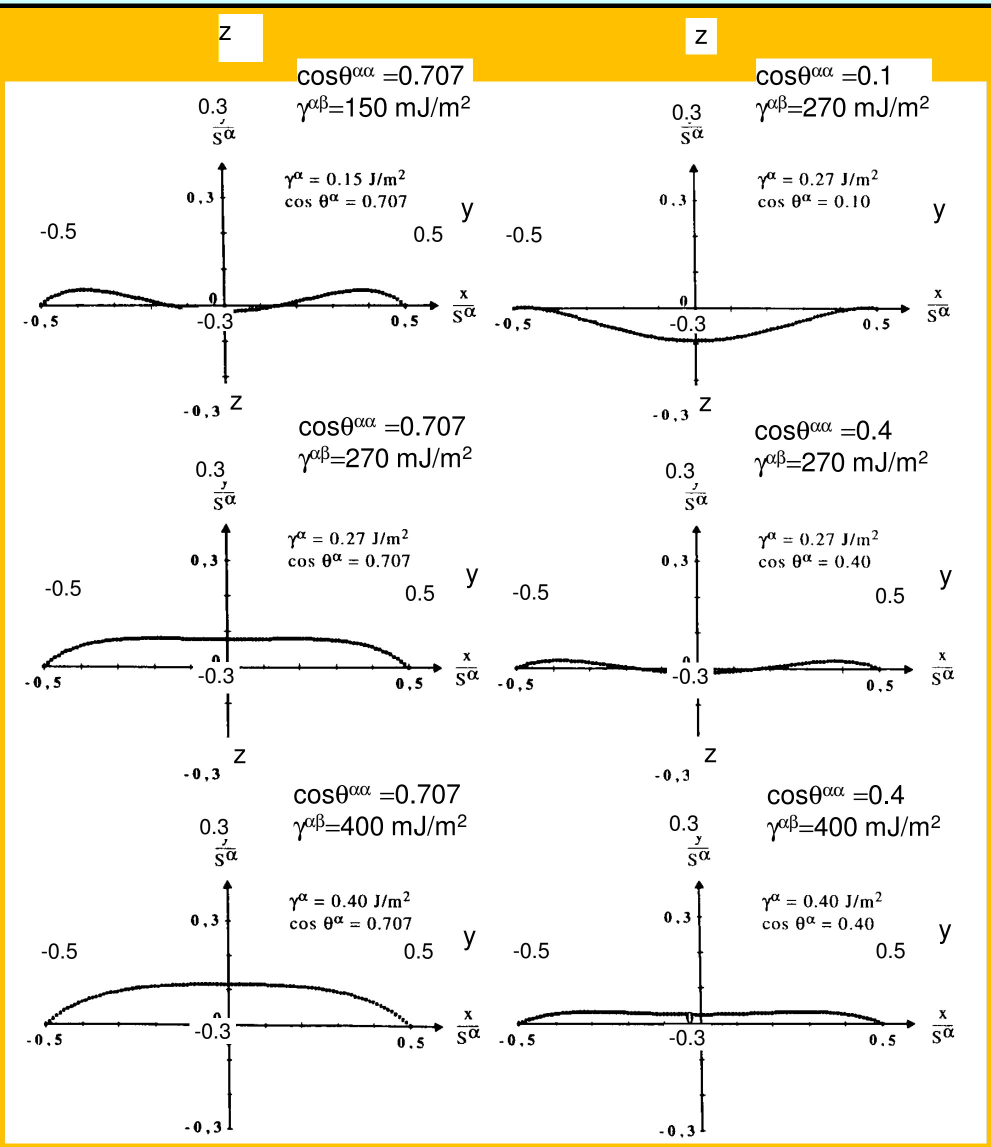
$$\frac{\gamma^{\alpha\alpha_o} V_m}{\rho} = \frac{v}{M^{\alpha\alpha_o}} - \Delta G_c^{\alpha}$$

$$\rho = \frac{\left[1 + \left(\frac{dz}{dy}\right)^2\right]^{1.5}}{\frac{d^2 z}{dy^2}}$$

$$y(x) = x_o - (x_o - x_e)\frac{\cosh\left(\frac{s(y)}{\lambda_{\alpha,l}}\sqrt{C}\right)}{\cosh\left(\sqrt{C}/2\right)}$$

D. Duly, M.G. Cheynet, Y. Brechet:
Acta Metall. & Mater. 42 (1994) 3855.

ΔG – local change of free energy at RF, *M* –RF mobility, V_m – molar volume of cellular aggregate, γ^{α/α_o} – α/α_o interfacial energy, *r* – local curvature of RF, *v* – growth rate



Mg-10 at.% Al aged at 493 K

D. Duly, M.G. Cheynet, Y. Brechet: *Acta Metall. & Mater*. 42 (1994) 3855.

Reconstruction of solute concentration profile in the α phase lamella (from known RF shape)

$$\rho = \frac{\left[1+\left(\frac{dz}{dy}\right)^2\right]^{1.5}}{\frac{d^2z}{dy^2}}$$

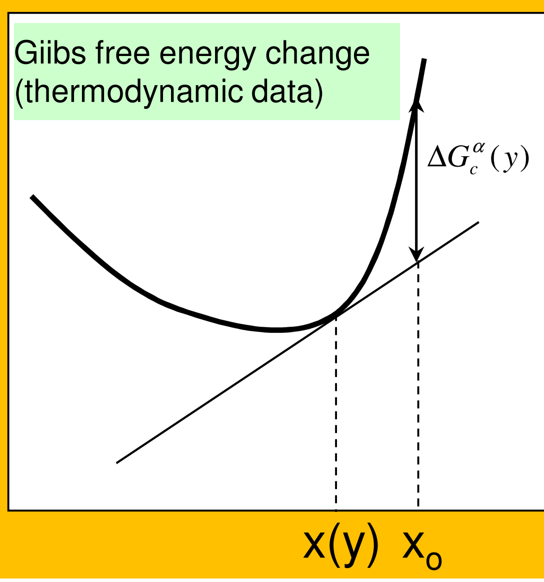
$$\frac{\gamma^{\alpha\alpha_o}V_m}{\rho} = \frac{v}{M^{\alpha\alpha_o}} - \Delta G_c^\alpha$$

For small solute content and small saturation (parabolic curve)

$$\Delta G_c^\alpha = \frac{RT\left[y(x)-x_o\right]^2}{2x_o}$$

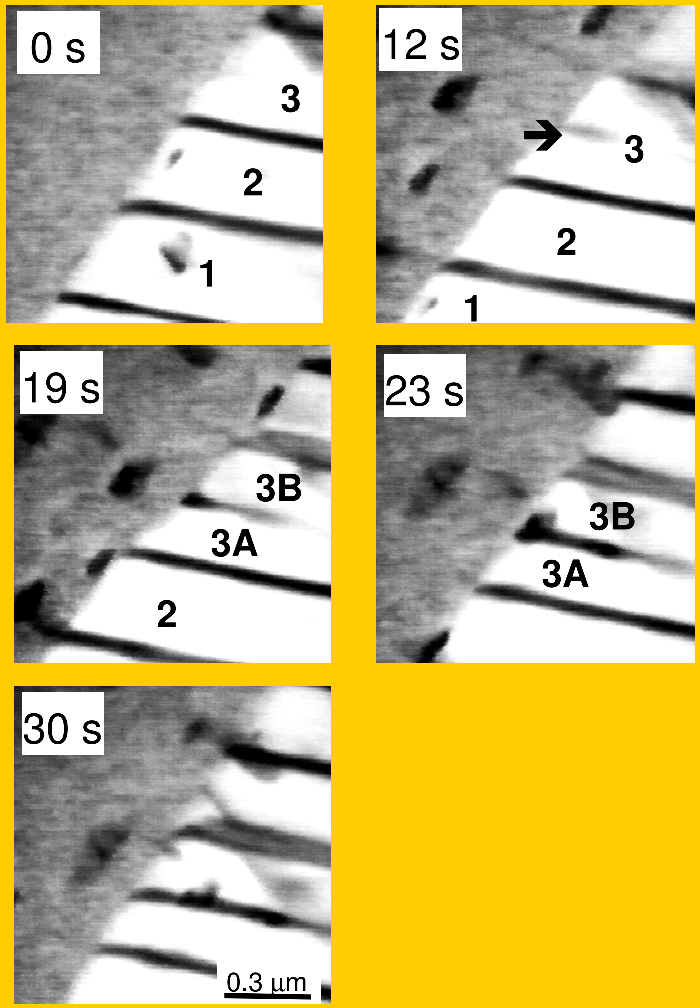
For small solute content (constant curvature)

$$\Delta G_c^\alpha = 0.5\left[x_o - y(x)\right]^2 \frac{d^2G_c^\alpha}{dx^2}$$

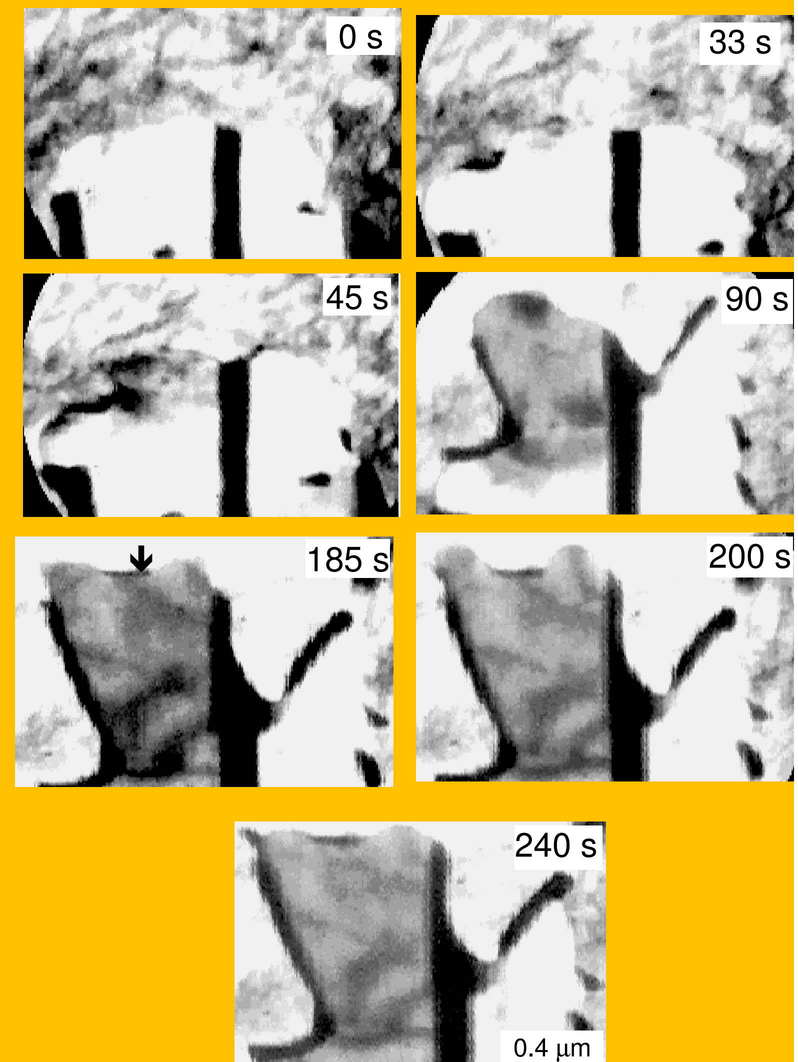


STEADY STATE GROWTH – IRREGULAR MORPHOLOGY

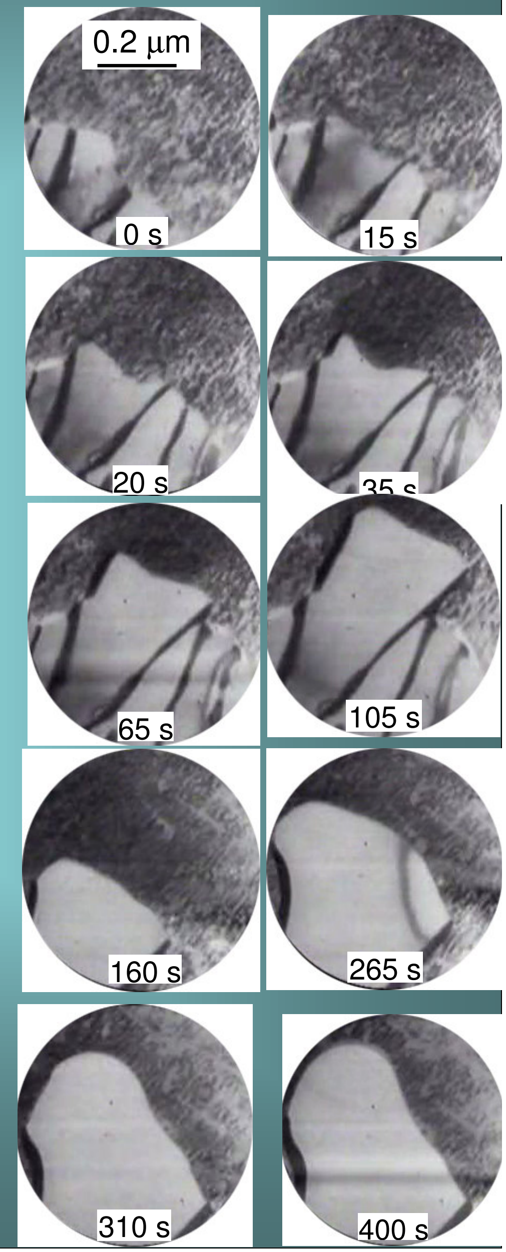
Re-nucleation



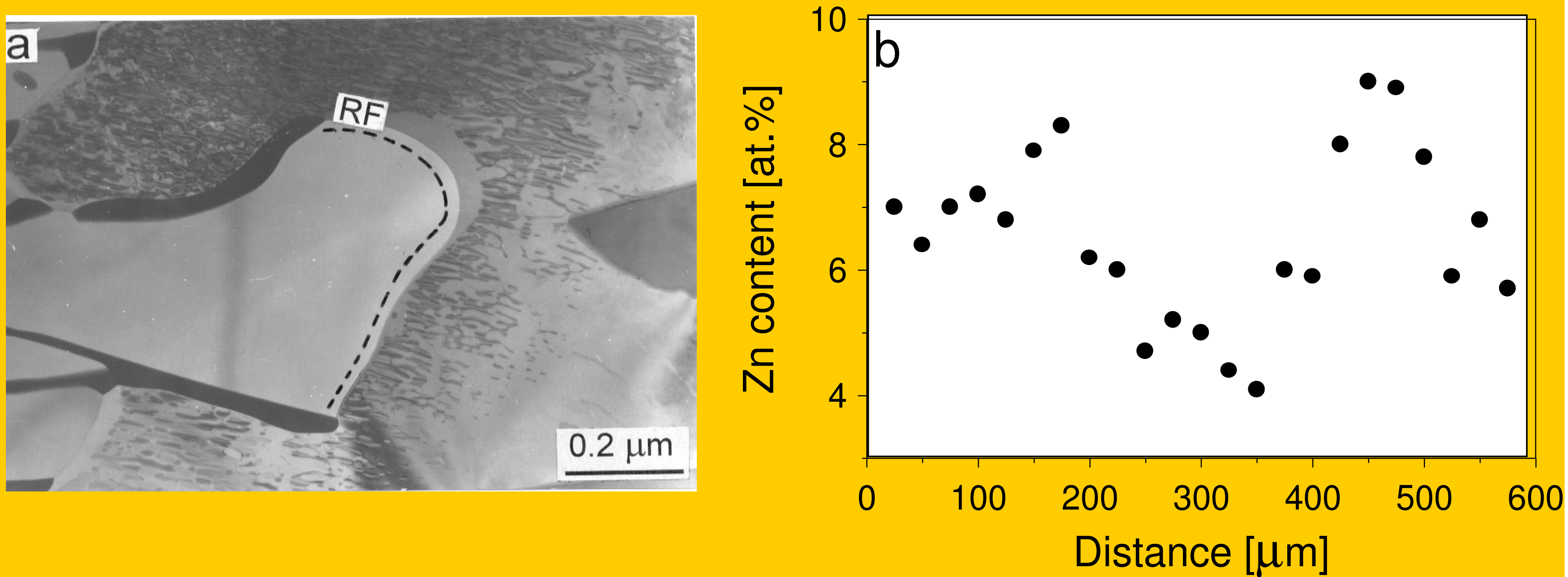
Re-nucleation and branching



Shape changing

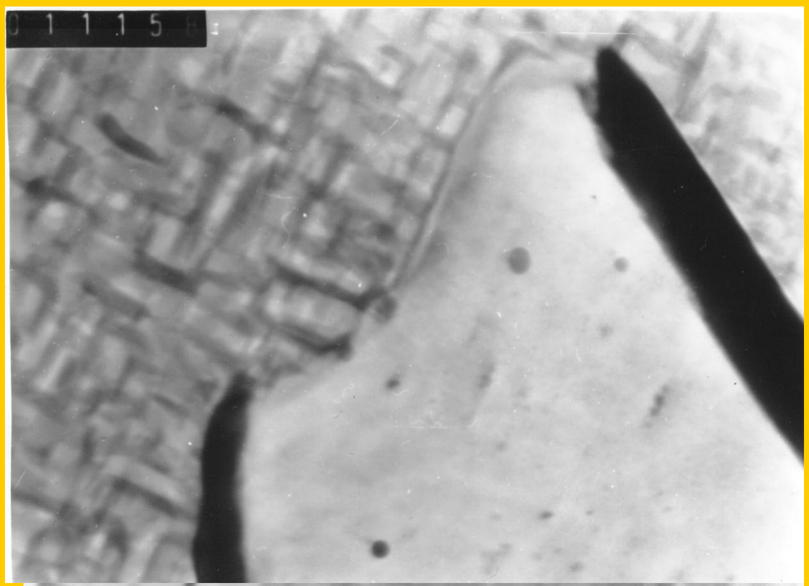


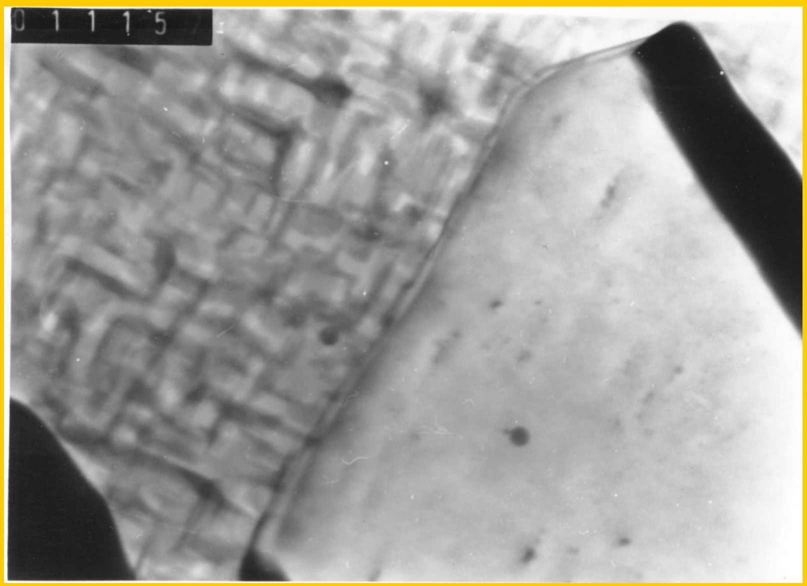
Shape changing



WZROST USTABILIZOWANY-MORFOLOGIA NIEREGULARNA

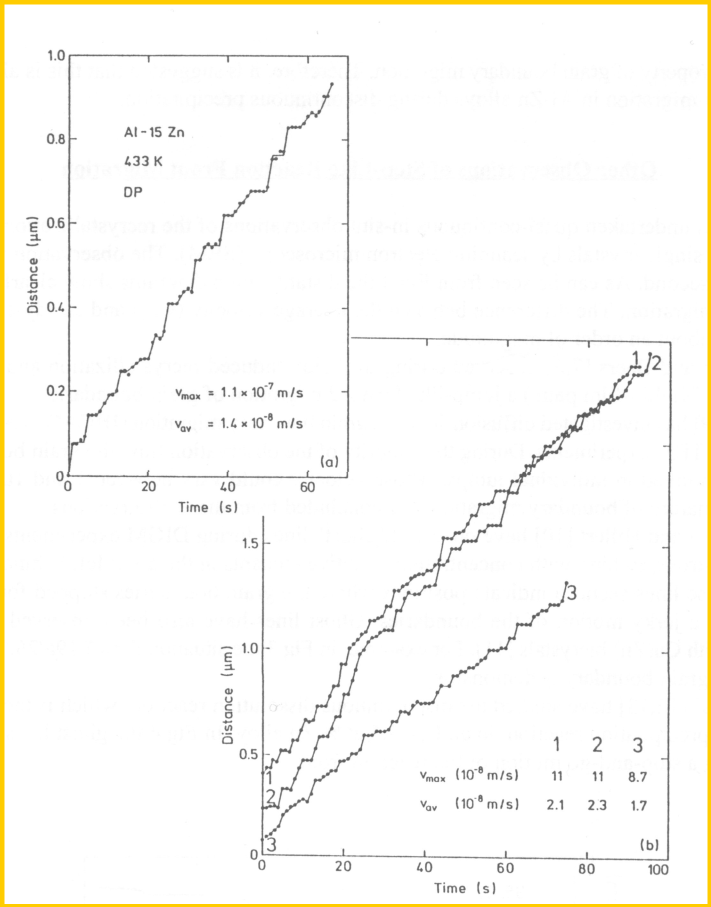
Zmiana kształtu frontu reakcji





Oscillatory movement?

STEADY STATE GROWTH – IRREGULAR MORPHOLOGY

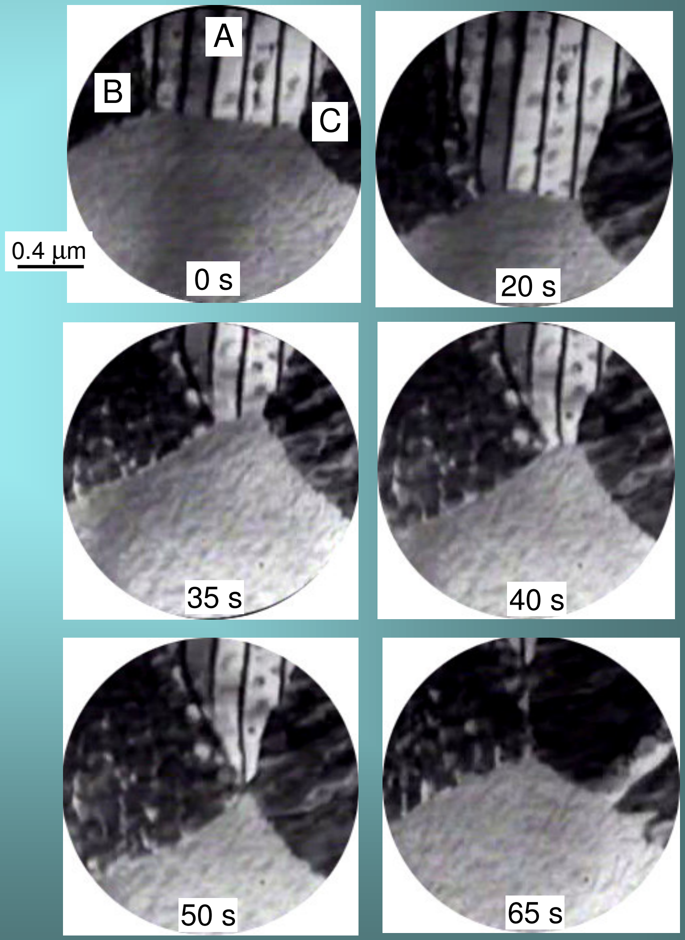


Stop- and go motion
oscillatory movement?

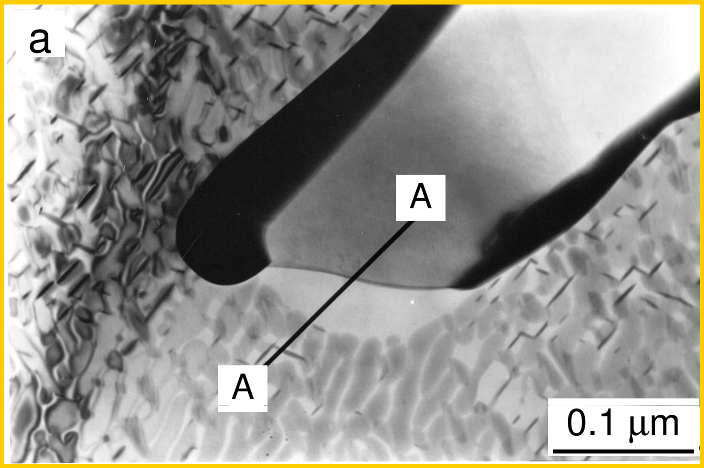
S. Abdou, G.I. Solorzano, M. El-Boragy, W. Gust, B. Predel,
Scripta Mater. 34 (1995) 1431

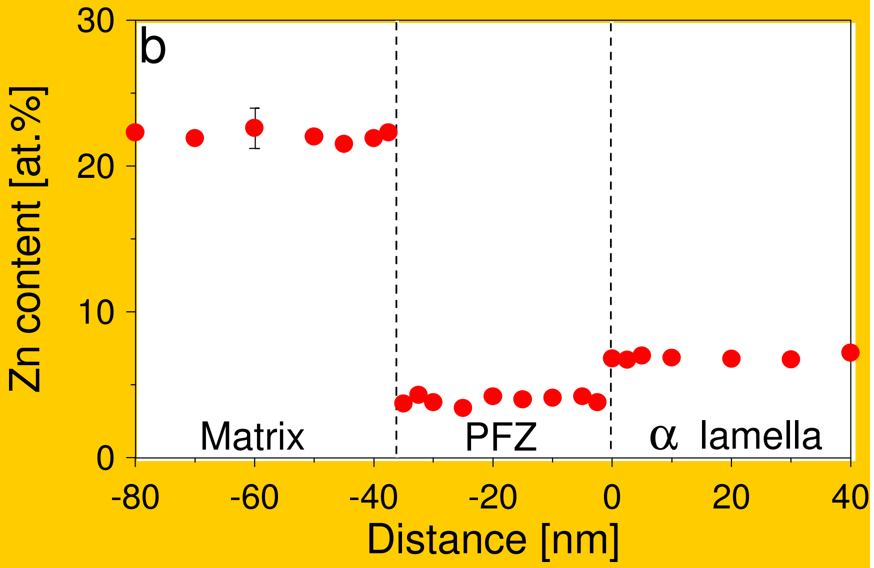
Al-15 at.% Zn alloy: DP: 433 K

Impingement of colonies



Precipitate free zone





Steady-state period of growth of DP reaction is influenced by various instabilities.

The system possesses some intrinsic capability to correct local RF shape to balance the forces acting on it if the perturbation is not larger than a certain critical value.

This sensitivity of the system may result in some asymmetry of the solute concentration profile.

If the critical value is exceeded or simply perturbation imposed is too large, re-nucleation and branching phenomena occur.

In some cases system becomes to be unstable: non-steady state growth.

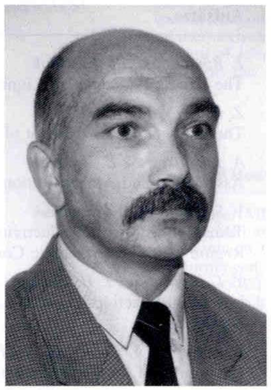
Termination of the DP reaction is due to impingement of colonies or PFZ formation (backward migration of the RF).

There is no HREM in-situ observation: How the atomic transport at the RF really looks like?

How to determine the solute profile across the α lamellae without a need for EDX/EELS analysis but based only on in situ recording of the RF shape?

What is the solute concentration profile within the RF from one to another neighbouring β lamella?

Werner-Köster-Preis 1999



DIE DEUTSCHE GESELLSCHAFT FÜR MATERIALKUNDE

verleiht zusammen mit dem

CARL-HANSER-VERLAG

Paweł Zięba

den WERNER-KÖSTER-PREIS 1999

für den Aufsatz

„In Situ Study of Discontinuous Precipitation and Dissolution in an Al-22 at.% Zn Alloy"

in der

Zeitschrift für Metallkunde 90 (1999) 669–674.

Der Aufsatz beschreibt beeindruckende In-situ-Untersuchungen, durch die neue Erkenntnisse zur Morphologie und Kinetik der diskontinuierlichen Ausscheidungs- und Auflösungsreaktionen gewonnen wurden.

Der Vorsitzende | Der Schriftleiter