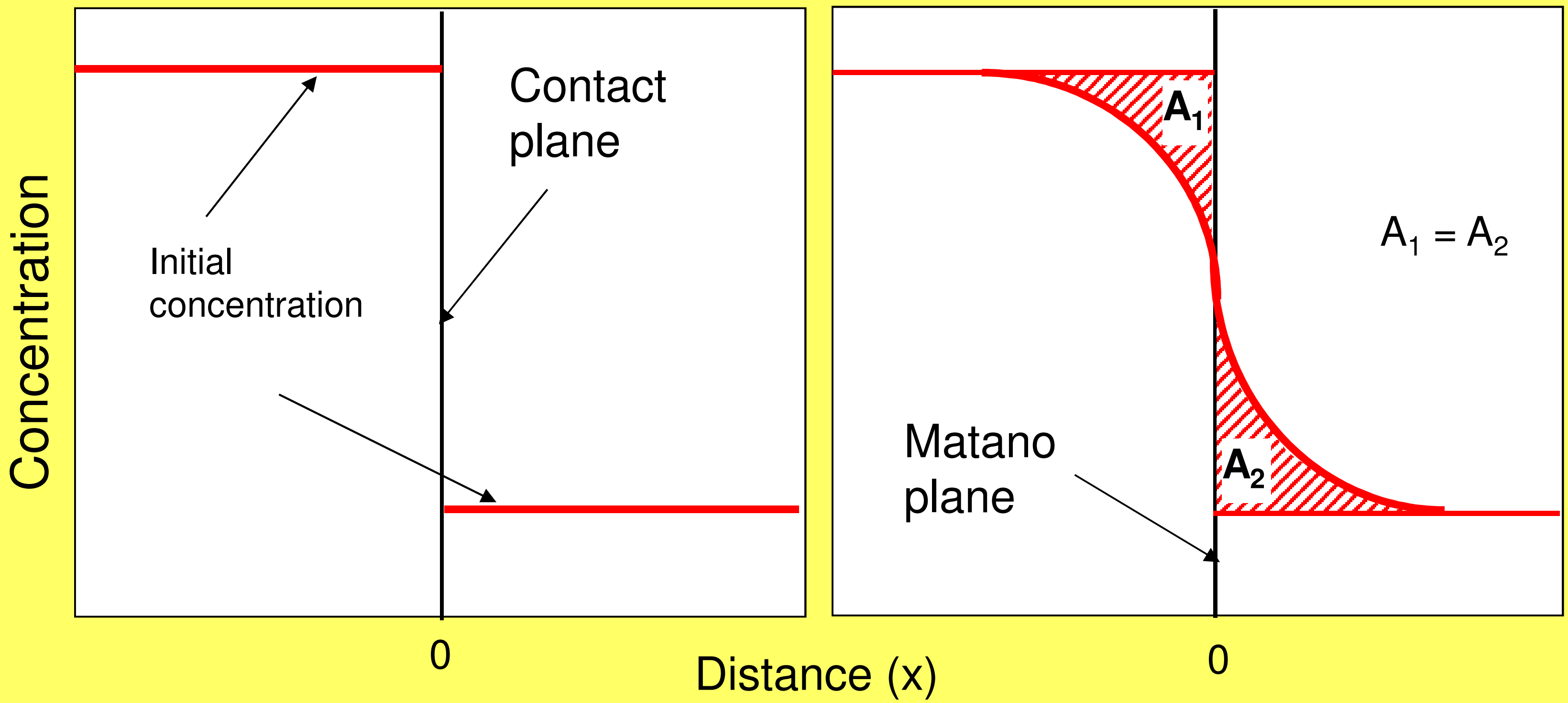
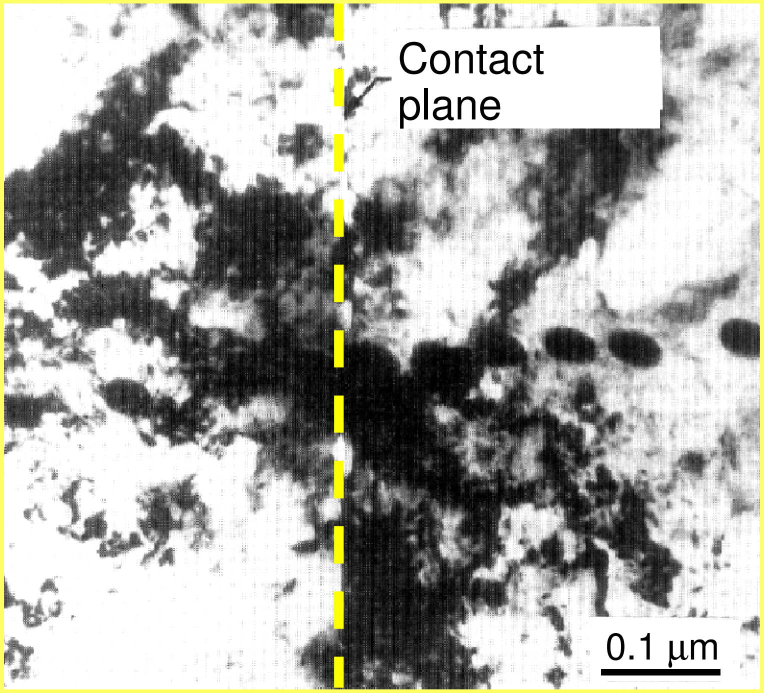
DETERMINATION OF VOLUME DIFFUSION COEFFICIENT

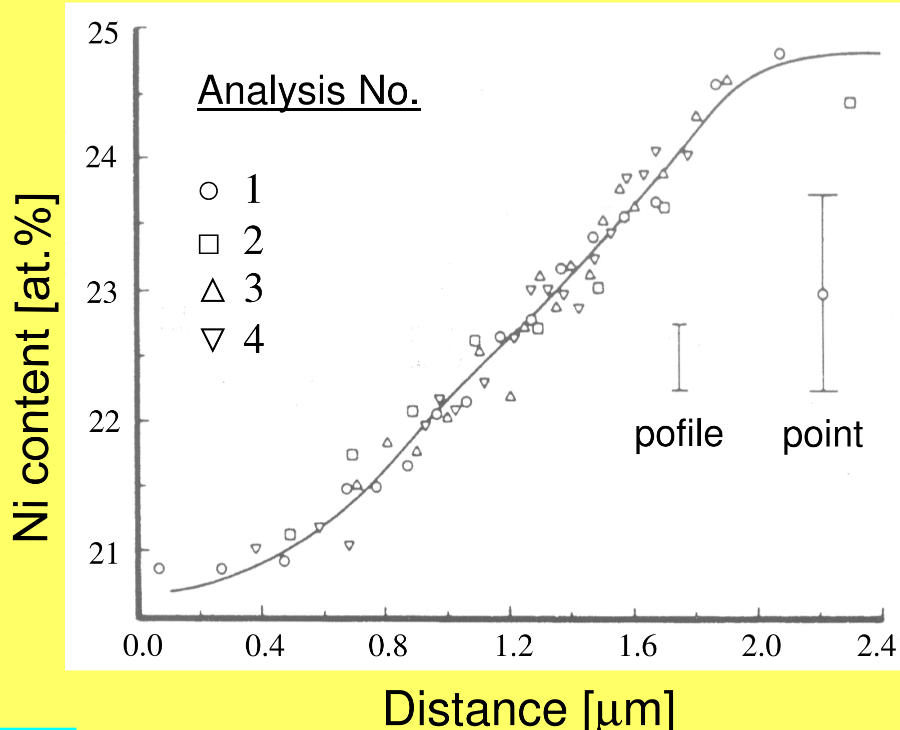
Volume diffusion coefficient-diffusion couple



$$\tilde{D}_{c=c_1} = -\frac{1}{2t}\frac{dx}{dc}\int_{0}^{c=c_1} x\,dc$$

Fe-25Ni / Fe-20Ni: 650 °C/12 days





Shorter annealing time: x 10 ↓

Shorter diffusion distance: < 0.2 µm

EPMA: > 25 µm

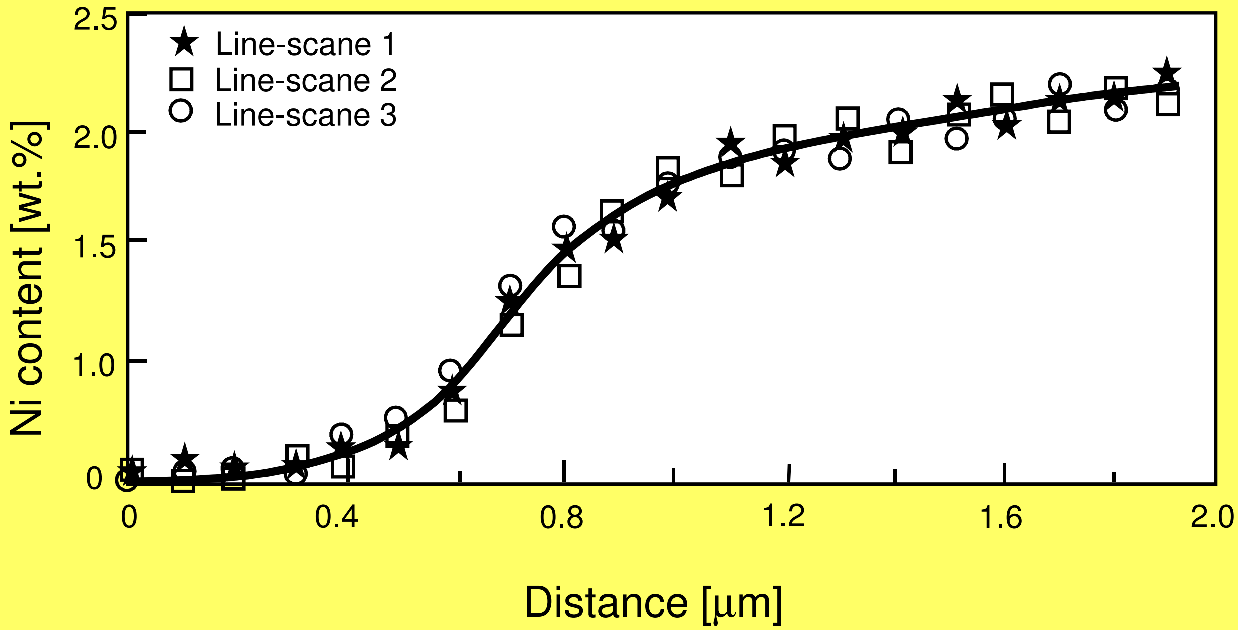
D_V at $T < 0.3\ T_m$

No grain boundary migration

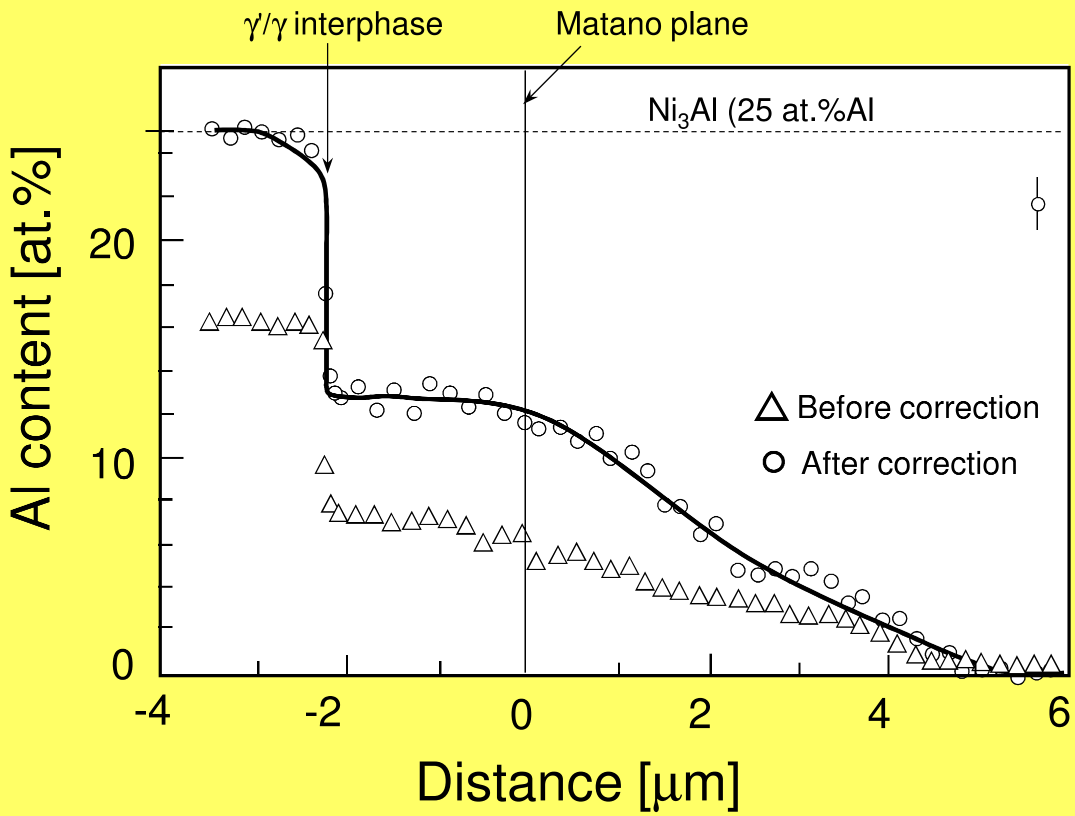
D.C. Dean, J.I. Goldstein,
Metall. Trans. A17, (1986) 1131

Volume diffusion coefficient-diffusion couple

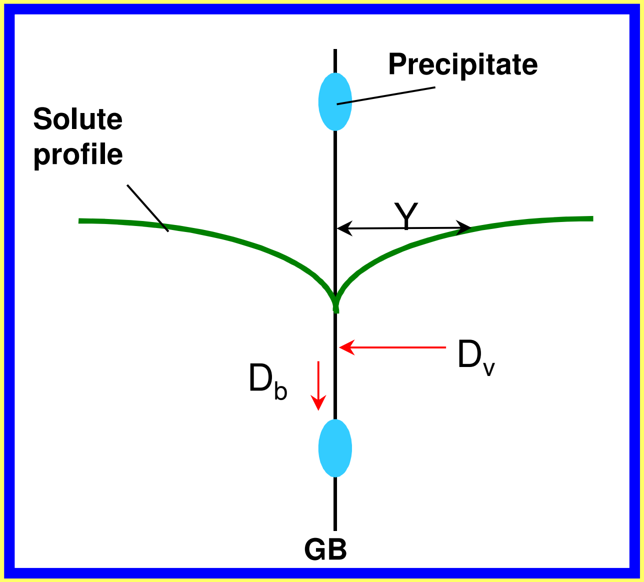
Ni concentration in Fe/Fe-2Ni wt.% diffusion couple annealed at 925 K for 30 h



Ni/Ni- 25 at.% Al diffusion couple annealed at 1100 K for 20 h



Precipitation of grain boundary allotriomorphs



The measurements of solute distribution close to the grain boundary occupied by the GB allotriomorphs is the method of obtaining of the reliable diffusion data at relatively low temperatures

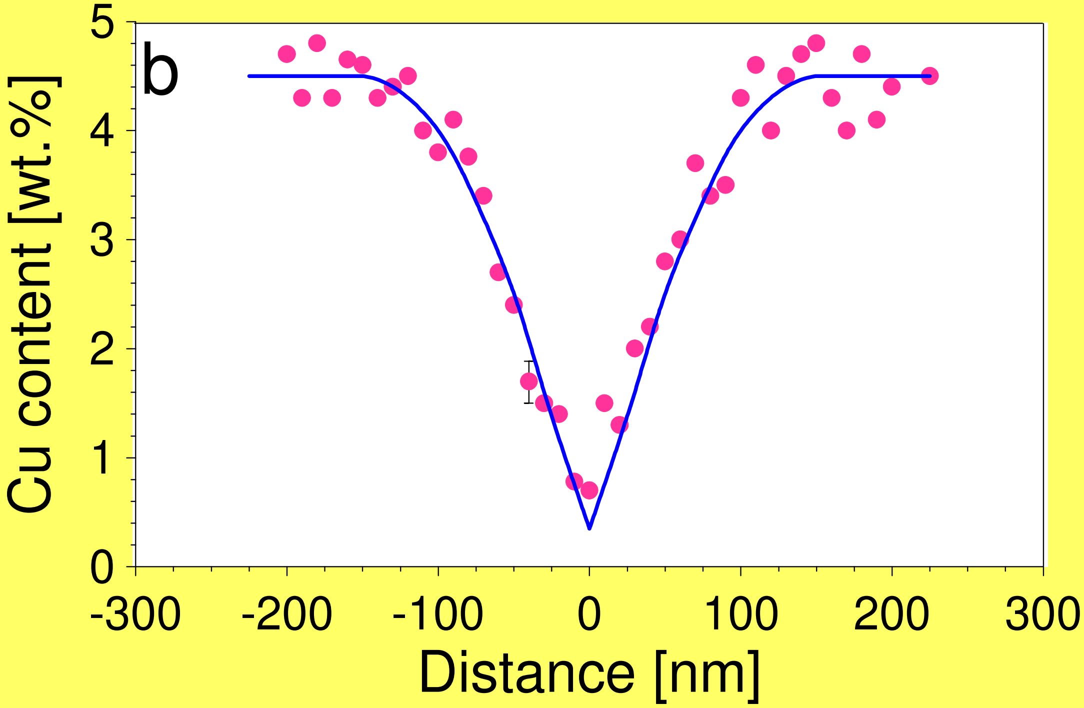
$$x(y) = x_o + (x_e - x_o)\,\mathrm{erf}\left(\frac{y}{2D_v t}\right)$$

t - time of annealing,
x_e-equilibrium solute content,
x_o-solute content in the alloy,
D_v-volume diffusion coefficient.

The half-width, Y of the solute depletion region

$$Y = 2\sqrt{Dt} \quad if \quad \frac{x(y) - x_o}{x_e - x_o} - \mathrm{erf}(1) \cong 0.84$$

Al-4 wt.% Cu

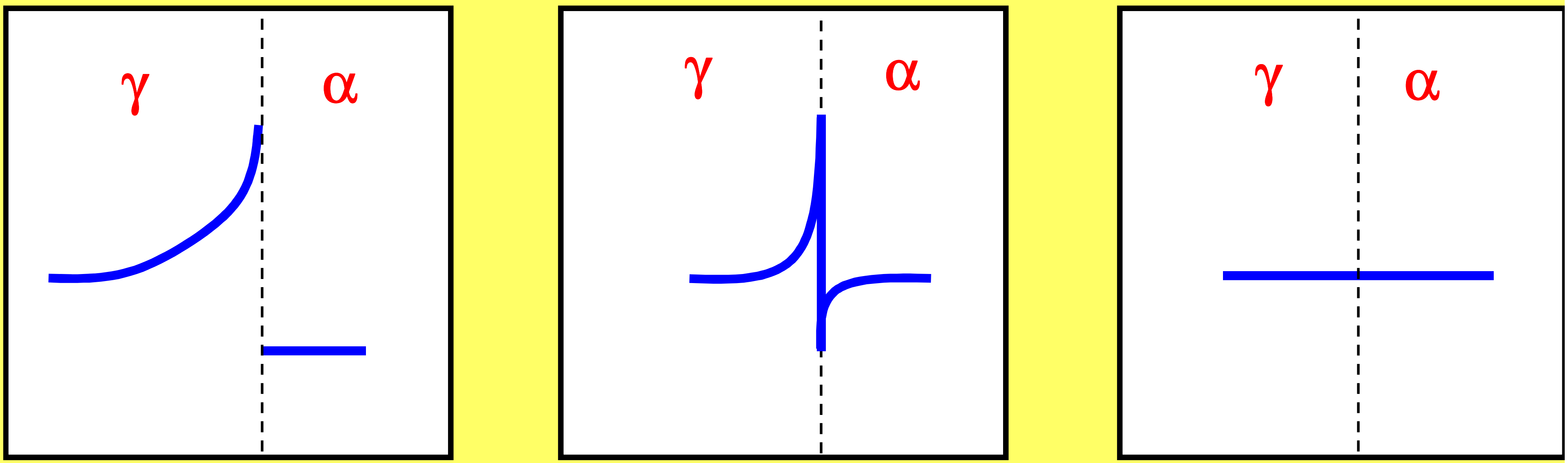


$$D_V = 1.15 \times 10^{-5} \exp\left(\frac{-32\ \text{J/mol}}{RT}\right) \text{m}^2/\text{s}: \quad 460 - 580\ \text{K}$$

DETERMINATION OF PHASE TRANSFORMATION TYPE BASED ON THE MICROCHEMICAL ANALYSIS

Growth of intragranular ferrite in Fe-Ni-P alloys

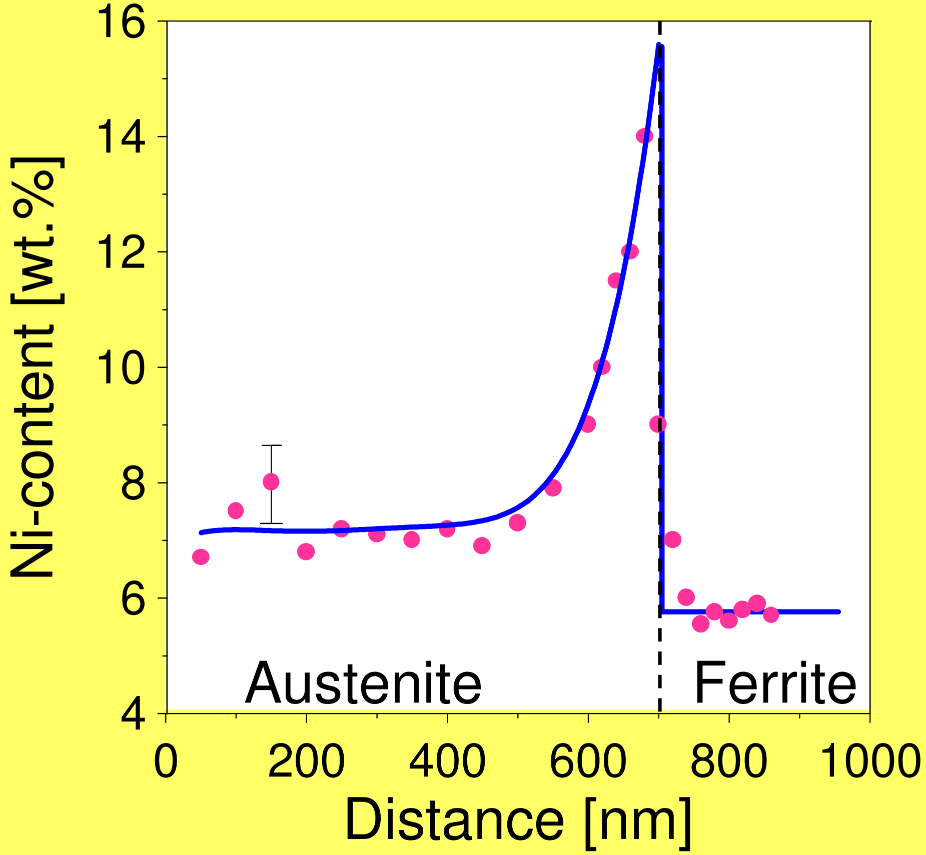
Three kinds of the partitioning behaviour of the alloying elements during the austenite (γ) to ferrite (α) transformation in the A-B-X ternary systems

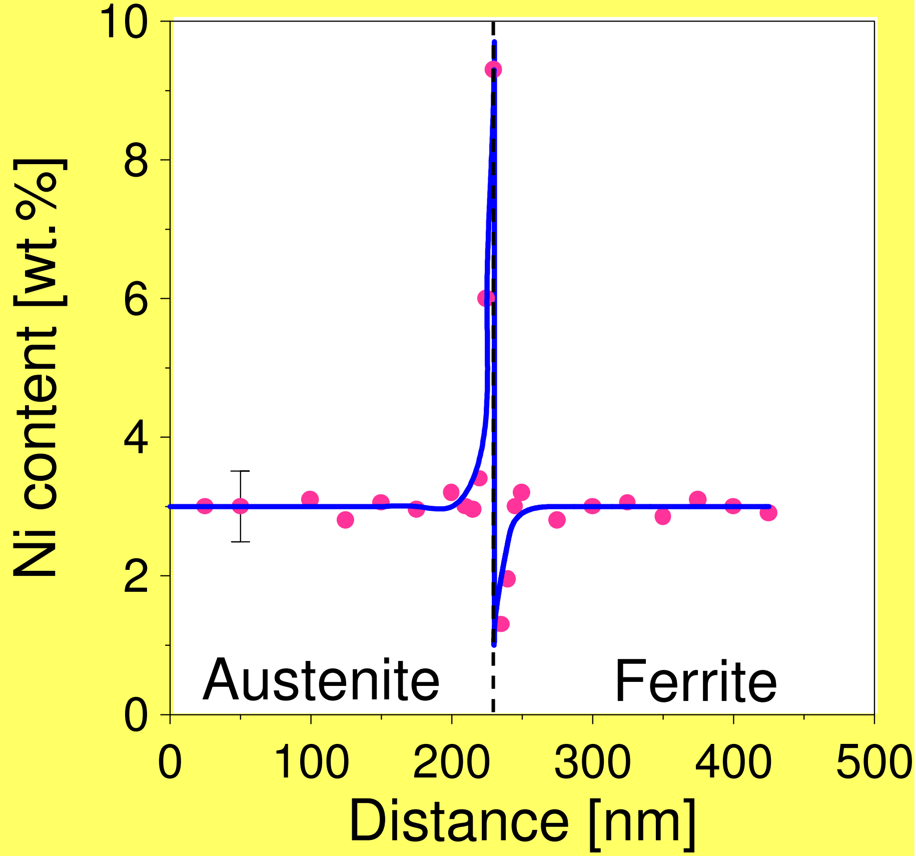


Full equilibrium | Local equilibrium | Para-equilibrium

The determination of the solute redistribution across the α/γ interface will indicate clearly, which mode of the partitioning is dominant.

Growth of intragranular ferrite in Fe-Ni-P alloys



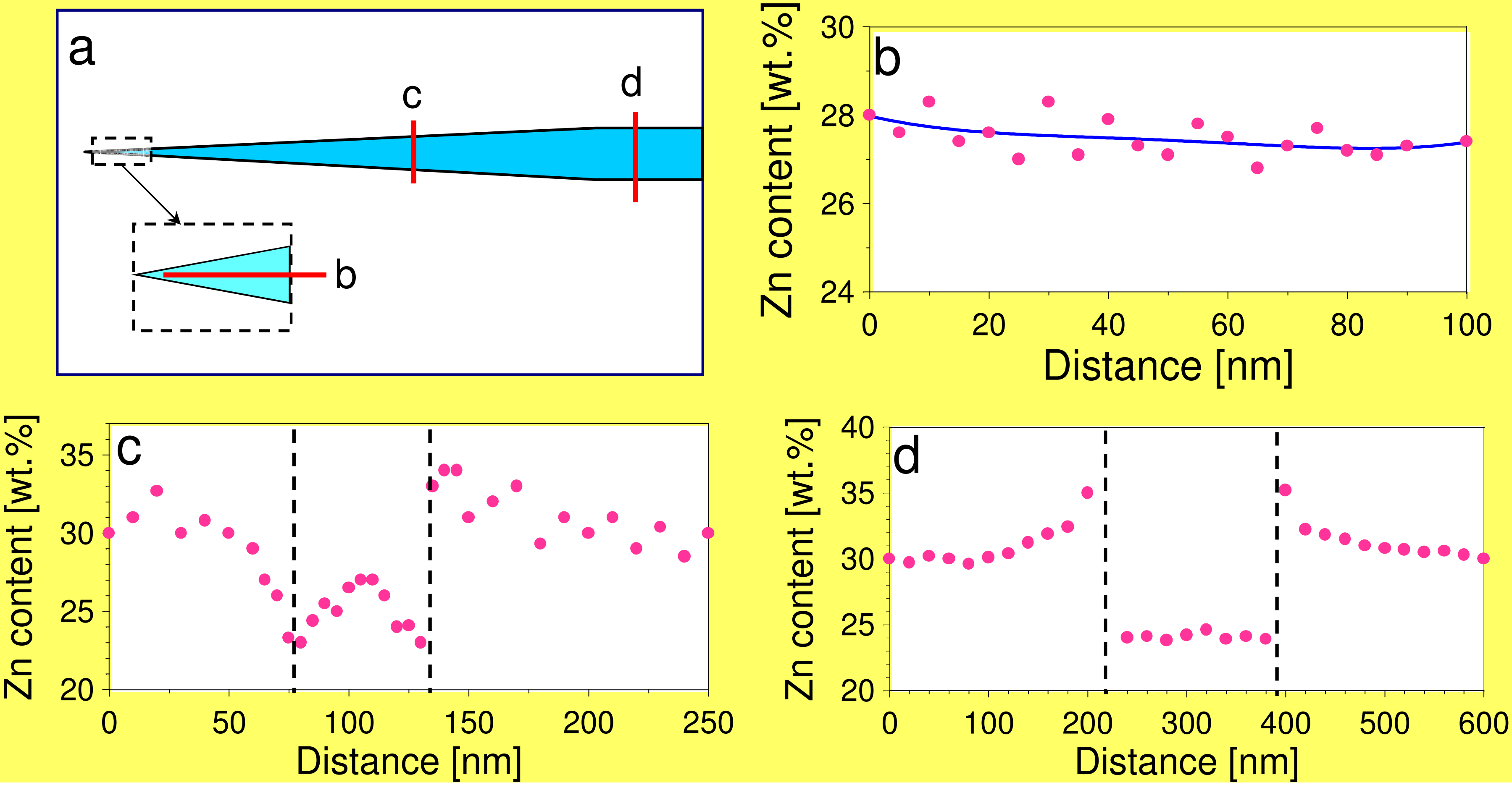


Fe-7.2Ni-0.5P (wt.%) alloy cooled from 1170 K to 925 K at the rate of 5 K/day

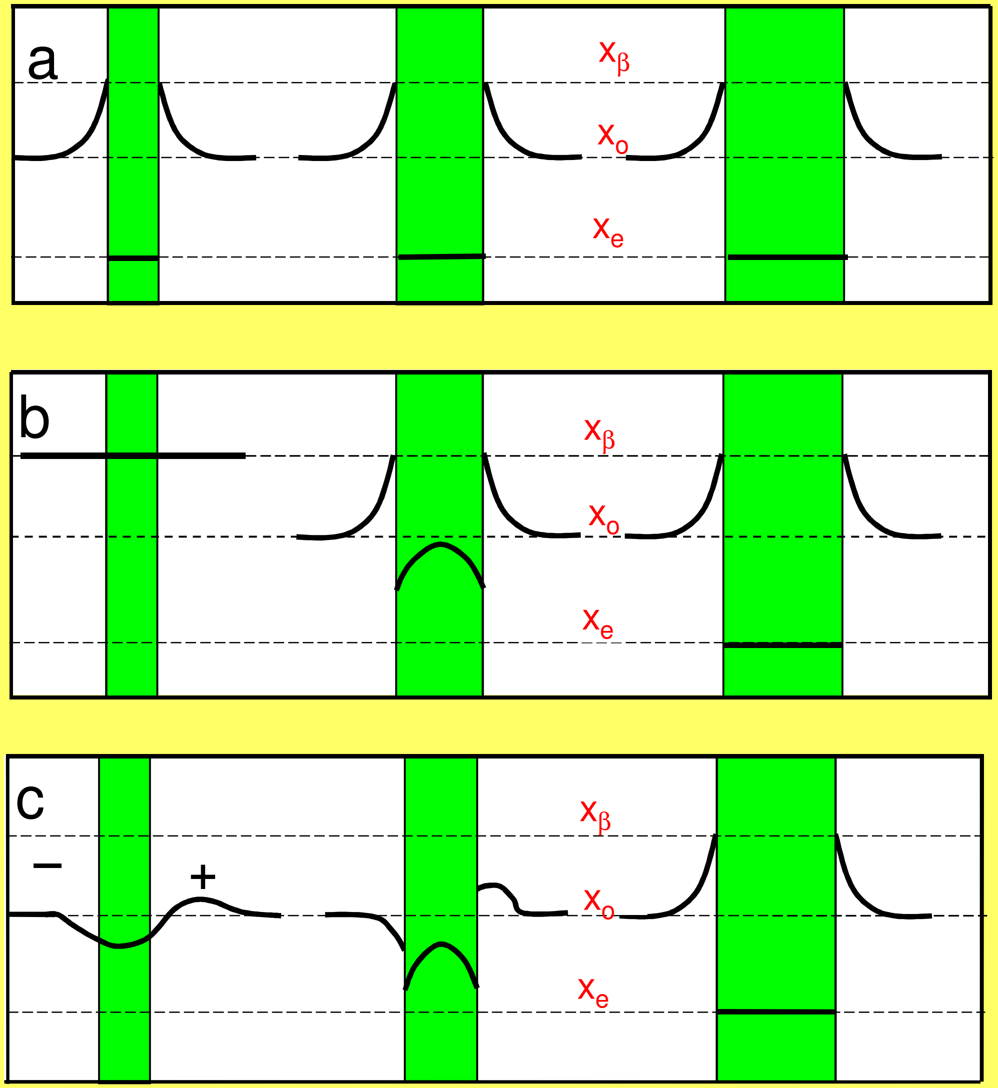
Fe-3Ni-0.6P (wt.%) alloys annealed at 1075 K for 3 months

Bainitic transformation in CuZnAl alloys

It is generally accepted that bainitic transformation requires both the martensitic shear and the diffusion-controlled mechanisms. The high spatial X-ray microanalysis can provide us with the information which mechanism prevails in nucleation and growth stage of the transformation



Redistribution of solute accompanying the bainitic transformation



(a) Bainite forms as an quilibrium phase during diffusion controlled process.

(b) Formation of bainite plate by pure shear mechanism (no change in the solute content). Growth controlled diffusion until the equilibrium state is obtained.

(c) Nucleation by shearing at the defects where the solute concentration is reduced due to stress induced diffusion. The diffusion from the compression (-) to tension (+) side in the stress field, activates the faster growth in (+) direction.

Conclusions

With careful assessment of experimental conditions, it seems likely that technique of analytical electron microscopy enables a quantitative microanalyses of relatively high quality and with a good spatial resolution approaching a few nanometers.

This makes possible the interdiffusion experiment at temperatures below 0.3 melting point based on the classical diffusion couples or grain boundary allotriomorphs.

Simultaneously AEM is an indispensable tool for the direct determination of the GB diffusivity at the moving reaction front of discontinuous precipitation and for establishing the mechanism operating in such phase transformations as: austenite to ferrite and bainitis in non-ferrous alloys.