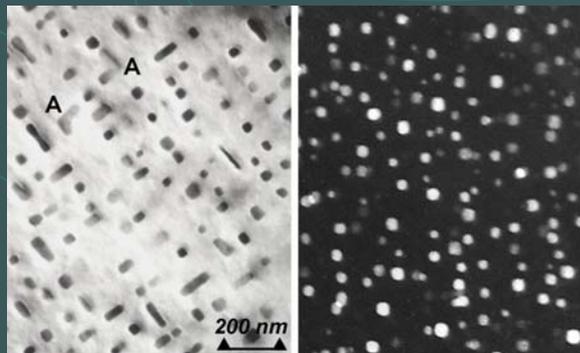


Coarsening of Ni-Al Precipitates in Inverse Ni₃Al Alloys

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We are investigating the coarsening behavior of γ (Ni-Al solid solution) in monolithic γ' (Ni₃Al). We call these alloys *inverse* alloys. The objective is to compare the coarsening of γ in inverse alloys with the well-known coarsening behavior of γ' precipitates in normal alloys. The interfacial and elastic energies in both types of alloys are equivalent, yet preliminary research shows that the coarsening behavior is different in significant ways.

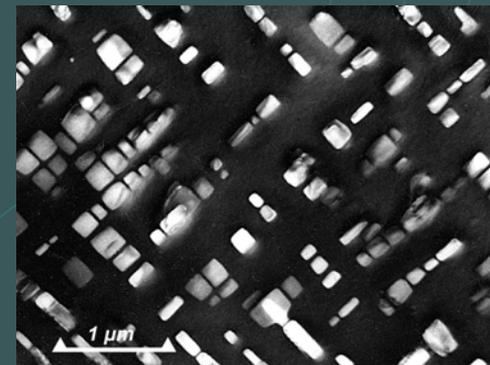


Inverse

Normal

- The figure at left shows coherent γ and γ' precipitates of approximately the same size (23 to 25 nm in dia.) and volume fraction (≈ 0.06).
- Coalescence of γ precipitates is much easier than coalescence of γ' precipitates, even producing L-shaped particles (indicated by "A").
- Coalescence of γ' precipitates at such small sizes is never observed.

- Nearest-neighbor γ' precipitates strongly resist coalescence if they are anti-phase related, as postulated by Wang and Khachaturyan, Scripta Metall. Mater. 31 (1994) 1425.
- The resistance to coalescence manifests itself in small gaps between large neighboring γ' precipitates (photo at right).
- Our results provide convincing, albeit indirect, proof that the hypothesis of Wang and Khachaturyan is correct.



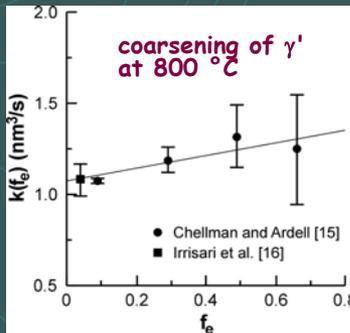
Large coherent γ' precipitates in a Ni-13.53 at.% Al alloy.

Trans-Interface Diffusion-Controlled (TIDC) Coarsening

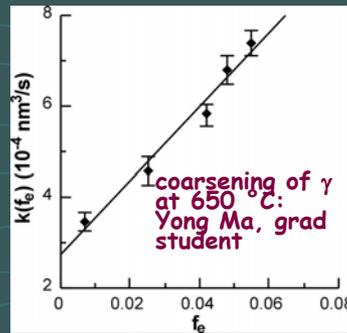
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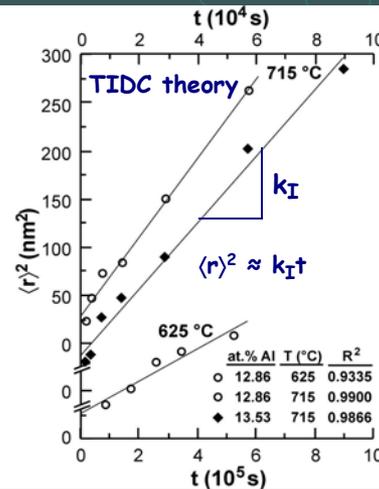
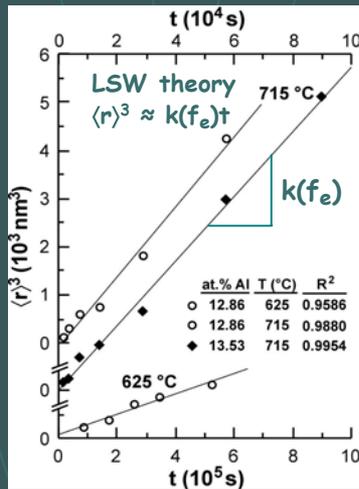
- Coarsening of γ precipitates in *inverse* alloys is very strongly dependent on volume fraction, f_e .
- Coarsening of γ' precipitates in normal Ni-Al alloys is essentially independent of f_e when $f_e > 0.05$ (see figure below, showing rate constants vs. f_e).
- Why is this behavior so different?



Normal



Inverse

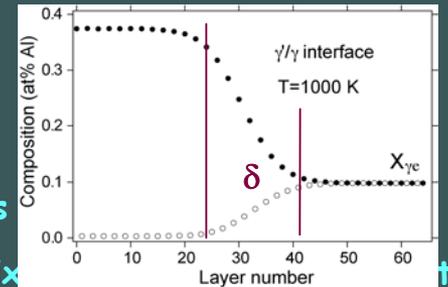


Comparison of predictions of the LSW theory with those of the TIDC theory. Published data on γ' coarsening in Ni-Al alloys. The values of R^2 show that the fits to the data are about equally good for both kinetic laws.

- Atomistic calculations show that the interface between the γ and γ' phases is not sharp.
- We propose that chemical diffusion through the interface (width δ) controls coarsening kinetics when the condition

is valid $\frac{\delta}{r} \gg \frac{D_{\gamma'}}{D_{\gamma}}$ the radius of the precipitate, is the chemical diffusion coefficient in the matrix in the interface.

- The interface is a diffusion bottleneck because diffusion in ordered Ni_3Al is about 100 times slower than in the disordered Ni-Al matrix.



The TIDC theory predicts new diffusion-controlled kinetic behavior for the growth of the average radius, $\langle r \rangle$ with time, t

$$\langle r \rangle^2 \approx k_I t$$

Which differs dramatically from classic LSW kinetics. The rate constant k_I is completely independent of f_e , as observed experimentally.