Relief of Internal Stresses by Precipitation

DURING an investigation of the recrystallization of two-phase silver–magnesium alloys, it has been observed that precipitation occurring in one of the phases, after deformation but before recrystallization, increases the temperature at which recrystallization starts in that phase.

This was shown in the following way. A silver alloy containing 31·8 atomic per cent magnesium (9·5 weight per cent) was water-quenched from 600° C., and an alloy containing 32·3 atomic per cent magnesium (9·7 weight per cent) was slowly cooled to 300° C. and quenched to room temperature. Both alloys, which then contained almost identical volume fractions of the two phases, were deformed by drawing to 80 per cent reduction in area and annealed at 350° C. for 30 min. During this annealing, the crystals of the α-phase recrystallized fully in both alloys. The crystals of the β-phase were almost fully recrystallized in the slowly cooled alloy, but showed no sign of recrystallization in the quenched alloy. Heavy precipitation of the α-phase occurred in the β-crystals of the quenched alloy, giving rise to a Widmanstätten structure, but no precipitation occurred in the slowly cooled alloy. This is shown in the microstructures, Fig. 1, *a* and *b*. The fact that precipitation occurred in the quenched but not in the slowly cooled alloy is in agreement with the phase diagram of the silver–magnesium system[1].

Fig. 2 shows the back-reflexion X-ray diagrams of the two alloys after annealing at 350° C. The inner ring is the 330 Debye–Scherrer circle of the β-phase and the outer ring is the 333 Debye–Scherrer circle of the α-phase. The top portion (Fig. 2, *a*) is half the diagram of the slowly cooled alloy ; it shows a spotted ring of the β-phase, indicating practically complete recrystallization of this phase. The lower part (Fig. 2, *b*) is half the diagram of the quenched alloy. Here the Debye–Scherrer circle of the β-phase is still continuous, which shows that no recrystallization has occurred ; however, the sharpness of the ring indicates that the internal stresses which had been present in the alloy due to the plastic deformation and had given rise to line broadening have been relieved.

When specimens of the deformed alloys were annealed at 300° C. the β-phase did not recrystallize in either case, and the β-lines in the X-ray patterns were broad, due to the deformation. These lines were sharper, however, in the diagram of the quenched alloy. Precipitation had occurred in this alloy but not in the slowly cooled alloy.

The conclusion is drawn from these experiments that the precipitation occurring in the quenched alloy is responsible for the relief of the internal stresses, thus reducing the tendency for recrystallization.

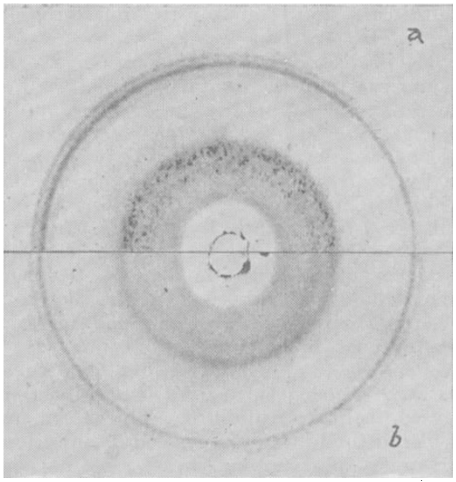

Fig. 2. Back-reflexion X-ray diagrams of alloys annealed at 350° C. (*a*) Slowly cooled alloy ; (*b*) quenched alloy

An explanation of this effect seems possible in terms of the dislocation theory. The dislocations in the deformed β-phase diffuse to the regions of misfit at the new boundaries created by precipitation, where they are no longer effective in causing internal stress. Cahn[2] suggests a similar movement of dislocations for stress relief by polygonization.

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L. M. CLAREBROUGH

Division of Tribophysics,
Commonwealth Scientific and
Industrial Research Organisation,
University of Melbourne, N.3.
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[1] Andrews, K. W., and Hume-Rothery, W., *J. Inst. Metals*, **69**, 485 (1943).

[2] Cahn, R. W., Phys. Soc., Rep. Conf. on Strength of Solids, 136 (1948).

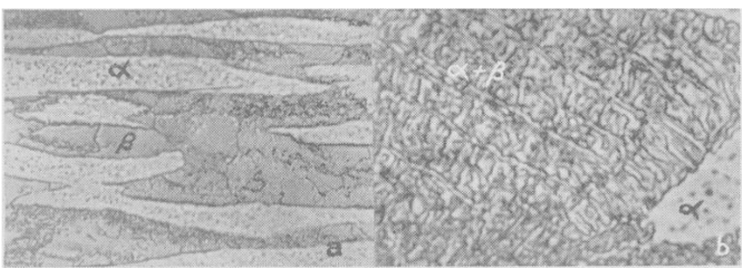

Fig. 1. Photomicrographs of silver–magnesium alloys annealed at 350° C.

(*a*) Slowly cooled alloy ; β-phase almost fully recrystallized (× 680) (*b*) Quenched alloy ; Widmanstätten structure in β-phase (× 2,100)

Elasticity and Rupture of Concrete and Stone at Constant Rates of Loading

EXPERIMENTS have been made to study the elasticity and rupture of concrete and stone cubes of 4-in. side while being loaded to failure in compression in a testing machine. An ultrasonic pulse was propagated through the cubes and, at intervals throughout the loading, the time of transmission of the leading edge of the pulse was measured across the concrete. The pulse travels through the medium with a velocity (V) which is related to the elasticity by the relation :

$$V^2 = \frac{E\,(1-\sigma)}{\rho\,(1-2\sigma)\,(1+\sigma)}, \qquad (1)$$

where V is the longitudinal wave velocity, E the elasticity, ρ the density, and σ is Poisson's ratio for the medium.