Precipitation Hardening and Ordering of Carat Gold Jewellery Alloys

The mechanical properties of gold jewellery alloys are dependant upon their thermal as well as their mechanical histories. An understanding of the mechanisms by which they harden during thermal treatment is therefore important. Two contributions to knowledge in this area are discussed in this note.

Although both precipitation and ordering occur during the heat treatment of gold-copper-nickel-zinc and many gold-silver-copper and gold-silver-copper-zinc alloys, knowledge of mutual interactions between these processes and of their effects on the mechanical properties of the alloys is by no means complete. While the latter may be expected to be additive in character in cases where the precipitated phase is finely dispersed and uniformly distributed throughout the grains of the alloy, no such definite statement can be made in cases where precipitation occurs discontinuously with the formation of coarse precipitates at grain boundaries, either without or prior to ordering.

Particular interest attaches therefore to studies which have been reported upon in recent years by investigators at the Institute of Metal Physics at the Urals Scientific Centre of the Academy of Sciences of the U.S.S.R. These have demonstrated that where ordering can be induced in a solution treated alloy, the antiphase domain walls become the preferred sites for nucleation of the precipitating phase, and discontinuous precipitation at grain boundaries is suppressed. The effect is a specific attribute of lattice defects arising from ordering, since similar suppression of discontinuous precipitation could not be induced by defects introduced either by plastic deformation or neutron bombardment.

Thus, in the case of a 58.3 gold/33.7 copper/8.0 silver weight per cent alloy, O. D. Shashkov, V. I. Syutkina and V. K. Rudenko (1) found that discontinuous precipitation of the silver-rich phase occurred at a progressively decreasing rate in the solution treated alloy at temperatures between 560 and 280°C, with the growth of large plates of precipitate from the grain boundaries. Below 280°C, ordering of Cu_3Au set in and the discontinuous pearlite-like precipitation at grain boundaries was completely suppressed and replaced by continuous precipitation within grains. Below this critical temperature also, the precipitation process was greatly accelerated. It remained a two-phase process, however, with the alloy consisting of particles of dispersed precipitated phase, with alternating portions of denuded and original matrix.

Analogous effects have been observed in a 75 gold/15 copper/7.5 nickel/2.5 zinc weight per cent white gold alloy by B. D. Razuvayeva, L. A. Gutov, V. I. Syutkina and O. D. Shashkov (2). In this alloy three phase transformations were observed. Discontinuous separation of large plate-like precipitates began at temperatures below 660°C. Below 360°C, however, ordering of Au_3Zn set in, discontinuous precipitation was suppressed, and continuous precipitation within the grains occurred at a relatively low rate. The alloy quenched from 800°C had to be heated for over 3 hours before a distinct structure was formed. At temperatures between 290 and 270°C, a further change was observed in that ordering of CuAu occurred. Large domain plates developed and the resulting internal stresses were sufficient to cause buckling and surface cracking of the specimens. Although these latter effects could be prevented by prior heat treating of the specimens at either 600 or between 360 and 290°C, these treatments proved too prolonged to be practically useful and the most effective method for obtaining a fine domain structure was to heat treat at 250°C. At this temperature discontinuous precipitation was completely suppressed and continuous precipitation within the grains occurred within 4 hours without the growth of large domain plates and excessive internal stresses.

Tensile testing of the specimens established that the heat treatments which resulted in discontinuous precipitation did not increase the mechanical strength of the alloy, whereas those which gave rise to ordering and continuous precipitation increased mechanical strength very considerably. AuCu ordering was more effective, however, than Au_3Zn ordering and if carried out at 250°C resulted in an alloy which was relatively stress-free.

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References

1 O. D. Shashkov, V. I. Syutkina and V. K. Rudenko, *Fiz. metal. metalloved.*, 1974, **37**, (4), 782-789

2 B. D. Razuvayeva, L. A. Gutov, V. I. Syutkina and O. D. Shashkov, *Phys. Met. Metallog.*, 1976, **42**, (1), 114-121