

Copper-Platinum Alloys

THE EQUIATOMIC Cu-Pt SUPERLATTICE

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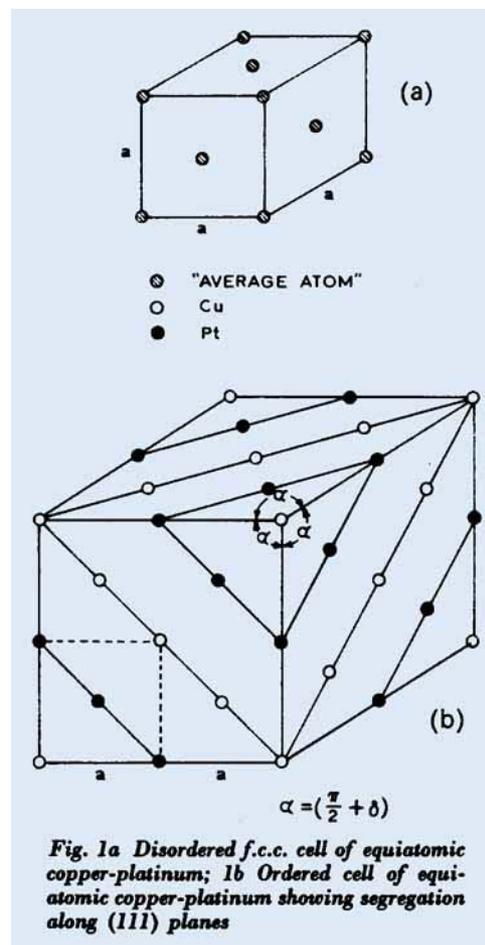
We have been trying to elucidate the mechanisms of ordering of the lattice structure in various copper alloy systems, among which the copper-platinum system is especially interesting because of its unique features.

The random f.c.c. solid solution in the equiatomic copper-platinum system shown in Fig. 1a is replaced below the critical temperature of 812°C by a long-range ordered rhombohedral lattice. The latter superlattice configuration consists of alternate layers of pure copper and pure platinum atoms arranged parallel to the (111) planes, there being the same number of nearest neighbours in both the ordered and disordered states, as shown in Fig. 1b.

CuPt is the only known superlattice with this structure but in fact surprisingly little work has been performed on the equiatomic alloy. The fact that there is no change in the number of nearest neighbours upon ordering has meant that most existing theories fail to account for the ordering in CuPt. However, Clapp and Moss (1) have attempted a formulation in terms of first and second nearest neighbours, the approach being referred to as the central pair-wise (CPW) model. The analysis predicts the long-range order behaviour from short-range order data, obtained by Walker (2) from diffuse X-ray scattering experiments on powdered samples, but there is no mention of why CuPt orders at all. The theory could be more rigorously tested using diffuse X-ray scattering from single-crystal samples of CuPt.

Our recent experimental study (3) has shown that CuPt conforms to the earlier established thermodynamic criteria (4) that order-disorder transformations are first-order

phase reactions. Moreover, the structural change involved (a rhombohedral lattice replacing a cubic one) means that substantial internal stresses are created which subsequently strengthen the material during the course of transformation, as shown in Fig. 2. Such hardening behaviour, coupled with the corrosion and oxidation resistance of the alloy, can be usefully employed when the



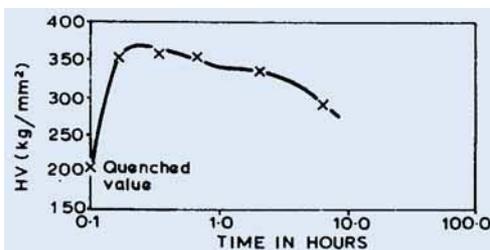


Fig. 2 Order-hardening of stoichiometric copper-platinum alloy; 700°C isotherm

alloy has been annealed for intermediate times below the critical temperature (812°C). A thermal polishing technique (5) for producing strain-free surfaces without recourse to electrolytic polishing, which is impracticable, has meant that it is now possible to perform polarised light metallography on bulk samples of CuPt (see Fig. 3) and thus interpret the mechanical characteristics in terms of the ordered morphologies.

Further work is in progress and a forthcoming publication will provide full details of our studies.

Palladium-Silicon Alloys

The high affinities of both palladium and platinum for silicon are well known, for disastrous consequences result when these metals are heated under reducing conditions in contact with siliceous materials. Although low melting point phases are formed, the alloying processes which result in this eutectic formation have been incompletely understood and since 1957 (1) it has been known that the palladium-silicon diagram originally published in Hansen was inaccurate. Rao and Winterhagen confirmed the existence of the compound Pd₃Si but concluded incorrectly that it reacted directly with pure palladium to form a eutectic melting at 760°C.

Dr E. Röschel and Dr C. J. Raub of the Forschungsinstitut für Edelmetalle at Schwäbisch Gmünd (2) have now re-examined the system, using silicon of semiconductor quality, and have revealed a fairly complex situation. As silicon is taken up by palladium, the compounds Pd₅Si and Pd₄Si are successively formed. Pd₅Si and Pd₃Si melt congruently at 835° and 1070°C and the intermediate compound Pd₄Si forms peri-

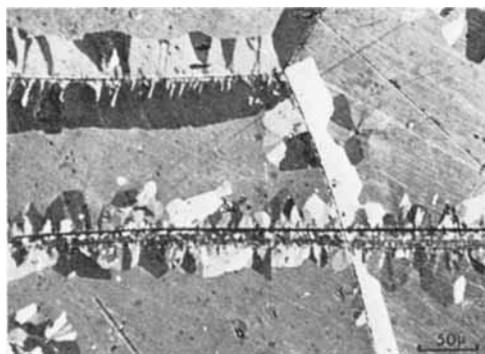


Fig. 3 Thermally polished sample of equiatomic copper-platinum alloy observed under polarised light after annealing for 85h at 550°C, showing ordered domains growing from surface imperfections, e.g. grain boundaries and pores

References

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tectically at 822°C. The first eutectic is formed between pure palladium and Pd₅Si and melts at 825°C. A second eutectic melting at 798°C then forms between Pd₅Si and Pd₄Si.

The diagram advanced by Röschel and Raub, although considerably more complicated than that previously accepted, is soundly based on the thermal analysis and metallographic evidence, both of which fix the eutectic compositions very precisely. Although the structures of Pd₅Si and Pd₄Si have not been completely elucidated, their diffraction lines are tabulated in considerable detail and the only remaining uncertainty in this system is the extent of the primary solid solution of silicon in palladium. As previously shown (3) this interstitially dissolved silicon causes discontinuous yielding effects.

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References

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