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Authors
Witcomb, M.J.
Dahmen, U.
Westmacott, K.H.

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M.J. Witcomb, U. Dahmen, and K.H. Westmacott

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An HREM Investigation of the Structure of Carbide Platelets in Platinum

M. J. Witcomb*, U. Dahmen, and K.H. Westmacott

Materials Science Division
National Center for Electron Microscopy
University of California
Lawrence Berkeley Laboratory
Berkeley, CA 94720

*University of the Witwatersrand
Electron Microscope Unit
Johannesburg 2050, South Africa

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AN HREM INVESTIGATION OF THE STRUCTURE OF CARBIDE PLATELETS IN PLATINUM

M.J. Witcomb*, U. Dahmen** and K.H. Westmacott**

*Electron Microscope Unit, University of the Witwatersrand, Johannesburg
**National Center for Electron Microscopy, Lawrence Berkeley Laboratory, Berkeley

High-purity platinum with only trace amounts of carbon in supersaturated solid solution is known to form thin precipitate plates on {100} planes during aging after a rapid quench from near the melting point. It was shown that these plates develop in stages from the single layer \( \alpha \) plates through the double-layer \( \alpha' \) to the four-layer \( \alpha'' \) plates with the transition from one to the next proceeding via a ledge mechanism. The precipitates could be interpreted alternatively as carbon-decorated {100} stacking faults, as combined precipitates of carbon and vacancies, or as platinum carbide precipitates whose excess volume was accommodated by vacancy loops. All three interpretations led to the same structure which was confirmed by microdiffraction from single platelets in edge-on orientation. The proposed structures in <001> projection are illustrated schematically in fig. 1. Direct evidence for these models was sought by HREM imaging.

Fig. 2 shows the \( \alpha \) and \( \alpha' \) platelets seen edge-on in a <011> orientation imaged on the JEOL ARM 1000 at 800 kV. At a defocus of -80 nm, the atoms appear as white dots and the contrast level is optimized because the contribution of specimen noise from surface contamination is selectively filtered out. The specimen thickness is estimated to be around 10nm. Due to a strong <112> texture a 30° tilt was required to reach a symmetrical <011> orientation. Fig. 2 confirms the predicted structure of \( \alpha \) and \( \alpha' \) precipitates as single and double-layer precipitates. Both plates are clearly atomically and uniformly flat along their entire length. The single-layer \( \alpha \) precipitate shown in (a) has the appearance of a simple {100} stacking fault. In the collapsed layer, small white dots appear at the position of the carbon atoms. However, whether these are actually due to the presence of the carbon remains to be examined by image simulations. The double-layer \( \alpha' \) precipitate seen in (b) clearly has the stacking sequence corresponding to that proposed in fig. 1b. Again, faint white spots are present at the proposed positions of carbon atoms.

Fig. 3 shows an <001> image of two adjacent \( \alpha' \) plates seen edge-on. In (a) the strain fields at the end of each particle are clearly visible. These strain fields give rise to the dislocation strain contrast used in earlier studies to analyze the nature of these particles. From (b) it can be seen that the two plates are not in immediate contact but leave a layer of Pt in between. In conventional microscopy this arrangement would give rise to stacking fault fringe contrast identical to that observed for \( \alpha'' \) plates since for small fault separations the combined displacement across a group of stacking faults determines the phase shift that causes the displacement contrast. On the basis of this evidence it is suggested that the structure of \( \alpha'' \) and all later stages of aging in Pt-C alloys is simply a stacking of \( \alpha' \) plates and not the structure proposed earlier and shown in fig. 1c.

References
References

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Fig. 1 Structure models for the three stages of {100} plates in Pt-C alloys. Single layer $\alpha$ structure in (a), double layer $\alpha'$ precipitate in (b) and four-layer $\alpha''$ precipitate in (c). (XBL 9012-3987.)

Fig. 2 High resolution images of $\alpha$ (a) and $\alpha'$ (b) precipitates seen edge-on in <011> orientation. (XBB 900-10148.)

Fig. 3 Two adjacent $\alpha'$ plates or one four-layer $\alpha''$ precipitate with a ledge seen edge-on in <001> zone axis (a), with magnified view (b) showing that the two plates are out of phase. (XBB 900-10147.)