LBL-30693

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Materials & Chemical Sciences Division

National Center for Electron Microscopy

Presented at the Electron Microscopy Society of America
Conference, San Jose, CA, August 4–8, 1991,
and to be published in the Proceedings

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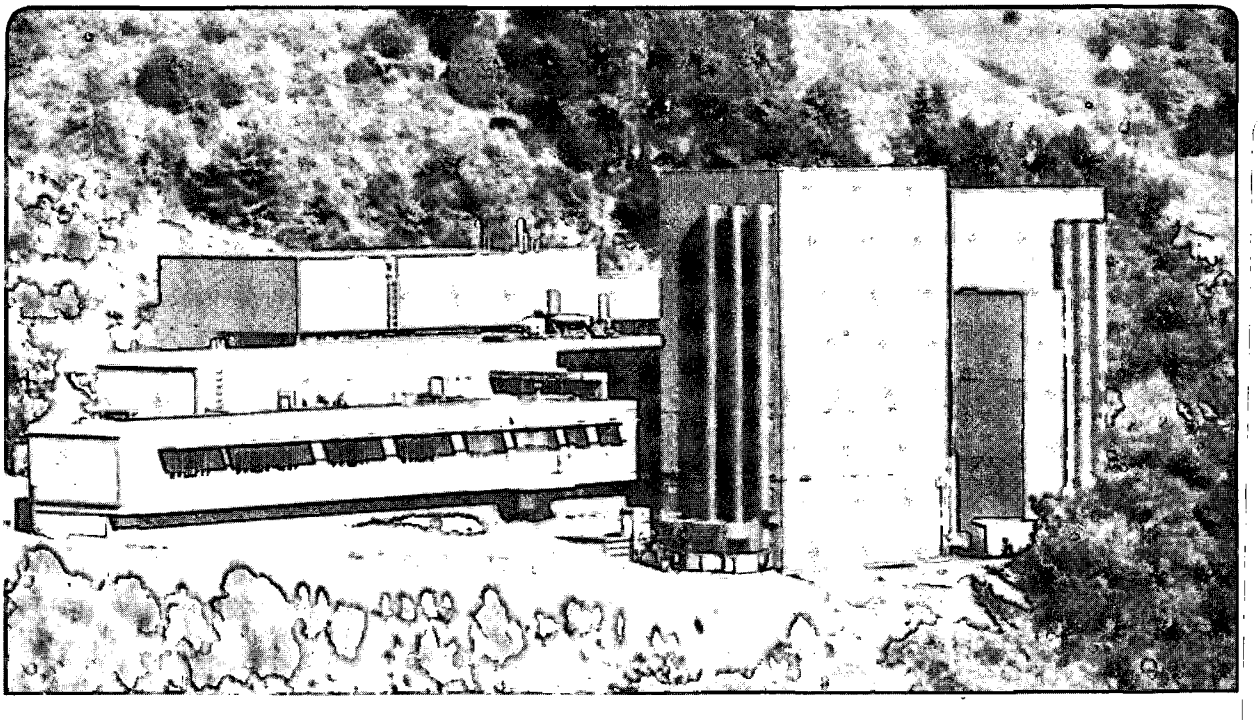
July 1991



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Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098

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Proc. EMSA/MAS Meeting, San Jose, 8/4-8/9/91

This work was supported in part by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Science Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

HREM IMAGING OF SINGLE UNIT CELL CARBIDE PRECIPITATES IN Pt-C ALLOYS

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Dilute Pt-C alloys are prototypical for studying oversize carbide phase precipitation from interstitial solid solution. Earlier studies showed the essential function of quenched-in vacancies in the precipitation process[1]. Vacancies play a dual, volume accommodation and structural, role in the transformation by modifying both the habit plane spacing and stacking sequence[2]. It was also shown how the precipitation sequence in interstitial Pt-C alloys is analogous to that in substitutional Al-Cu alloys. Initially a "GP zone" consisting of a monolayer plate of carbon atoms and vacancies forms. Atomic resolution images of the so-called α precipitates have confirmed their structure[3]. During subsequent coarsening of the precipitates, α' platelets form. Schematic diagrams illustrating the α and α' structures in <100> projection are given in Fig. 1. The single-layer α structure, or GP zone is identical to a {100} stacking fault stabilized by an intercalation of carbon. The two-layer α' structure is the first true precipitate phase and has a crystal structure anti-isomorphous with calcium fluoride. In the present contribution, simulated images based on this structure are compared with experimental images obtained at 800kV on the JEOL-1000 ARM. In addition to confirming the proposed precipitate structure, the results show the potential for successful imaging of precipitate structures containing light elements.

Due to a strong <112> foil texture, it was difficult to obtain high resolution images in low-index orientations. The high angle tilt goniometer of the ARM allowed imaging in both the <110> zone axis at about 30° from the foil normal and the <100> zone axis at about 35° from the foil normal. Although only a single unit cell thick, the plates are of substantial diameter. Through-focus series of images were recorded near the thin edge of the foil. Earlier results obtained at the <110> zone axis were in agreement with the model structure but image simulations showed that the the sensitivity to the presence of carbon atoms was far greater in a <100> zone. Fig. 2 shows images of α' plates in <100> orientation, recorded at -40 (a) and -80nm (b) defocus. Atomic columns in the matrix are black in (a) and white in (b).

The corresponding image simulations are shown in Fig. 3. The projected potential is illustrated in (a) and the two defocus conditions equivalent to those in the experimental images in Fig. 2 are seen in (b) and (c). Note that the carbon atoms are not directly resolved under either defocus condition but give rise to a bridged intensity between Pt atom dots. However, the effect of the presence of carbon is clearly apparent by comparison with images simulated for the same imaging conditions and the same Pt atom configuration but without the carbon atoms. This is shown in Fig. 3 (d-e). These results directly confirm the structure model proposed earlier and provide a more sensitive probe for the presence of carbon than similar images in <110> orientation[4].

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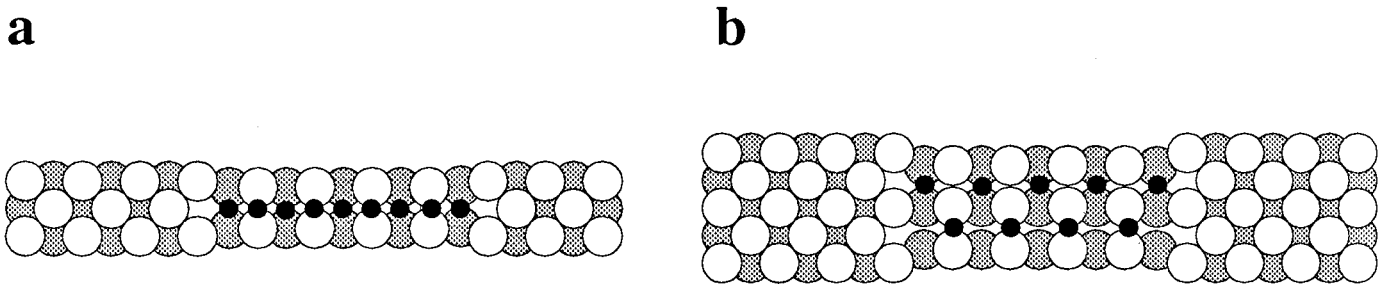

Fig. 1.--Schematic illustrations of the single layer α and double layer α' platinum carbide precipitate structures in <100> projection with carbon atoms shown as small black circles and the alternate ABAB stacking of Pt atoms in {100} layers indicated by shading.

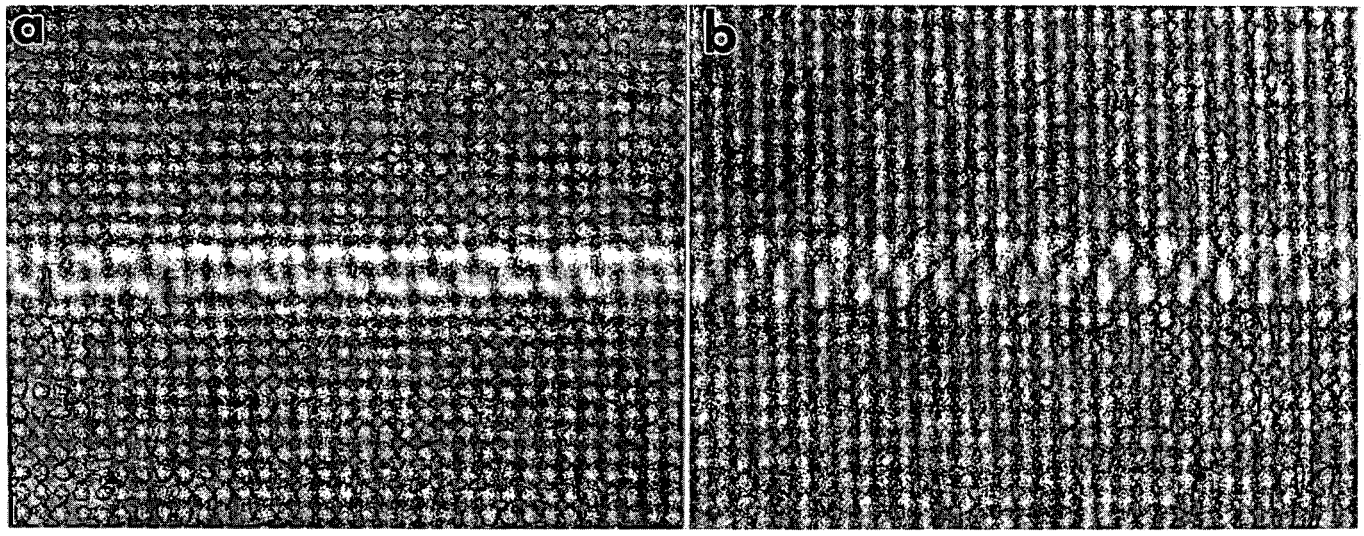

Fig. 2.--High resolution images of {001} α' plates seen on edge in <100> zone axis orientation. The foil was tilted by about 35°. The image in (a) was obtained in the JEOL ARM 1000 at 800kV and a defocus of -40nm and that in (b) at -80nm.

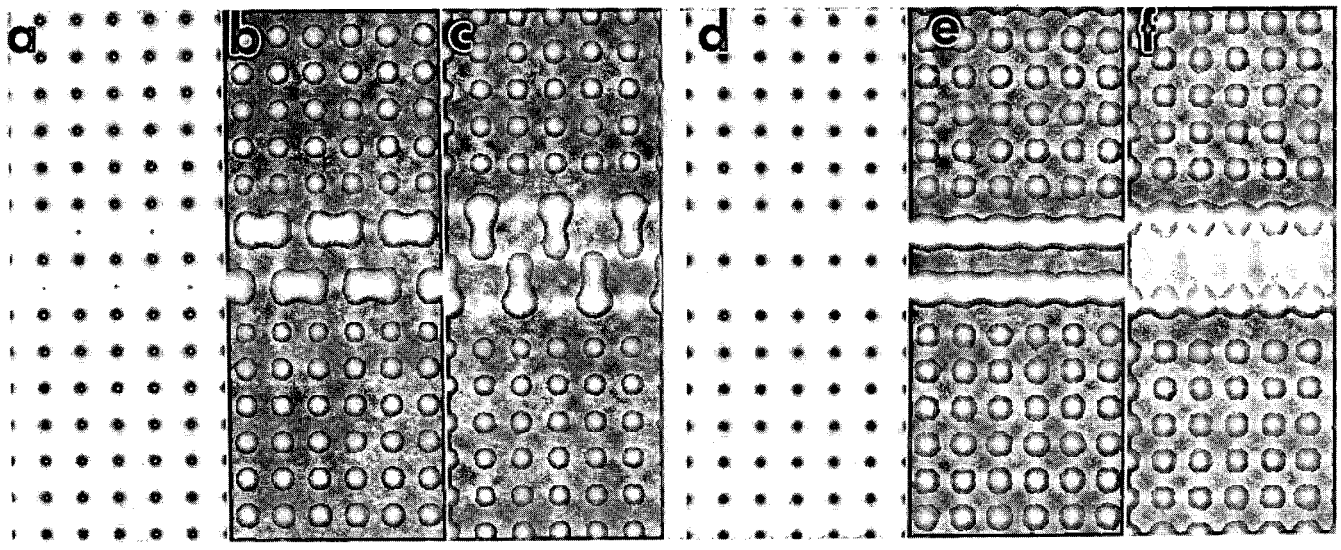

Fig. 3.--Image simulations for the conditions of fig. 2 at a foil thickness of 4nm, 800kV and 0.03nm vibration, with projected potential (a), -40nm defocus (b) and -80nm defocus (c). The same configuration but without the carbon atoms is shown in (d)-(f). Note clear effect of carbon. Only the carbon-containing model matches the experimental images in fig. 2

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