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Publication Date
1965-10-01

University of California

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Berkeley, California

Submitted to Acta Metallurgica Letters

UCRL-16452

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
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AEC Contract W-7405-eng-48

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Darling, Mintern, and Chaston[1] have shown that gold and platinum form a continuous solid solution at high temperature and that at lower temperatures a miscibility gap exists; the structures of the high temperature solution and the conjugate phases within the gap are all face centered cubic. Tiedema, et al.[2] and Van Der Toorn[3] have found, in x-ray investigations, the mechanism of precipitation of gold-platinum alloys within the spinodal region of the miscibility gap to be of spinodal type, i.e., a modulated structure is produced during early stages of aging. X-ray diffraction patterns of such alloys exhibited sidebands and the hardness of the alloys increased markedly. It was also observed that the Pt-rich alloys were brittle and showed intercrystalline cracking in the homogenized and quenched state; the brittleness became less pronounced with aging. The brittle behavior was attributed to quenching strains and was not observed in gold-rich alloys. Because of the large hardness response to aging and the fact that apparently no brittleness was experienced in gold-rich specimens subjected to the same quenching treatment, we have investigated the fracture characteristics in these alloys.

Experimental Work

Tensile fracture tests have been conducted on two alloys: 80% Pt-20% Au and 40% Pt - 60% Au. Specimens used were wires of 0.020 inch diameter and 3.25 inches long. The wires were heated by direct resistance in argon and cooled by helium gas quenching after homogenization. Quenching rates up to 3400°C per second were used. Aging heat treatments were carried out in the same way, or in a molten salt bath followed by ice-water quenching.

Several different homogenizing treatments were used for the 80 Pt-20 Au specimens: 0.75 hrs. up to 1.5 hrs. at 1205°C and 0.5 hr. at 1300°C. X-ray diffraction examination indicated that the alloys were single phase after these treatments. Metallographic investigation revealed that in all cases some precipitation had occurred in the grain boundaries upon quenching, particularly at the grain boundary nodes, as shown in Fig. 1. These specimens fractured in a brittle manner and the fracture path followed the grain boundaries. Similar specimens aged for various times at 680 and 515°C fractured in the same way. Metallographic examination showed that further grain boundary precipitation had occurred during aging.

Wires of the 40 Pt-60 Au alloy were homogenized at 1220°C for one hour and x-ray examination again indicated a single phase. Metallographic examination showed the grain boundaries to be much cleaner in this case (Fig. 2). However, the irregular width of the grain boundaries suggest that some precipitate is present. The fracture was transgranular shear type rather than intercrystalline. When these alloys are aged at 510°C for various times the fracture changes to one of brittle character, and the fracture path for aged alloys is intercrystalline. Figure 3 shows that for one hour aging at 510°C, significant amounts of grain-boundary precipitation have occurred compared with the quenched structure shown in Fig. 2.

Microhardness measurements were made on all alloy specimens in both the homogenized and quenched conditions and for various aging treatments. It was observed that the grain boundary regions were always softer than the interior regions of the grains. The Vicker's indenter was wider than the grain boundaries so a direct quantitative comparison of the hardness cannot be made.

Discussion

The microstructural appearance of the quenched 80-20 specimens differs substantially from those of Tiedema, et al. and Van Der Toorn. This difference may result from a difference of quenching rate, however the brittle nature of the fracture in the 80-20 quenched specimens is confirmed. Our alloys also exhibited sidebands during early stages of aging. We suggest that if quenching stresses are responsible for the brittle fracture in the 80-20 alloys, the same behavior should be found in the 40-60 alloys which were quenched in the same manner. The previous workers found brittleness to decrease with increased aging of the 80-20 specimens. We have observed no change in the fracture mode of these alloys on aging. On the other hand, the 40-60 alloys show a sharp change in fracture character from transgranular shear in the quenched state to brittle intercrystalline in the aged state, and the change is accompanied by an increase in the amount of precipitate in the grain boundaries. The softness of the grain boundaries relative to the grains themselves is opposite to the usual observation in which intergranular brittle fracture is attributed to a brittle intermetallic or impurity compound film in the boundaries. It is probable that in this case the intergranular brittle fracture is due to precipitation in the grain boundaries of a thin film of soft nearly equilibrium phase material, which is much weaker than the grains themselves. In the case of the 80-20 alloys, the grain boundary film should be gold-rich while in the 40-60 alloys it should be Pt-rich, according to the phase diagram of Darling, Mintern and Chaston.

This work was performed under the auspices of the United States Atomic Energy Commission.

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FIGURE CAPTIONS

Fig. 1. 80% Pt-20% Au Alloy Homogenized and Quenched Showing Precipitate at Grain Boundaries. 1000X

Fig. 2. 40% Pt - 60% Au Alloy Homogenized and Quenched. 1000X

Fig. 3. 40% Pt - 60% Au Alloy Aged 1 Hour at 510°C. 1000X

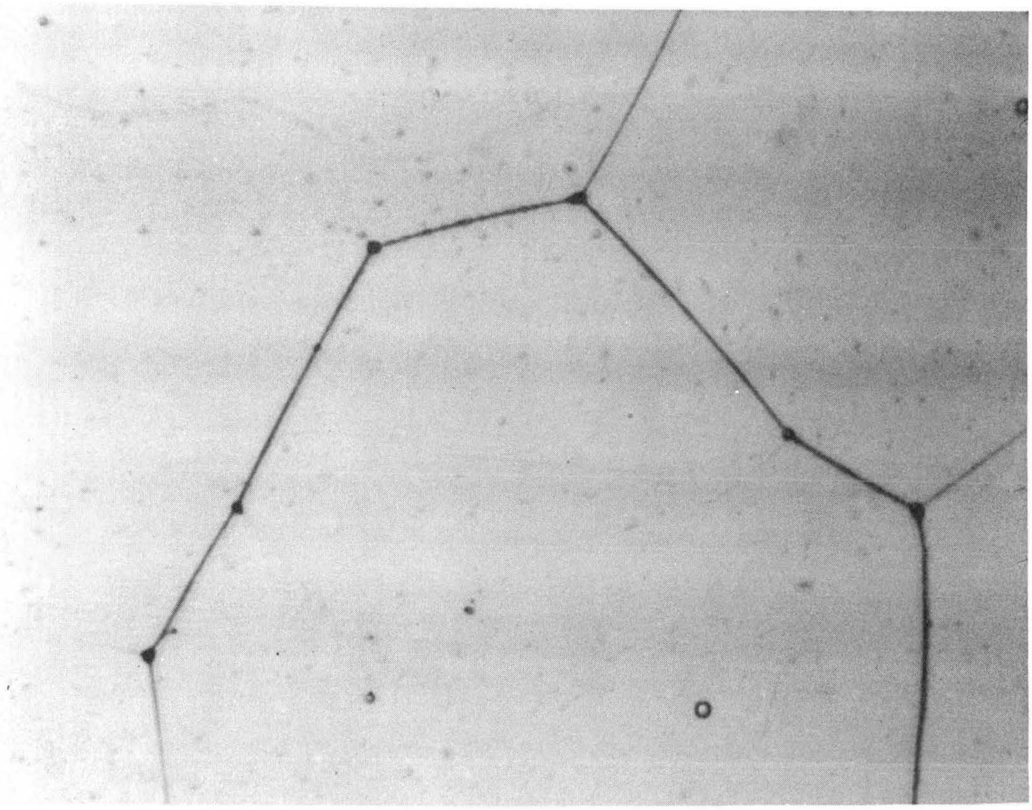

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Fig. 1

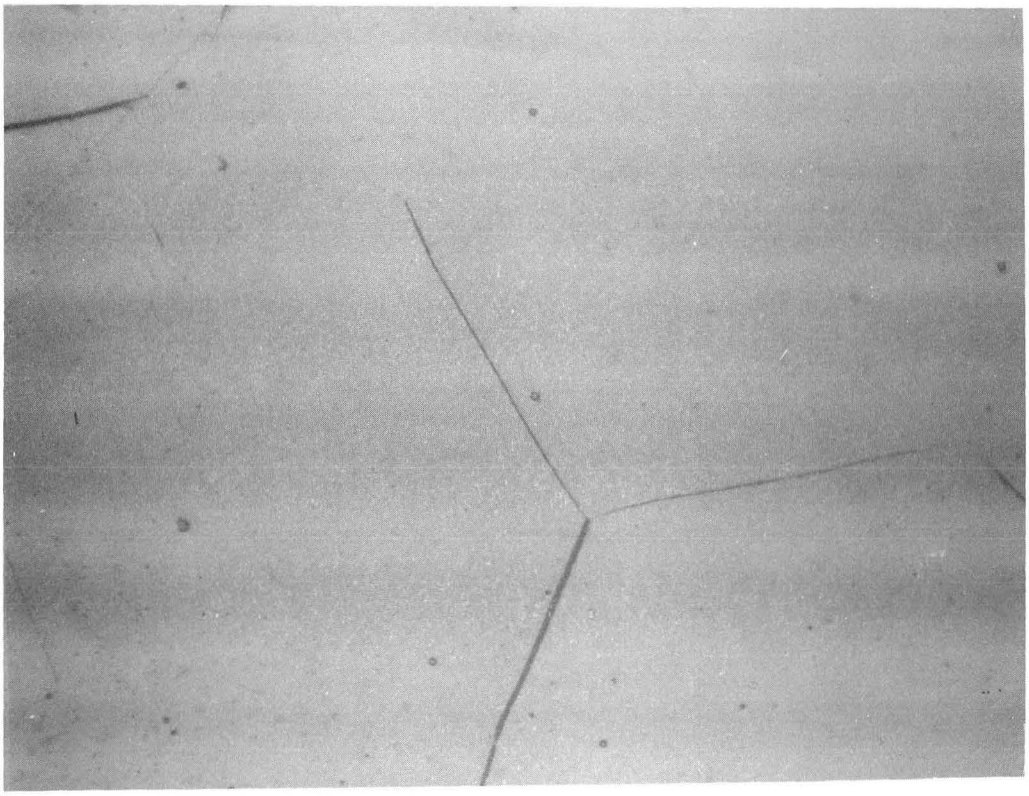

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Fig. 2

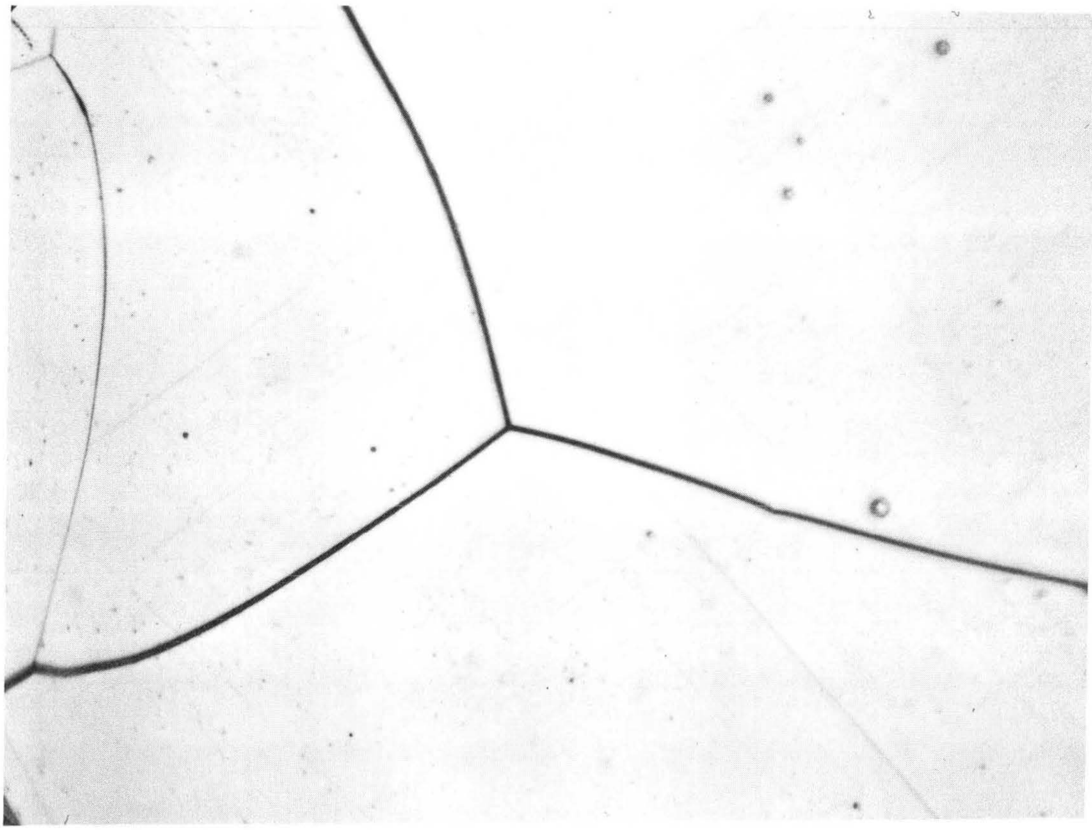

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Fig. 3