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The effect of trace element additions on the grain boundary composition of Ir + 0.3% W alloys*

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Iridium alloys are currently used as cladding and post-impact containment material for radioactive fuel in radioisotope thermoelectric generator heat sources. In this application, the cladding must exhibit at least 15% elongation during high temperature impact (h.t.i.), which for purposes of this study will denote an overall elongation rate of 85 m/s with a gauge length of 1.27 cm in the temperature range 1200–1500 °C.

Liu & Inouye (1976) have reported that doped Ir + 0.3 % W normally fails intergranularly during h.t.i., with elongation between 3 and 15 %. Intergranular failure at lower temperatures and strain rates has been reported by others, and has been attributed to the presence of impurities or precipitates at the grain boundaries. Hecker *et al.* (1979) and White *et al.* (1979) have recently studied the composition of grain boundaries in Ir and Ir + 0.3 % W by using Auger electron spectroscopy (A.e.s.). They were unable to find any impurity segregated to the grain boundaries, and concluded that intergranular fracture is intrinsic to Ir, and not related to impurities.

Liu & Inouye also reported the h.t.i. properties of an Ir + 0.3 % W alloy to which 40 μg/g Al, 80 μg/g Fe, 30 μg/g Th, 16 μg/g Ni and 75 μg/g Rh were added (designated DOP-4 alloy). The results of their study show that except for very large grain sizes the h.t.i. ductility of the DOP-4 alloys is much greater than for the undoped Ir + 0.3 % W. More significantly, the failure mode of the DOP-4 alloy during h.t.i. tends to be transgranular (cleavage), or ductile necking as opposed to intergranular for the undoped alloys. Improved h.t.i. ductility has also been reported for Ir + 0.3 % W alloys doped with various combinations of the dopants used in the DOP-4 alloy. The common factor in all of the alloys showing improved h.t.i. ductility is the presence of at least a few micrograms of thorium per gram.

The purpose of this paper is to report the results of a study of the grain boundary composition of Ir + 0.3 % W alloys doped with various concentrations and combinations of Al, Fe, Th, Ni, and Rh. These alloys all fail intergranularly at room temperature, allowing A.e.s. to be used to study their grain boundary composition. The results indicate that thorium has segregated to the grain boundaries in the doped alloys while the grain boundaries in the undoped alloys are relatively free of impurities and dopants. Inert ion sputtering experiments suggest that the thorium enriched region at the grain boundaries is probably only a few atom layers thick. The function, if any, of the other dopants is unclear at this time.

References (White *et al.*)

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* Extended abstract.
† Full version of the paper.