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Structural Nickel-Doped Iridium-Aluminium Materials

Materials used in high temperature structural applications are now required to withstand higher operating temperatures than ever before in the drive for more efficient function of equipment and plant. This is particularly true for materials used in high performance gas turbine engines where the nickel-based superalloys currently used reach their operational limit at < 1200°C. One focus of work in this area for the next generation of materials has been the ordered intermetallics, and Nb₃Al has been intensively investigated, but it shows poor ductility and low oxidation resistance.

Now, scientists at Iwate University in Japan report on the high temperature strength and ductility of ordered intermetallics, based on iridium, specifically IrAl and Ir_{1-x}Ni_xAl (with $x = 0-0.8$) at temperatures of 25 to 1400°C (A. Chiba, T. Ono, X. G. Li and S. Takahashi, *Intermetallics*, 1998, **6**, (1), 35-42). The high melting point of iridium at 2243°C may impart excellent high temperature strength, while the formation of a surface film of Al₂O₃ is anticipated to give good oxidation resistance.

Compression testing confirmed the postulated high room-temperature strength of IrAl at ~1900 MPa but revealed little ductility below 800°C. The ductile-brittle transition occurs between 800 and 1000°C, and above this there is pronounced compressive ductility resulting in steady state deformation after yield. The Ir_{0.2}Ni_{0.8}Al exhibits good ductility above 800°C but work hardens during deformation at 1000°C. Below 800°C its ductility is inferior to that of IrAl.

Adding nickel improves the ductility of IrAl, but the ductile-brittle transition temperature decreases with increasing nickel. At yielding IrAl is an order of magnitude stronger than NiAl, and Ir_{0.2}Ni_{0.8}Al shows improved strength by a factor of ~5. Generally, the strength of Ir_{1-x}Ni_xAl decreases with increased nickel content.

The creep behaviour of the materials also differs markedly. Both IrAl and NiAl exhibit normal primary creep where the creep rate decreases with increasing strain, but Ir_{0.2}Ni_{0.8}Al exhibits inverse primary creep. The steady state secondary creep of Ir_{0.2}Ni_{0.8}Al was measured between 950 and 1100°C, giving an activation energy, Q_c , of 400 kJ mol⁻¹ and steady-state exponent $n = 3.2$, typical of class I behaviour. Microstructural analysis revealed that only Ir_{0.2}Ni_{0.8}Al and NiAl exhibited a single-phase type B2 structure; IrAl contained secondary phase precipitates, contradicting earlier reports of an ordered single-phase structure from 48 to 52 mol%. The authors postulate that this may be due to deficiencies in their homogenisation heat treatments, and thus could not accurately produce the activation energy and exponent for IrAl. However, an exponent of 4.2 and class II behaviour are suggested. Creep strengths of IrAl and Ir_{0.2}Ni_{0.8}Al were four orders of magnitude higher than for NiAl for a given applied stress.

Overall, results are promising for the IrAl/NiAl based systems, although the relatively low temperatures of the present study would suggest that further evaluative work would be of considerable benefit.

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