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Al-Cr-Ni-Ta (Aluminum-Chromium-Nickel-Tantalum)

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In an effort to improve the mechanical properties of ordered intermetallics such as NiAl, [1995Joh] explored several directionally solidified eutectics that contain a refractory metal with one or more intermetallic phases. The characteristics of the NiAl-NiAlTa-Cr ternary eutectic in this quaternary system were studied.

Binary Systems

For brief descriptions of the Al-Cr, Al-Ni, and Cr-Ni phase diagrams, see the update on the Al-Cr-Ni system in this issue. Brief descriptions of the Al-Ta and Ni-Ta phase diagrams are given in the Al-Ni-Ta update in this issue. The Cr-Ta phase diagram [1996Oka] shows an intermediate phase with two crystal modifications: βCr_2Ta (*C*14, $MgZn_2$-type hexagonal) and αCr_2Ta (*C*15, $MgCu_2$-type cubic).

Ternary Systems

Updates on the Al-Cr-Ni and Al-Ni-Ta systems appear in this issue. The Al-Cr-Ta phase diagram does not appear to have been studied. [1990Gup] reviewed the Cr-Ni-Ta system and presented partial liquidus and solidus projections and partial isothermal sections at 1250 and 1000 °C.

Quaternary Phase Equilibria

Using high-purity metals, [1995Joh] prepared alloy compositions by induction and arc melting. By metallographic examination, the final alloy compositions were bracketed to yield the maximum volume fraction of the eutectic mixture. Directional solidification was then done by electromagnetic levitation. The constrained liquid zone moving at 19 mm/h produced near-equilibrium microstructures. The eutectic mixture consisted of a NiAl matrix containing rods of Cr and laths of the Laves phase. Annealing of the eutectic structure around 1400 °C showed no large change in the spacing between phases and no evidence of a solid-state transformation.

The tentative liquidus projection constructed by [1995Joh] is shown in Fig. 1 on a triangular section of the composition tetrahedron obtained by joining NiAl to Cr and Ta corners. The phase distribution at the undetermined eutectic temperature is shown schematically in Fig. 1. E is the composition of the eutectic liquid. [1995Joh] pointed to the possibility of a continuous solution between NiAlTa and Cr_2Ta Laves phases.

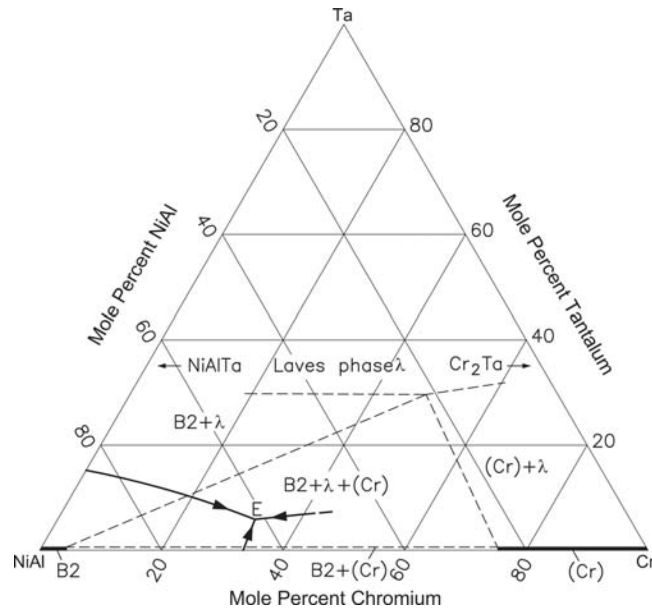

Fig. 1 Al-Cr-Ni-Ta partial liquidus projection on the NiAl-Cr-Ta plane [1995Joh]

The equilibrium partition ratios of Al, Cr, and Ta between liquid and γ (Ni) were determined in Ni-rich quaternary alloys by [1999Sun] in the temperature range of 1421-1342 °C. The ratio k_{Ta}, equal to (wt.% Ta in fcc)/(wt.% Ta in liquid), is 0.6 for dilute Ta and 0.85 for 17 wt.% Ta. The ratios for Al and Cr vary less for this Ta range and are between 0.92 and 0.96. [1999Sun] also developed regression equations to describe the γ liquidus temperatures as a function of Al, Cr, and Ta contents.

References

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