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A STUDY OF THE Pt-Al-Ru SYSTEM AT 600°C

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The Pt-Al-Ru system is being studied as part of a larger project to develop and optimise Pt-based alloys for high temperature use [1]. These alloys are based on a two-phase microstructure of ~Pt_3Al in a (Pt) matrix, analogous to the γ/γ' microstructure of Ni-based superalloys. Work has been done on the Pt-Al-Ru system [2,3] and the liquidus surface has been derived from as-cast alloys [3].

Six alloys were selected from the alloys so as to contain the phases of interest. The samples were sealed in silica tubes backfilled with argon and annealed at 600°C for 3 weeks. They were prepared metallographically and studied with a LEO 1525 SEM and Oxford INCA EDS. The phases were confirmed, as far as possible, using a Philips XRD with Cu K alpha radiation on solid samples.

The ~Pt_{51}:Al_{21}:Ru_{28} sample comprised coarse needles of (Ru) in a binary eutectic of fine (Ru) needles and ~Pt_3Al. Compared to the as-cast sample, the fine needles had coarsened, and there were no traces of the (Pt) component. Thus the heat treatment had removed the ternary eutectic which appeared due to non-equilibrium cooling. There was precipitation of ~Pt_3Al in the coarse (Ru) needles; this indicated that the (Ru) solvus slopes to lower Ru contents at lower temperatures, and agrees with Obrowski's observations in the Al-Ru system [4].

The as-cast ~Pt_{25}:Al_{46}:Ru_{29} sample comprised very cored ~RuAl dendrites in a matrix of ~PtAl + Pt_5Al_3 which had originated from solid state decomposition of the high temperature beta phase. The heat treated sample showed much reduced coring (Fig. 1) and coarsening in the matrix phases.

The ~Pt_{39}:Al_{52}:Ru_9 sample in the as-cast condition had a complex structure that revealed primary formation of cored ~RuAl followed by the formation of PtAl and Pt_2Al_3. The actual reactions were difficult to interpret since the PtAl and Pt_2Al_3 phases were extremely fine. Annealing at 600°C reduced the coring in ~RuAl and coarsened the microstructure so that a eutectic between ~RuAl and ~PtAl was revealed. The ~PtAl within the eutectic had a higher Ru content, and so had a slightly darker contrast as indicated by the arrow in Fig. 2.

As-cast ~Pt_{14}:Al_{54}:Ru_{32} was another complex sample and was not at equilibrium since it contained four phases: ~RuAl, ~$RuAl_2$, ~$PtAl_2$, and ~$Ru_{12}Pt_{15}Al_{73}$, a new ternary phase [3]. The annealed sample only had three phases: ~RuAl, ~$RuAl_2$ and ~$PtAl_2$. In addition, there was precipitation of ~$RuAl_2$ within ~$PtAl_2$

The as-cast ~Pt_{28}:Al_{64}:Ru_8 specimen contained dendrites of ~$Ru_{12}Pt_{15}Al_{73}$ surrounded by ~$PtAl_2$, in a eutectic comprising ~$PtAl_2$ and ~$Ru_{12}Pt_{15}Al_{73}$. In the annealed condition, there was much less of the ~$Ru_{12}Pt_{15}Al_{73}$ phase and the eutectic had coarsened.

In the as-cast condition, the ~Pt_8:Al_{85}:Ru_7 alloy had two distinct microstructures locally and the primary phase was different in each: ~$Ru_{12}Pt_{15}Al_{73}$ and ~Pt_5Al_{21} respectively. The other phases were

~$RuAl_6$ and (Al). Although the annealed sample contained regions which appeared different, the ~Pt_5Al_{21} phase had disappeared, and the ~$RuAl_6$ phase was not discerned. However, since the ~$Ru_{12}Pt_{15}Al_{73}$ phase still showed coring, it is likely that the ~$RuAl_6$ phase was still present and was in local equilibrium with the less Pt-rich composition of ~$Ru_{12}Pt_{15}Al_{73}$, but too fine to detect.

The phase and alloys' EDS analyses were plotted and compared to the as-cast values. The alloys suffered minimal aluminium loss on annealing. Pt_3Al had lost all discernible Ru, which agrees with other work [2]. Similarly, $RuAl_2$ had negligible Pt after annealing, showing that the solubility for Pt decreases with temperature. The composition of ~$Ru_{12}Pt_{15}Al_{73}$ moved to slightly lower Pt contents at lower temperatures. Two samples exhibited a similar and a higher Ru composition for the ~$PtAl_2$ phase than in the as-cast samples, indicating that the solubility increased with temperature. Both the PtAl and Pt_2Al_3 phase compositions shifted to more stoichiometric values after annealing, indicating a contraction in phase width at lower temperatures. At 600°C, the penetration of the ~RuAl phase was reduced compared to the as-cast samples: from ~26 at. % Pt to ~22 at. % Pt. In addition, the phase width narrowed at lower temperatures.

Annealing the samples at 600°C equilibriated them to some degree; no sample had more than three phases, and the compositions had changed to more stoichiometric values. The only unexpected result was that the ~$PtAl_2$ phase extended to higher ruthenium contents.

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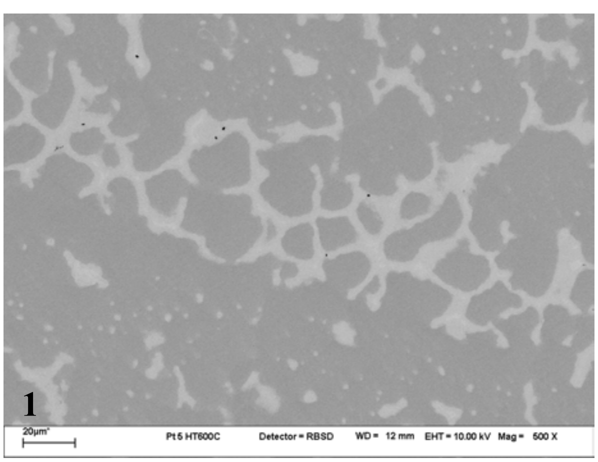

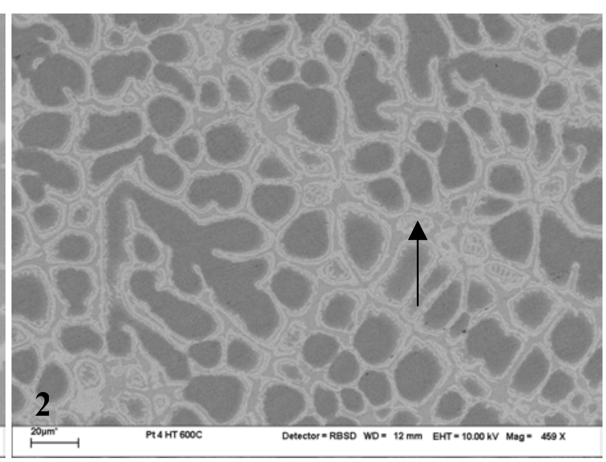

Fig. 1. ~Pt_{25}:Al_{46}:Ru_{29}: BSE image showing ~RuAl (dark) in a matrix of ~PtAl + Pt_5Al_3 (light).
Fig. 2. ~Pt_{39}:Al_{52}:Ru_9: BSE image showing ~RuAl (dark), ~PtAl (light) and Pt_2Al_3 (medium grey).

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