NON-EQUILIBRIUM PHASES IN RAPIDLY QUENCHED Al-RICH Al-Pt ALLOYS

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Recently, we reported the results of examination on rapidly quenched samples of Al-rich Al-Pt alloys (of up to 3at.% Pt)[1,2]. According to Shunk, Pt appears to be insoluble in Al, and Al_4Pt, the most Al-rich equilibrium intermediate phase, exists at 20 at.% Pt. However, by liquisol-quenching we were able to obtain supersaturated Al-solid solutions (α-Al) of up to 2 at.% Pt. The metastable solubility of Pt in Al was determined by means of X-ray diffraction measurements of the α-Al lattice parameters of those samples which on X-ray films gave no other lines except those of α-Al. (For this purpose a Debye-Scherrer camera of 114.6 mm was used, and for phase analysis a Nonius Guinier-de Wolf quadruple focusing camera..

Metastable solid solubility was found in samples thinner than 10 μm and with no more than 2 at.% Pt. The thicker samples, 10 - 20 μm, contained no Al_4Pt phase, or hardly detectable amounts of it, together with a new phase of unknown structure (ε-metastable). Samples thicker than 20 μm contained large amounts of Al_4Pt and ε-metastable.

In the examined range of Pt concentrations (up to 3 at.%) two phases could be distinguished in both quenched and isochronally and isothermally annealed samples. One of them could be indexed as Al_4Pt phase, while the other could not be identified with any well-known intermediate phase in the Al-Pt system. Forty diffraction lines belonging to this unknown phase were observed, and the best indexing was obtained with a tetragonal cell with parameters a=13.580 A and c=16.646 A.

In this article we report on the results obtained with the same type of samples using electron diffraction measurements. By means of transmission electron microscopy the existence of metastable solid solution could be established in thinner, more effectively quenched samples.

In Fig.1 in the as-quenched sample of Al-1.34 at.% Pt there is no evidence of the existence of small clusters. In Fig.2 the dark field micrograph is shown of the same (but aged) sample as was that in Fig.1. We can see small Pt-rich clusters with diameters from 1.5 to 2.5 nm. On further annealing, these clusters grow to rod- like precipitates of a new phase (called ε) the structure of which was determined by means of X-ray diffraction[1].

In Fig.3 a, we see the rods of the ε-metastable phase which are 24 to 84 nm long, have diameters from 6 to 18 nm and are oriented in the [100] and [010] directions. The respective electron diffraction image is shown in Fig.3b. The Al crystal is in [001] zone orientation, so that the precipitate habits are (100), (001) and (010) planes of the Al matrix.

In the same figure can be seen the respective indexing: the more intensive spots (marked with o) belong to the aluminium matrix, the weaker spots (marked with Δ) are caused by precipitates, and the spots marked by crosses are caused by double diffraction (DD).

In Fig.3, precipitates oriented in the [100] and [010] directions, respectively give, at every point of the reciprocal lattice, streaks in the directions [010] and [100]. The streaks in Fig.3b originate from the rod-like precipitates in the [100] and [010] directions.

The precipitates begin to grow in the aluminium matrix in the shape of thin sheets, the Pt atoms segregate on the {100} planes of the matrix, becoming completely coherent with the matrix so that the lattice of the precipitate remains continous with that of the matrix. Later on, during the process of precipitation, the structure of the precipitates begins to consolidate, and their reflections begin to appear (Fig.3b). Precipitates grow by interchanging the Al and Pt atom places up to the moment when the interface of the matrix precipitate becomes overstrained. The inter-atomic links break and the coherency is lost.

In the further course of precipitation ε-phase precipitates (rods) appeared within the grains and the precipitates of equilibrium Al_4Pt-phase emerged in the grain boundaries. ε-phase precipitates grew to critical proportions (in the Al-Pt system about 84 nm), when these ε-precipitates begin to transform into Al_4Pt precipitates. These precipitates have an irregular shape and their greatest lengths are from 88 to 300 nm.

From the reciprocal lattice points shown in Fig.3b the d-values of ε-phase were measured and are given in Table 1 together with the respective d-values calculated using the tetragonal lattice parameters a=13.580 Å and c=16.646 Å.

Table 1.

Measured d_{hkl}-values using electron diffraction (Fig.3b), and $d_{hkl\,c}$ values calculated according to tegragonal lattice parameters, determined from X-ray diffraction measurements

d_{hkl}(Å)	phase	hkl	d_{hklc}(Å)
6.475	DD or ε	210, 200	6.074, 6.79
4.089	DD	non	
3.237	ε	105	3.232
2.285-2.158	ε	600	2.264
2.100	ε	336	2.096

From the results presented it will be seen that our transmission electron microscopy and diffraction results confirm our X-ray diffraction measurements:

a) the appearance of a new metastable phase in the precipitation process was confirmed;

b) observed d-values, measured by means of electron diffraction, are in accordance with those measured by X-ray diffraction;

c) in samples which were not quenched fast enough to produce solid solution of Pt in aluminium, precipitates of the ε-metastable and Al_4Pt phases were observed.

References:

1. A.M.Tonejc, A.Tonejc and A.Bonefačić, J.Mat.Sci.9, (1974)503
2. A.M.Tonejc, Ph.D.Thesis, University of Zagreb (1980)

Fig.1. - Al-1.34at%Pt asquenched sample.

Fig.2. - The same sample (Fig.1) annealed

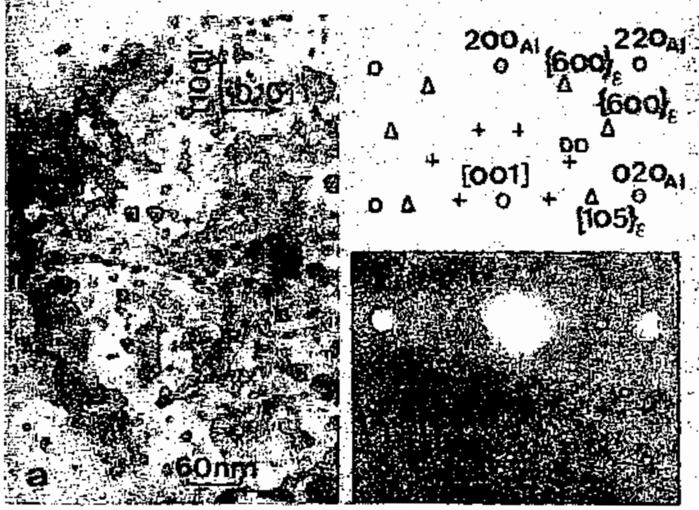

Fig.3.a) Rods of ε-phase, b) Corresponding selected area pattern.