INVESTIGATION OF VACANCY LOOPS AND PRECIPITATES IN Al-3d ALLOYS RAPIDLY QUENCHED FROM THE MELT

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As-quenched samples of Al-0.06at%Ce and Al-2at%Ni alloys were investigated by means of transmission electron microscopy (TEM).Two kinds of defects were occasionally observed: dislocation loops and helicoidal dislocations (an example is shown in Fig.1a).

The existence of dislocation loops in metastable solid solutions have been stated earlier by Warlimont et al.(1) in AlFe and AlCr. They concluded that vacancies condense into dislocation loops at least up to 0.5at% Fe and up to 5at%Cr, respectively. This indicates that the binding energy of vacancies and solute atoms $E^B_{V-Cr} << E^B_{V-Fe}$. In our investigations we observed dislocation loops up to 2at%Ni. This suggested that $E^B_{V-Cr} < E^B_{V-Ni} < E^B_{V-Fe}$. An analogous conclusion could not be drawn for Ce dissolved in aluminium because at the metastable solubility limit (0.06 at%Ce) loops were still observed.

We found (Fig.1a) that the loops are arranged in rows along <110>directions in both investigated systems. The formation of rows of loops was explained according to the model of Saada (2), Grilhé (3) and Guyot (4). In this model vacancies precipitate on the screw dislocations and diffuse along the dislocation core thus forming clusters which collapse to Frank loops. Beyond a certain size, loops are immobile thus anchoring the dislocations. The energy supply, due to the quenching stresses, opens two possibilities: a) the screw dislocation is torn away, leaving loops in <110> directions; further precipitation of vacancies transforms them into Frank loops, b) the clusters are sufficiently large to form Frank loops; the screw dislocations can be pulled off the loops by the unfaulting process. In this process the Shockley partial sweeps a loop, giving rise to a perfect prismatic dislocation loop. Now, according to the Grilhé model (3), these perfect loops can react with the screw dislocation to form a helix.

Fig 1a
Rows of loops in Al-0.06%atCe splat cooled

Fig 1b
Dark-field micrograph showing the growth of a new phase in Al-0.06at%Ce on dislocation loops

The rows of dislocation loops we observed may have their origin according to a) or b). According to theory (4), the critical loop size in aluminium is about 14 b_p or 30Å. The loops in the Al-0.06at%Ce alloy, shown in Fig.1a, have a radius from 300 to 500 Å. These loops may have originated from small loops (30Å or less) which escaped from the screw dislocations and grew to their size by further vacancy condensation. During the annealing of the specimen in the microscope we observed the growth of a new phase on the dislocation loops and the precipitates of the new phase were arranged in rows. This was observed in both investigated systems. The precipitates in the Al-Ce system can be seen in Fig.1b. This is further evidence of discontinuous precipitation during splat cooling, which was first observed in Al-Cr alloys (1).

References:

(1) H.Warlimont,W.Zingg,P.Furrer,Proc.second conf.on metastable alloys,Boston,1975.
(2) G.Saada,Acta Met.10(1962)551
(3) J.Grilhé,Ph.D.Thesis,1965,Paris-Orsay
(4) P.Guyot, Phys.Stat.Sol.(a),5,(1971)95