

Morphological Evolution and Coalescence of γ' Precipitates

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Ni-base alloys have been widely used in the aeronautic and aerospace industries for their high melting point, high strength, high thermal stability and a good creep and oxidation resistance. Their superior properties are strongly affected by the presence of the dispersed γ' $\text{Ni}_3(\text{Al,Ti})$ precipitates that are coherent with the solid solution γ matrix. The γ' characteristics including particle size, morphology, distribution, and volume fraction, play important roles in strengthening these alloys [1-4]. The purpose of this work is therefore to investigate the morphological evolution and coalescence of γ' precipitates at different temperatures and aging times. Samples of Ni–11.5 wt. % Ti alloy were obtained by melting in an electric-arc furnace under an argon atmosphere using pure elements (99.9 %). Furthermore, those samples were subjected to a solution heat treatment at 1200 °C for 2 h and aging treatments at 750 and 650 °C for different times. Microstructural characterization was carried out by High Resolution Scanning Electron Microscopy (HR-SEM) using a JSM-7401F microscope and by transmission electron microscopy with a JEOL JEM-1230 microscope. The Fig. 1 shows a strong dependence of morphological evolution, and spatial distribution of precipitates with the time. The morphology of precipitates changes depending on the increasing aging time from irregular-type morphology with random spatial distribution towards a cuboidal-type and parallelepiped-type morphology with faces aligned along directions $\langle 100 \rangle$, which are the elastically softer directions of the matrix. Furthermore, the alignment of the faces and the formation of arrays are originated by elastic deformation fields around the precipitates, elastic interactions and coalescence between precipitates. On the other hand, it is observed that the precipitates that coalesce generate arrangement of them (Fig. 2). The coalescence of the γ' precipitates is associated antiphase domains of $L1_2$ structure. The type of spatial correlation between these antiphase domains commonly are known in-phase or out-of-phase ordered precipitates. Precipitates of different domains antiphase, i.e. out of phase, never coalesce regardless of the size, shape, separation distance and relative position between them, because a domain antiphase boundary would be produced, whose energy is always greater than interfacial or energy elastic that to be reduced. Precipitates with same antiphase domains i.e. in-phase, whose ratio is 1/4 with respect to out-of-phase precipitates, are able to coalesce.

References.

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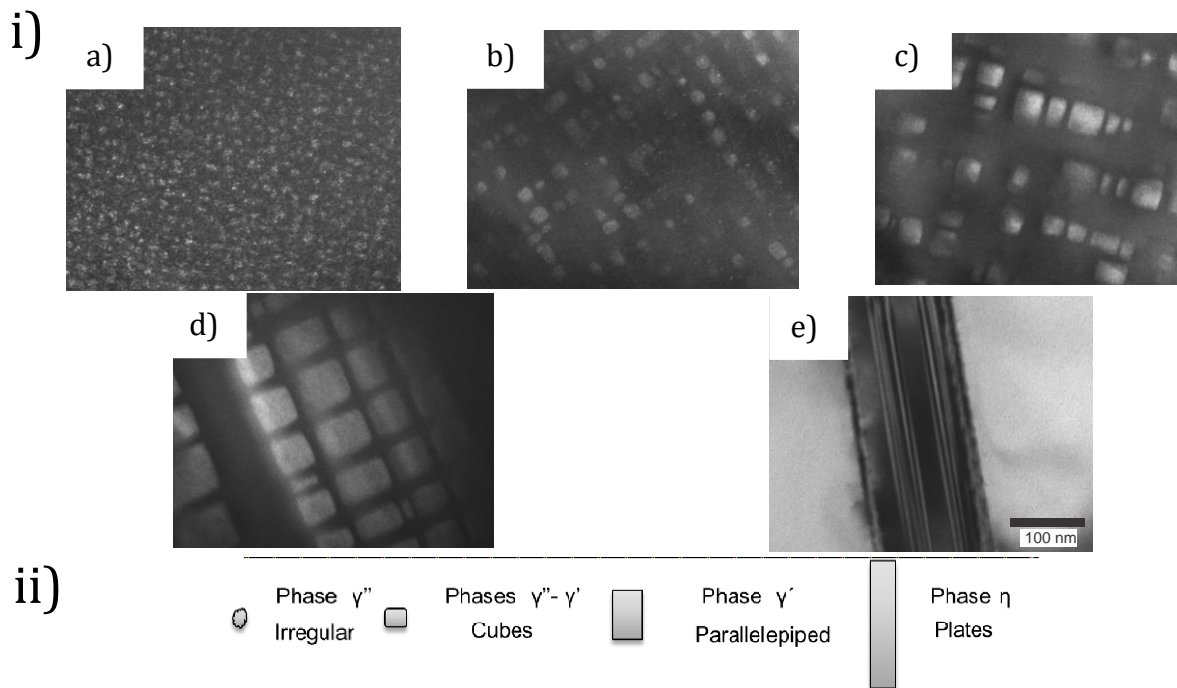


Figure. 1 i) DF-TEM micrographs showing the effects of time on the morphology of phases present in Ni-12 at.% Ti alloy after aging at 750 °C for 5 (a), 50(b), 500(c), 5000(d) 25000(e) and 50000(f) min., and ii) Equilibrium morphologies.

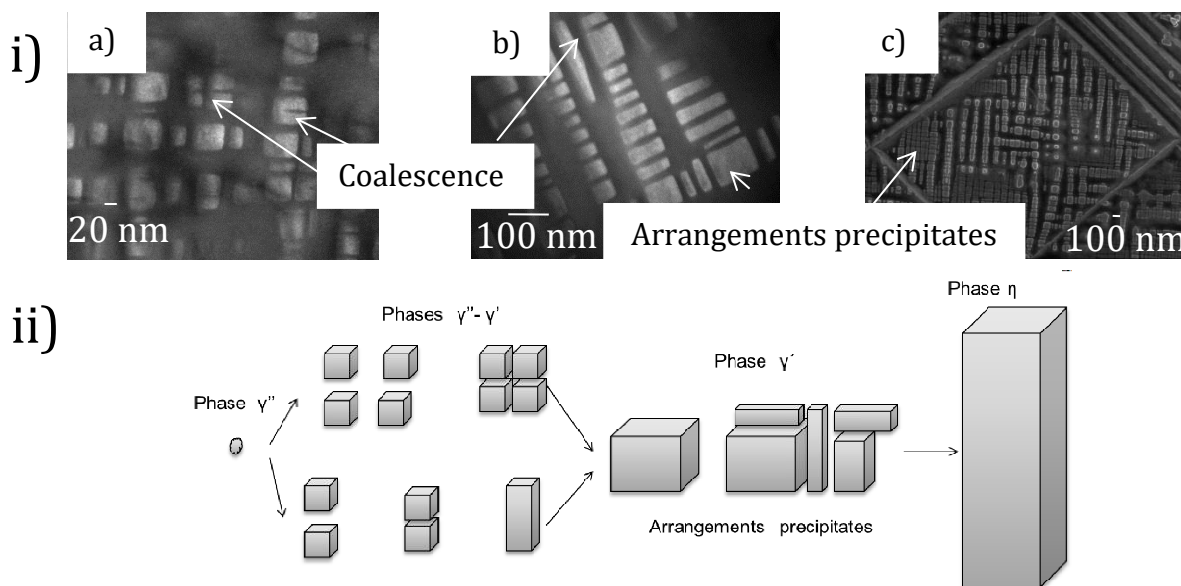


Figure. 2 i) Coalescence and formation of arrangements precipitates in Ni alloy at 12% Ti during aging at different times and temperatures (A, 650 °C for 50000 min-TEM, B and C, 750°C 5000 min-TEM-SEM, respectively) and ii) morphological evolution of precipitates.