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Study of Coarsening in γ' Precipitates by Diffusion Couples

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The Ni-rich Ni-Ti system has been studied by many researchers using many different techniques. The mentioned studies have concluded that cuboidal-type γ' precipitates ($L1_2$ structure) aligned along <100> directions with faces parallel to {100} planes are the cause of hardening, but these precipitates coarsen at high-temperature and prolonged service time causing loss of coherency and eventually affect the mechanical properties. Coarsening is theoretically described by the model proposed by Lifshitz-Slyozov and Wagner (LSW theory) [1, 2] which predicts (for diffusion-controlled coarsening) precipitates dispersed in a fluid matrix (volume-fraction of the precipitates (f_v) close to zero) that coarsen according to the relationship, $r^3 = k_r t$. A different behavior of k_r during the coarsening has been reported for Ni-based alloys with elastic strains, where k_r decreases in function of increasing f_v (at low volume-fraction), which is known as anomalous coarsening [3-5]. Taking into account the anomalous coarsening with a more realistic model, where coarsening is independent f_v, has been developed by Ardell and Ozolins [6] and Ardell [7] and is called trans-interface diffusion-controlled (TIDC) theory. A rate law of type $<r>^n \approx k_I t$ is predicted by the TIDC theory.

Miyazaki [8] proposed a characterization method to study the precipitation process in binary alloys, called the macroscopic concentration gradient (MCG) method. This method allows determining solubility limits, phase equilibrium and coarsening; it is based on the microstructural observation of different composition alloys formed by a continuous concentration gradient. Thus, the purpose of this work is to analyze the coarsening of γ' precipitates in Ni-rich Ni-Ti alloys using diffusion couples in order to determine which model, LSW or TICD, fits better.

Buttons of Ni–11.5 wt. % Ti alloy (C1) and pure Ni (C2) were melted in an electric-arc furnace under an argon atmosphere using pure elements (99.9 %). An assembly consisting of the specimens C1 and C2 was placed into an austenitic stainless steel holder with two screws, encapsulated into a quartz tube under an argon atmosphere and heat treated at 1200 °C for 28 h to promote the diffusion and generate the concentration gradient in the diffusion couple, subsequently, the diffusion couple was isothermally aged at 850, 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 with Energy Dispersive Spectroscope (EDS).

The Fig. 1 and 2 show the precipitation front generated in the diffusion couple and the morphology of the γ' precipitates after aging at 750°C, respectively. From the obtained results, it can be concluded that during coarsening of γ' precipitates the experimental coarsening kinetics did not fit well neither LSW nor TIDC theoretical models, because of the presence of strong elastic interaction between precipitates [9].

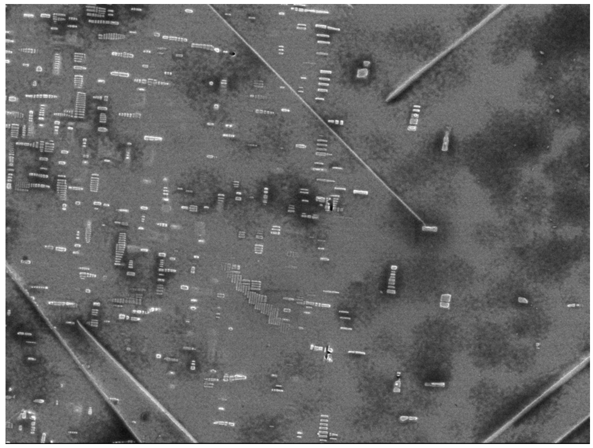

Figure 1. HR-SEM images of precipitation front after aging.

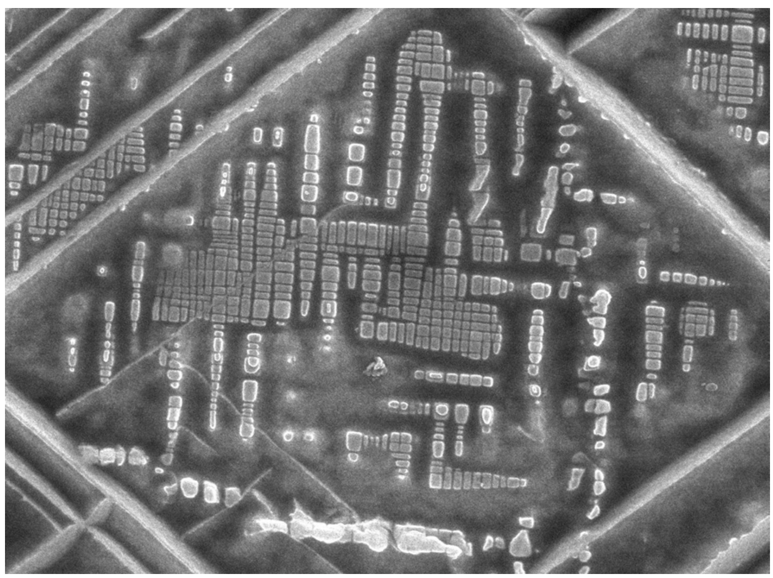

Figure 2. HR-SEM micrograph with general morphology of γ' precipitates after aging.

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