ESRF	**Experiment title: "in situ"deformation at high temperature of Ni base single crystal superalloy: measurement of the evolution of the internal strain, relation between lattice parameters and internal stresses at the γ/γ' interfaces**	**Experiment number:** HS651
Beamline:	**Date of experiment:** from:20/11/98 to: 01/12/98	**Date of report:** 26/02/99
Shifts:	**Local contact(s):** A. Royer	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

A. Royer ESRF BP 220 F-38043 Grenoble
P. Bastie LSP BP 87 F-38402 Saint Martin d'Heres
M. Veron LTPCM BP 75 F-38402 Saint Martin d'Heres
A. Jacques LPM Parc de Saurupt F-54042 Nancy
J.P. Feireisen LPM parc de Saurupt F-54042 Nancy

Report:

Superalloys are used in manufacturing airjet engine turbine blades. In these alloys the mechanical properties at high temperature depend largely on the precipitation of the ordered γ' phase (L12 structure) inside the disordered γ matrix (FCC) structure. The use of single crystal blades limits creep strain and the high precipitate volume fraction (70 % at room temperature) provides a good structural hardening. Most of their mechanical properties are related to the matrix-precipitates misfit $\delta=2 . (a\gamma'-a\gamma)/ (a\gamma'+a\gamma)$ and to the interfacial coherency state. A directional coarsening occurs under stress. It is driven by the internal stresses which are related to the lattice parameter mismatch. When a tensile deformation is applied at high temperature, the cuboidal morphology evolves to a platelet structure perpendicular to the axis of deformation. Up to now the measurements were performed in temperature on crept deformed samples after stress removing [1]. For the first time bulk measurements on creep test specimen were performed "in situ" at high temperature (1050°C and 1080°C) under stress (150 MPa) using the ID15A Triple Crystal Diffractometer set-up and a furnace developed at LMP, Nancy especially for this type of experiment. The energy of the incident beam was 150 keV (0.08A). The first stage of the deformation level was analysed in parallel and perpendicularly to the applied deformation axis at 1050°C. Then the deformation was driven up to rupture at 1080°C. As it took 96 hours to reach the rupture only

the direction (002) was analysed.

The measured lattice parameter mismatch values are larger than those measured after stress removing. This is due to the applied stress and is in accordance with the sign of the misfit and with the relative strengthening of the γ and γ' phases.

Figure 1 shows the typical deformation curve obtained for a tensile deformation at 1080°C under 150 MPa.

Figure 2 shows the evolution of the lattice parameter mismatch measured as a function of time during the "in situ" deformation in the direction parallel to the applied deformation axis. These measurements show a strong correlation between the lattice parameter mismatch behavior and the deformation level of the creep curve. The three stages of the creep deformation curve are clearly observed. During the first stage of deformation when the raft structure develops, a dislocation network takes place at the γ/γ' interfaces which become incoherent relaxing interfacial stresses, the misfit value becomes larger. During the secondary creep stage which corresponds to the turbine blades operation time this parameter evolves slowly and monotonously. During the third creep stage, when the rafts break up, the misfit value evolves very fast and tends to become smaller. To complete this analysis and to relate the misfit evolution to the internal stresses distribution, the same analysis should be done for the misfit values in the raft plane ((200) and (020) directions)

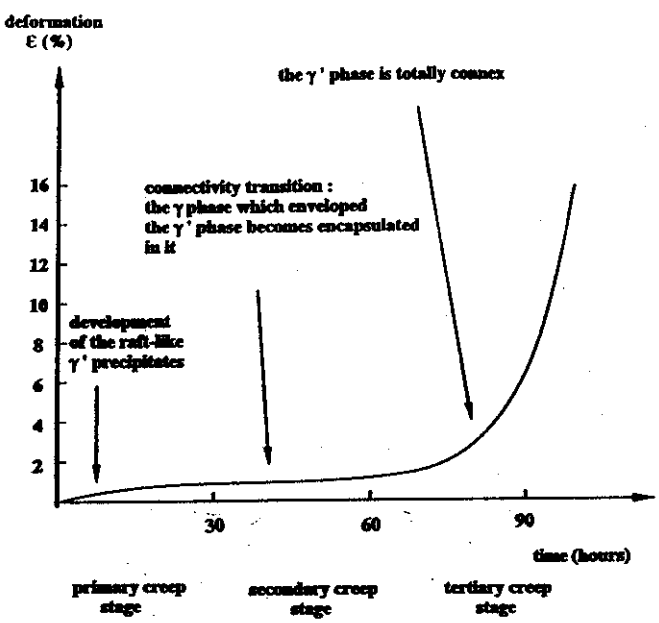

Figure 1: deformation curve for AM1 superalloy at T=1080°C under σ=150Mpa

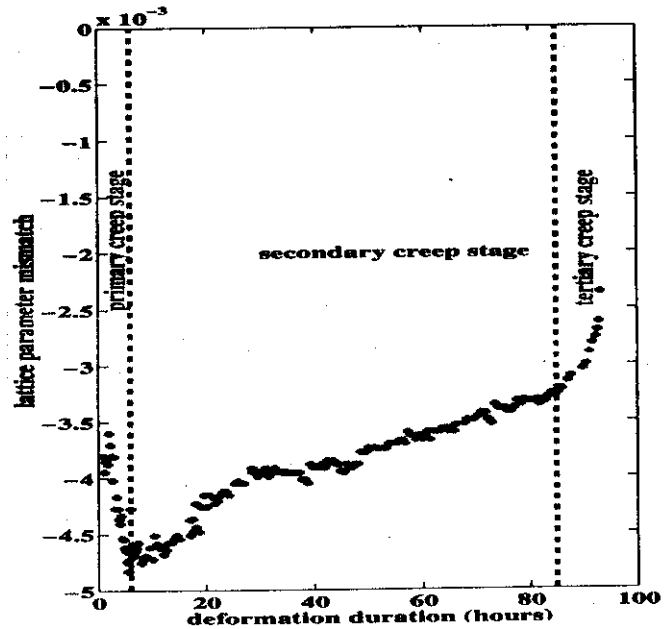

Figure 2: Evolution of the misfit measured in the direction perpendicular to the raft plane

Reference : [1] A.Royer,P.Bastie and M.Veron,"in situ" determination of the γ' phase volume fraction and of relations between lattice parameters and precipitates morphology in Ni-based single crystal superalloy" Acta Materialia, 46,pp. 5357-5368,1998