ESRF

Experiment title:
Lattice parameters of single crystal Ni-based superalloy AM 1 : - Influence of plastic deformation Temperature measurements on prestrained samples

Experiment number:
HC 470

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Report:

Ni based superalloys are diphasic compounds : an ordered γ' phase precipitates in a disordered γ phase matrix. Most of their mechanical properties are related to the lattice parameter mismatch between the two phases ($\Delta d/d = (a\gamma' - a\gamma) / \langle a \rangle \approx 10^{-3}$) and to the interracial coherency state. Previous neutron experiments showed that these two quantities hugely depend on the precipitate morphology (1) and then on the thermomechanical history of the material. After standard heat treatments, precipitates are cuboidal with an average edge of 0.45 μm. Under tensile stress at high temperature, this morphology evolves to platelets perpendicular to the deformation axis.

The triple crystal diffractometer (TCD) of the high energy beam line was very well suited to this Ad/d measurement because :

- as for neutron, the measurements are related to the bulk of the sample (thickness up to 3mm at 125 keV and we can expect more with the new superconducting wavelength shifter making possible the study of plain turbine blades of aircraft engines). Measurements are not perturbed by surface modification (oxidation, polishing, ···).
- the resolution is much better than that we could get with neutron. In particular, accurate two dimensional maps of the reciprocal space were drawn
- small area of the sample (less than 0.1 *O. 1 mm^2) could be analysed
- sample environment was easy to install and high temperature measurements up to 1050°C were performed.

First we studied, at room temperature, three specimens creep-deformed along the (001) directional 850°C, 900°C and 1000°C. Due to the particular shape of each specimen, the applied stress depends on the position in the sample and four different values of the plastic strain were obtained. Figure 1 shows three typical maps recorded on the sample crept at 1000°C. We remark that the mosaicity is not homogeneous in the sample and that the misfit sign depends on the direction considered (parallel or perpendicular to the stress axis) and its value on that of the plastic strain (or of the applied stress).

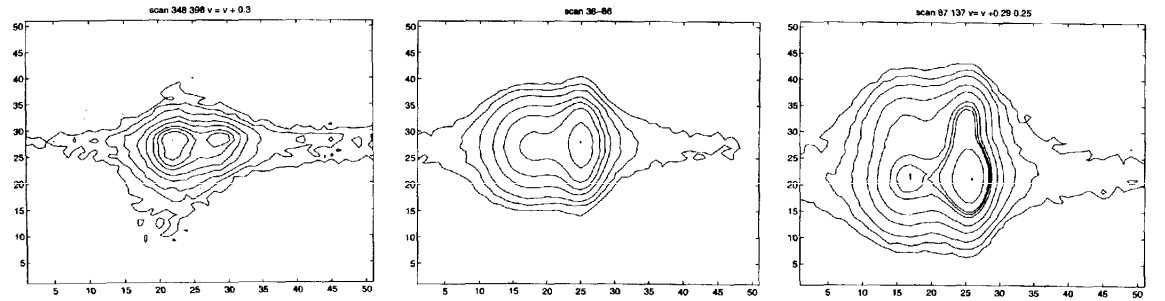

Fig 1 : (a) Isointensity map around the (200) reflection of the sample crept at 1000°C (ε=1 .55%). Misfit measured perpendicular to the stress axis.
(b) and (c) Isointensity map around the (002) reflection of the sample crept at 1000°C (ε=0. 19% and 1.55% respectively). Misfit measured parallel to the stress axis.

In a next step, a sample predeformed at sufficiently low temperature to preserve the cuboidal precipitate morphology was studied at 1050°C for 8 hours. During such an annealing a directional coarsening of the precipitates occurs (2). Comparing with a reference sample which was not predeformed, it appears that the main change in the lattice parameters occurs during the prestraining (increase of the misfit). While, during the annealing, it is the FWHM of the diffraction peaks which decreases ; this effect is associated to a relaxation of the internal stresses at the γ-γ' interfaces.

We studied also the evolution of the misfit during heating from room temperature to 1050°C for a sample prestrained in the same conditions and annealed 20 hours at 1050°C. Perpendicularly to the rafts, we observed a change of the misfit sign around 800°C ($\Delta d/d$=+0.0016 at RT, O at 800°C and -0.0034 at 1050°C), while parallel to the rafts, the misfit is almost independent of the temperature. Such a behaviour is in accordance with previous neutron measurements (1) although the conditions which induced the directional coarsening were different. But the values of the misfit are different and are probably a signature of the thermomechanical treatment.

(1) A. Royer, P. Bastie, D. Bellet, J.L. Strudel
Phil. Msg. A 72, 669-689, (1995)
(2) M. Veron, Y. Brechet, F. Louchet
Phil. Msg. letters (in press)