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<tr><td></td><td>Experiment title: “In situ” study of the lattice parameter mismatch of the MC-NG new generation superalloy during a creep test at high temperature</td><td>Experiment number:
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18</td><td>Local contact(s):
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Report:

Due to their good mechanical properties at high temperature, Ni based superalloys are used to manufacture aircraft engine turbine blades. The improvement of the turbine performances goes through an increase of the gas temperature at the turbine entrance. For this aim, a superalloy of a new generation named MC-NG is currently under development at the ONERA. As the previous superalloys, it is a diphasic compound with ordered γ ’ precipitates inside a FCC γ matrix. The creep characterisation of this new material shows a significant increase of the life duration before rupture compared to the superalloys of the previous generation (AM1, MC2). Furthermore the shape of the creep curves differs significantly from that of the previous generation. Preliminary studies by scanning electron microscopy (SEM) allow to correlate the creep characteristic to the microstructural evolution of the γ ’ precipitates. Among the parameters which control this evolution, the lattice parameter mismatch between the γ and the γ ’ phases is one of the most important. The aim of this study was to determine the evolution of the lattice parameter mismatch of this new superalloy during a creep test, as a function of time and therefore of deformation, in order to understand the microscopic mechanisms at the origin of the differences between the two generations of superalloys.

Using the Triple Crystal Diffractometer (TCD) installed on the high energy beamline ID15A which allows “in situ” bulk measurements, we measured the evolution of the lattice parameter mismatch of a MC-

NG sample during a creep test. Before the experiment, the specimen received the standard heat treatments which lead to a cuboïdal precipitate morphology with a cube edge of 0.40 µm. It was submitted to a tensile creep test at 1100°C under 150 MPa up to rupture which was reached in 60 hours. During such a creep test, the precipitates evolve to a rafted shape perpendicular to the applied stress. The evolution of the lattice parameter mismatch was measured for the reflection (200), so for lattice plane parallel to the applied stress. This corresponds to a direction parallel to the rafts appearing during the creep deformation. The aim of these measurements was first a comparison with a similar measurement performed on the AM1 superalloy (1) in order to check the differences between these two alloys which could be at the origin of the better performance of the new superalloy. Indeed, as shown for the AM1 superalloy (2), it is mainly this type of measurements which allows to understand and to model the creep behaviour of the material.

The obtained results are not fully analysed. However, some conclusions can be reported now. First the temperature behaviour of the sample before the beginning of the creep experiment exhibits similarities with that of the AM1 superalloy. In particular the misfit is slightly negative at room temperature and its absolute value increases with T. But the volume fraction of the γ ' phase remains larger at high temperature. The hardening phase presents a better structural stability at the temperature of the test. It is certainly one of the origin of the improved mechanical properties at this temperature. During the creep test, the misfit evolution presents some similarity with that of the AM1 superalloy. However, in the case of MC-NG, the splitting of the diffraction peak, which corresponds to the first stage of the deformation curve, takes more time, showing that the stability of the cuboïdal precipitates is stronger. But the evolution of the misfit during stage two is faster than that of the AM1. The rafted precipitates dislocate faster than in AM1 as confirmed by SEM observations.

Now we have to perform the “in situ” creep experiment for the reflection (002) in order to follow the time evolution of the misfit under stress, along the direction perpendicular to the rafts. This will allow us to check the validity of the model previously proposed for the AM1 superalloy (2) and to apprehend the origin of the difference in the mechanical properties at high temperature.

References

[1] A. Royer, P. Bastie, M. Véron, A. Jacques
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[2] A. Royer, A. Jacques, P. Bastie, M. Véron
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