ESRF	**Experiment title:** Influence of elastic interactions on the coarsening mechanism in alloys	**Experiment number**: HS-2383
Beamline: ID10A	**Date of experiment**: from: 30/06/04 to: 06/07/04	**Date of report**: 01/08/05
Shifts: 18	**Local contact(s)**: Dr. Federico ZONTONE	*Received at ESRF:*

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Report:

Combining X-ray photon correlation spectroscopy, XPCS, with (detrended) fluctuation analysis, (D)FA, can be used for studying slow dynamics in alloys, where the dynamics is characterised by the so-called fluctuation exponent α. In particular, distinguishing different coarsening mechanisms in phase-separating alloys at late stages of phase separation is possible by comparing experimental with simulation results [1]. Up to now only elastically isotropic systems (Al-Ag, Al-Zn, Al-Li), where precipitates are spherical – apart from possible facetting – and isotropically arranged, were studied with this approach.

Here we report on XPCS measurements of coarsening dynamics in the elastically anisotropic Ni-Al-Mo system, belonging to the so-called "superalloys". By varying the Mo content different lattice constants of the supersaturated Ni fcc matrix, a_m, and hence different misfits, $\delta=(a_p-a_m)/a_m$, can be realised, where a_p denotes the lattice constant of the $L1_2$-ordered Ni_3Al precipitates [2]. For $\delta=0$ spherical precipitates are found, whereas for $\delta >> 0$ precipitates are cuboidal and arranged along the elastically soft [001] directions [3].

We have performed XPCS experiments at the TROIKA beamline ID10A on several Ni-Al-Mo single-crystalline ($\underline{1}$10)-oriented samples with different Mo content and thus different lattice misfit. The samples were in quasiequilibrium, i.e., no significant precipitate growth and hence no change in the SAXS pattern could be measured during the experiment. The samples were held at up to 975°C in a transmission furnace equipped with kapton windows that preserved the coherence properties of the beam. A *12* µm pinhole upstream of the sample ensured spatial coherence. Guard slits were used to cut parasitic pinhole scattering. Temporal coherence was achieved by the high energy resolution of $\delta E/E=10^{-4}$ of the used *8*

keV photons. Time series of diffraction patterns were taken with a CCD camera (Princeton Instruments, direct illumination, *22.5×22.5* μm^2 pixel size) placed about *1.85* m downstream the sample in order to resolve the speckle structure. Figure 1 shows such a diffraction pattern for a sample with almost no lattice misfit, left hand side, and with δ*=+0.65%*, right hand side, respectively. The obtained time series of fluctuating speckle intensities were evaluated by the DFA*1* technique [4] for different momentum transfers, *Q*, in [001], [111], and [110] direction. Figure 2 shows the obtained $\alpha(Q)$ curves for the two samples. As can be seen, the correlation behaviour for the δ*<0.10%* sample is identical in all three directions. The $\alpha(Q)$ curves for the δ*=+0.65%* sample, however, reveal more strongly correlated dynamics along [001] than for the other directions, reproducing simulation results (not shown). The picture is that due to the strains in the δ*=+0.65%* sample precipitate-forming atoms are "trapped" in the elastically soft directions. Thus, the probability of finding them along [001] in the next time step again is extremely high. This persistence manifests in large fluctuation exponents over a very broad range in [001] direction.

In the present study we have followed coarsening dynamics in elastically anisotropic Ni-Al-Mo alloys in situ. The correlation behaviour is dependent not only on the absolute value but also on the direction of the scattering vector ***Q***, which leads to a direct insight into the dynamics in real space [5].

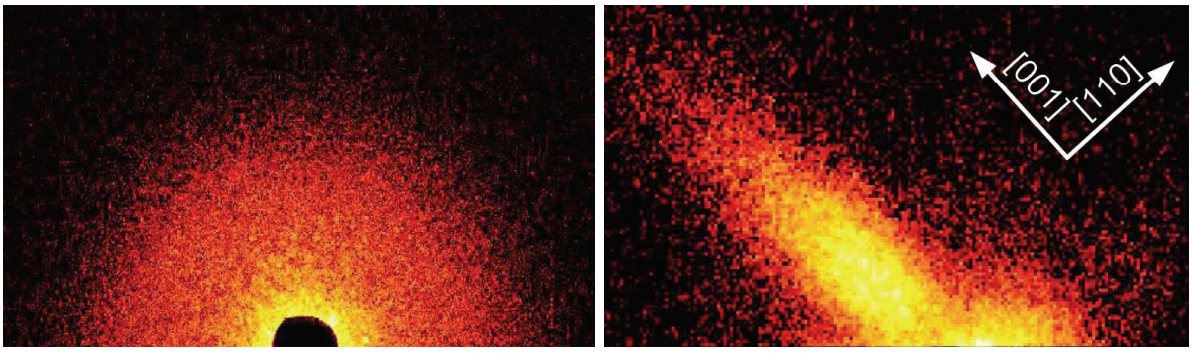

FIG. 1. Left: Isotropic coherent SAXS pattern for Ni-*7.7*at.%Al-*7.9*at.%Mo with δ*<0.10%*. Right: Anisotropic coherent SAXS pattern for Ni-*12.5*at.%Al-*2*at.%Mo with δ*=+0.65%*.

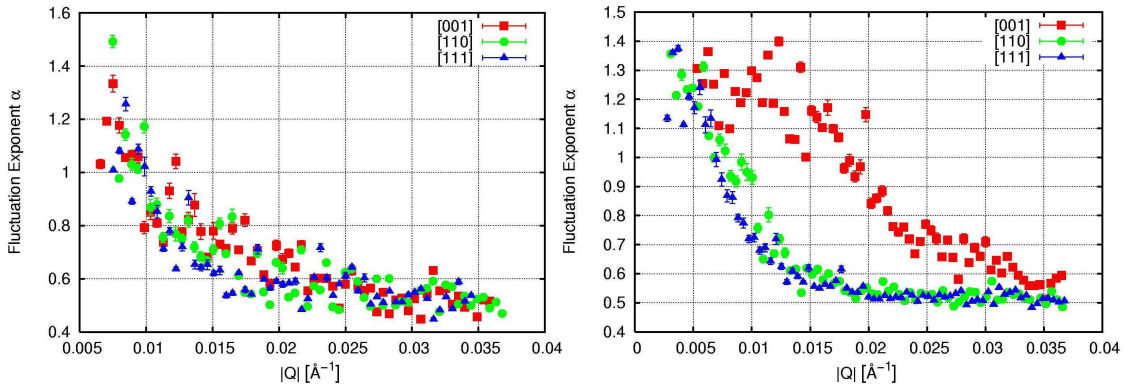

FIG. 2. Obtained $\alpha(Q)$ curves. Left: δ*<0.10%* sample at 825°C. Right: δ*=+0.65%* sample at 775°C with highly correlated dynamics in the elastically soft [001] direction.

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