ESRF	**Experiment title:** Study of glass dynamics at the ferromagnetic-to-paramagnetic transition using XPCS	**Experiment number**: HC-1959
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Report:

The temperature-/time-resolved evolution of the atomic dynamics of the melt spun amorphous $Fe_{72.5}Cu_1Nb_2Mo_2Si_{15.5}B_7$ (at.%) during series of isothermal heatings was investigated in transmission mode by in-situ X-ray photon correlation spectroscopy (XPCS) at the ID10 undulator beamline in ESRF (Grenoble, France). The as-quenched alloy in the form of thin ribbon (thickness 19 µm) was mounted inside the metallic frame of the standard tomography furnace available at the ID10 beamline. Annealing was done under vacuum atmosphere. Each series of XPCS measurements started with the fresh piece (width 5 mm, length 15 mm) of a fully amorphous material. Highly monochromatic, collimated and coherent photon beam with energy of 7000 eV and cross section of 10×10 μm^2 was used. The scattering intensity was collected in transmission geometry by the two IkonM charge-coupled devices from Andor Technology (1024×1024 pixels, 13×13 μm^2 pixel size), placed 70 cm behind the sample. Angular acceptance of the furnace and positioning of the detector behind the sample allowed collecting of the principal diffuse peak located at q_0=3.08 $Å^{-1}$.

One of the main goals of our experiments was to follow atomic dynamics at the ferromagnetic-to-paramagnetic transition. As suggested from preliminary X-ray diffraction studies the $Fe_{72.5}Cu_1Nb_2Mo_2Si_{15.5}B_7$ metallic glass exhibits structural relaxation which is taking place in the temperature region around the ferromagnetic-to-paramagnetic transition. In order to relax amorphous structure and thus enhance sensitivity to atomic dynamics around the Curie point we started our XPCS experiments with isothermal annealing at 400 °C. The sample was heated from ambient temperature up to 400 °C with the heating rate of 3 °C /min. During isothermal annealing at 400 °C we acquired 1000 speckle patterns which were analyzed according to the procedure described in Ref. [1]. Due to readout, data transfer and mostly scattering power of the sample the temporal resolution (time difference between the two consecutive images) was 6.67 s.

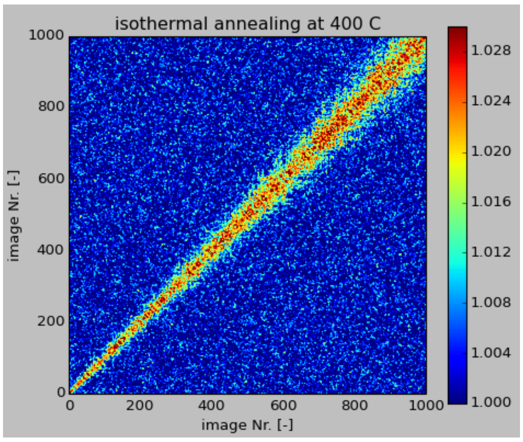

Fig.1 Two-time correlation function measured during isothermal annealing at T = 400 °C by means of XPCS.

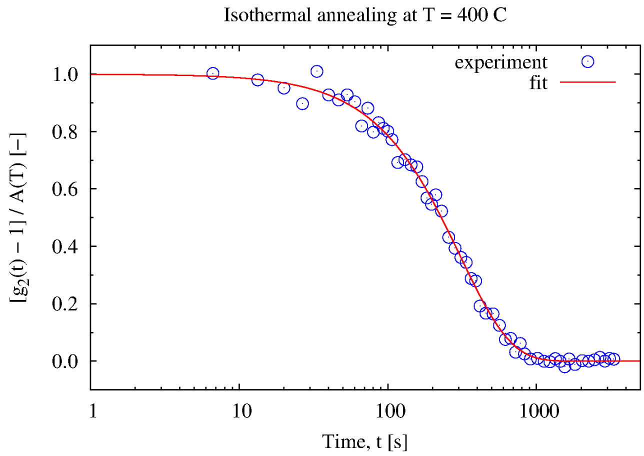

Fig.2 Correlation function $g_2(t)$ measured for q_0 = 3.08 $Å^{-1}$ during isothermal annealing at 400 °C. The red line is the best fit using a KWW model function.

Figure 1 shows two-time correlation function measured during isothermal annealing at 400 °C. The broadening of the yellow-red ridge along the main diagonal ($t = t_1 - t_2 = 0$) is due to slowindg down of the atomic dynamics (so called ageing). Figure 2 introduces the correlation function $g_2(t)$ extracted from the two-time correaltion function presented in Fig.1. The data are presented together with the best fit obtained by using the Kohlrausch-Williams-Watt expression $g_2(t) = 1 + A\exp[-2(t/\tau)^{\beta}]$, with τ (=527 s) being the structural relaxation time, β (=1.27) the shape parameter, and $A=A(q,T)=B(q)f_q(T)$, where $f_q(T)$ is the nonergodicity factor appearing in the expression of the final decay of the intermediate scattering function, $f(q,t) = fq(T)\exp(-t/\tau)^{\beta}$. After isothermal annealing at 400 °C the same sample was cooled down through the series of isothermal annealings at temperatures 360, 345, 335, 325, 310, 285, 220 and 155 °C. At each temperature we collected series of at least 1000 speckle patterns. Figure 3 shows temperature dependence of correlation functions $g_2(t)$.

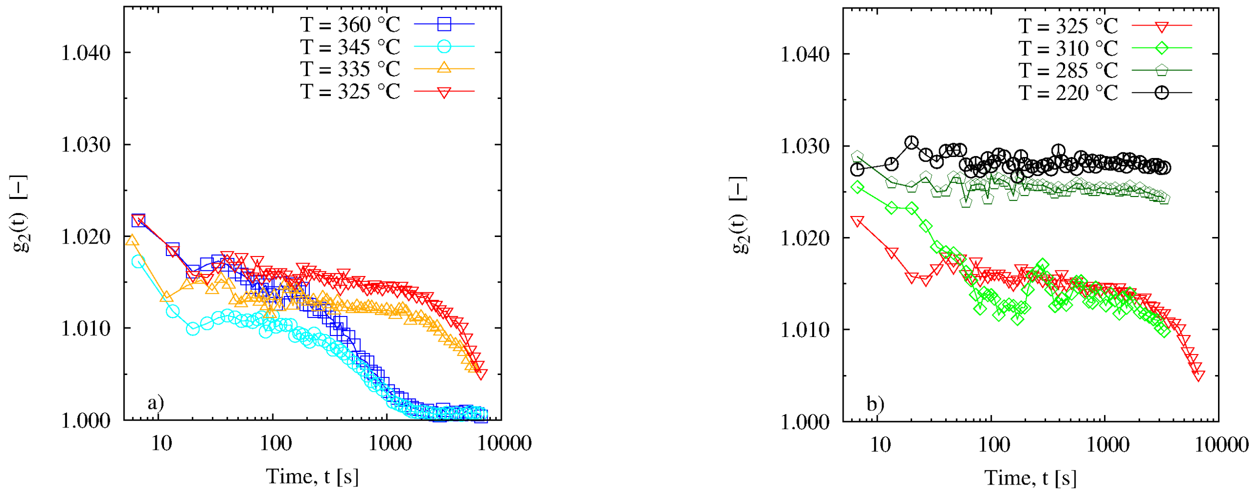

Fig.3 Temperature dependence of correlation functions $g_2(t)$ measured for q_0 = 3.08 $Å^{-1}$ by means of XPCS.

Repeating similar series of XPCS measurements, however at slightly different energy 7110 eV, resulted in qualitatively the same results. The obtained correlation functions were more noisy and showed lower contrast due to the fact that atomic scattering factor of Fe slightly decreased at 7110 eV.

References

[1] Y. Chushkin, C. Caronna, and A. Madsen, J. Appl. Crystallogr. 45, 807 (2012).