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Studies of atomic scale diffusion by X-ray photon correlation spectroscopy

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Although Quasielastic Neutron Scattering (QNS) has proven successful in investigating diffusive dynamics at the atomic level in solid state physics, the limits for the diffusion coefficient are relatively low. Therefore QNS is in general limited to measurements in the vicinity of the melting transition. Also, because of the specific scattering cross section of neutrons, it favors selected atoms like hydrogen or lithium. The goal of our studies in the last years was to overcome these limitations by using a new method to study atomic motion at the fundamental level. This method should ideally work in a broad spectrum of solids and enlarge the accessible range of temperatures.

Our group managed to develop the relatively new technique of X-ray photon correlation to work on the atomic scale. This technique operates in the time regime rather than in the energy regime and measures chemical fluctuations instead of self diffusion. Atomic scale X-ray photon correlation spectroscopy (aXPCS) is therefore not subject to the limitations mentioned above. The time resolution towards faster dynamics is only limited by the readout time of the detector and intensity of the X-ray beam. Towards slower dynamics it is limited by the stability and the duration of the experiment. Even though at the moment a high contrast in the scattering length of the system under investigation is required due to today's technical limitations at synchrotron sources, there is practically no restriction to certain elements for this technique. aXPCS therefore allows to investigate atomic scale diffusion in the temperature range of intermetallic phases or to study dynamics of glasses well below glass transition temperatures.

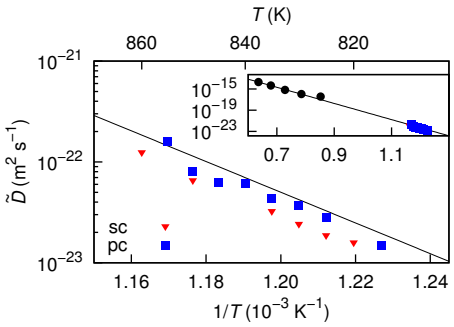

Figure 1: Diffusivities of Ni-Pt solid solution measured with aXPCS at the ESRF for single crystal (sc) and polycrystalline sample (pc) compared with tracer data (circles) [3]. (This data was published in [2].)

The first successful aXPCS experiment was carried out only a few years ago by our group [1]. This poster will give an overview of an experimental setup and show what we have been able to experimentally achieve since then. The systems presented will be a Ni-Pt solid solution with jump frequencies in the order of $\tau^{-1} \sim 10^{-3}\,\mathrm{s}^{-1}$ (see Figure 1) [2] and an Fe-Al intermetallic alloy.

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References

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