ESRF	**Experiment title:** **Test of feasibility of studying diffusion by scattering of synchrotron radiation into Bragg directions**	**Experiment number:** HS-584
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Report:

With nuclear resonant scattering of synchrotron radiation (SR) it is possible to determine directly the elementary diffusion jump of atoms in single-crystaline solids. In this project the scattering was measured in Bragg geometry.

SR scattered from crystalline and amorphous media in the forward direction maintains its coherency. Disturbing effects like diffusion destroy coherency, and we can observe accelerated decay of intensity in forward direction. In crystalline solids the coherency should be preserved also for SR scattered in Bragg directions. One can expect that diffusionally accelerated decay of intensity will also occur in Bragg directions.

A furnace with a Fe_3Si single crystal cut with its (220) plane normal to its surface was mounted on a goniometer head. The detector was placed in a position where the Bragg condition for the (220) plane was fulfilled. Resonant counts of 14.4 keV radiation were measured as a function of time after the prompt SR pulse at two temperatures (see Fig. 1). The decrease of intensity at 850K corresponds to the undisturbed decay of ^{57}Fe whereas at

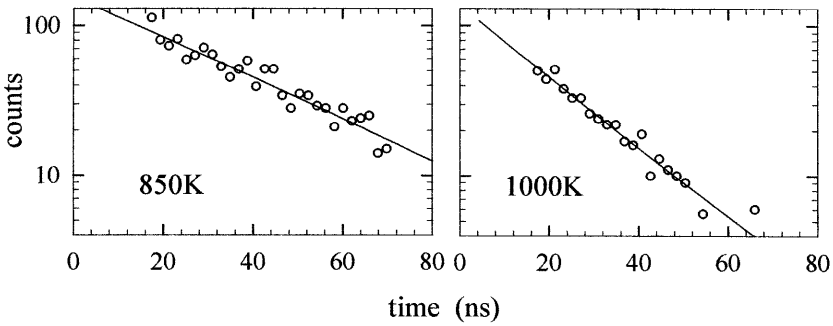

Fig. 1. Decay of SR intensity scattered from the crystal plane $(\bar{2}20)$ Fe_3Si at 850K and 1000K.

1000K a diffusionally accelerated decay is clearly visible. The solid lines are fits of the data to the solutions of the scattering theory [3]. The results of the fitting procedure are compared with the predictions derived from a simple diffusion model [2].

Model-calculations for a wave vector $|\mathbf{Q}| = 7.3 Å^{-1}$ with components for scattering from the (220) plane Q = (6.15, -2.52, 3.03) predict effective decay rates of -2.2 and 1.0 (au.) and corresponding weights of 0.6 and 0.4 respectively (see Ref.[2]). Actually, the time dependence should be composed of two exponentials - compare Fig. 2. of Ref. [2] where two-exponential decay was clearly visible. Unfortunately 16-bunch mode was not operational and we had to measure for 4 shifts in single bunch mode with insufficient intensity and another 1 shift in 32-bunch mode where only a 88 ns time window was available. Due to these limitations it was impossible to resolve the two-exponential decay. *Nevertheless the diffusional acceleration of intensity decay in Bragg direction scattering could be definitly established as proved by the faster decay at 1000K.* This method of measurement has the following advantages compared to the forward scattering of SR: the prompt-signal intensity is strongly reduced compared to the forward scattering. This effect should be specially useful in backscattering geometry allowing measurements starting at shorter time after prompt X-ray impulse, widen the available time window. In backscattering geometry one can investigate samples which are not accessible in transmission geometry.

[l] B.Sepiol,A.Meyer, G.Vogl, R.Rüffer, A.I.Churnakov, andA.Q.R.Baron, Phys.Rev.Lett.76,3220 (1996).

[2] B.Sepiol, A.Meyer, G.Vogl, H. Franz, and R.Rüffer, Phys. Rev. B57, 10433 (1998).

[3] G.V.Smimov and V.G.Kohn, Phys. Rev. B52,3356 (1995); B57,5788 (1998).