Contribution ID: **59** Type: **Poster**

Pushing the resolution limit of neutron backscattering: A GaAs option for IN16B at ILL

Friday, 2 September 2016 17:50 (1h 25m)

Since its beginning, the developments in neutron backscattering instrumentation have been primarily focussed on increasing the intensity, while little progress has been made in enhancing the energy resolution. This is restricting investigations like on hyperfine splitting, rotational tunnelling or diffusive processes in solids, e.g. with relevance for battery materials.

During an ongoing 'GaAs extension' project, we are developing a prototype spectrometer with a crystal surface corresponding to 1/10 of a full scale instrument, aiming at an energy resolution δE < 50 neV FWHM and an energy transfer range ΔE = ±5 μeV.

Measurements in a dispersion-free two-crystal setup on IN10 of commercial GaAs wafers yield convolved line widths of 17–28 neV FWHM, confirming the possibility to significantly improve the energy resolution. Yet, in order to retain this high resolution in a full scale instrument, all other limiting parameters need to be controlled to a similar level. This includes variations of the lattice parameter $a/a < 10^{-6}$, the angular misalignment Δθ < 0.1°, and the temperature variation ΔT < 0.1 K. In addition, a temperature gradient of 3.3 K/m along the 3m high analysers is required to compensate the gravitational energy shift of 103 neV/m.

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Session Classification: Poster Session