Channeling of Heavy Ions

L. Görgens, A. Bergmaier, P. Neumaier, M. Schubert, F. Grüner, W. Assmann, and G. Dollinger

Ion channeling is an established analysis method for the characterization of crystals. Main topics are the characterisation of impurities and the estimation of growth defects, i.e. stacking faults and other dislocations. However this experimental method is almost exclusively performed using light ions (H, He), which are easily provided by single ended accelerators and is therefore limited to RBS-like (Rutherford backscattering spectroscopy) experiments. The use of swift heavy ions as available at the Beschleunigerlaboratorium der LMU und TU München, allows channeling under ERD (elastic recoil detection) condition, which gives access especially to diluted light elements in a heavy matrix, i.e. O in Si or N in GaAs.

Quantitative interpretation of the measured data can only be done in comparison with simulations. The simulations and the theory have shown to work well for experiments with light ions. However it is not clear if they work well also for heavy ions. Differences could arise from the reversed proportion in masses of the beam ion and the target atom, changing i.e. from ^{4}He to ^{127}I for the analysis of ^{28}Si.

A succesfully used simulation package is FLUX by P. Smulders et. al [1]. To test the validity of FLUX we measured the angular dependence of the recoil-yield of Si from an ^{127}I beam incident on the (110) and (111) planes as well as on the <111> axis. For the simulations version 7.2 from FLUX was used.

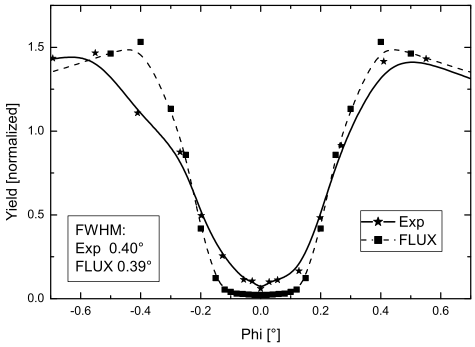

Fig. 1: Measured (EXP) and calculated (FLUX) close encounter probability for a 170MeV ^{127}I beam with an incident angel Φ along a plane tilted 45 deg of the (111) plane

The experimental curve for axial channeling (Fig. 1) has a more gaussian shape compared to the simulated profile. The small asymmetry is due to a minor misalignment of the crystal. However the fwhm, the minimum yield and the overall shape are still in good agreement.

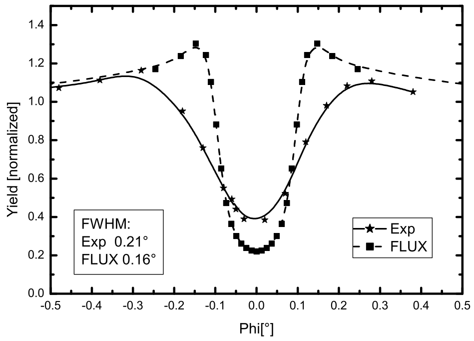

Fig. 2: Measured (EXP) and calculated (FLUX) close encounter probability for a 127MeV ^{127}I beam with an incident angel Φ to (110) plane

For the planar case (Fig. 2), the differences are more significant. The measured yield has a much more gaussian shape than the theoretical curve, the minimum yield is significantly higher and the fwhm show a noticeable difference.

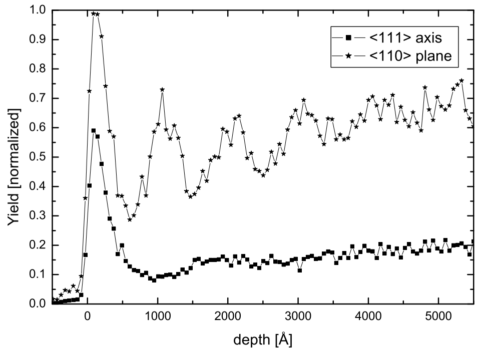

Fig. 3: Measured Si recoil yield from a 127MeV ^{127}I beam incident on the (110) plane and the <111> axis

In Fig. 3 the measured Si recoil yield is displayed versus the length the beam ion penetrated the sample under planar and axial channeling conditions. Both yields display the same behaviour as it is known from light elements under similar conditions. However as far as we know, this is the first time that the oscillatory behaviour of the recoil yield in the planar case could be demonstrated for swift heavy ions. These measurements and the accompanying simulation can provide information about the ion-lattice interaction potential.

References

[1] P.J.M. Smulders and D. O. Boerma, Nucl. Instr. Meth. **B29** (1987) 471