ESRF	**Experiment title:** **Spatially resolved diffractometry by using extremely asymmetrically cut analyzer crystals**	**Experiment number:** **HS-1043**
Beamline: **ID19**	**Date of experiment:** from: **24.02.2000** to: **28.02.2000**	**Date of report:**
Shifts: **12**	**Local contact(s):** **Jürgen Härtwig**	*Received at ESRF:*

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Report:

For this experiment we were not given beamtime, however, our proposal was put onto the reserve list of ID19. We were glad to get, nevertheless, beamtime for Dez. 99. For technical reasons we exchanged this with beamtime for HS-1177 for Feb. 2000.

One of our intentions was to check the feasibility of diffractometry on the submicrometer scale. Therefore one of the requirements was to investigate a 'real' sample. We decided to investigate samples with ZnSe-gratings on GaAs. Such samples are used for the preparation of semiconductor structures (e.g. quantum wires) and are therefore close to topics of current research. We have chosen 85 nm thick ZnSe-layers with a periodic line pattern. The periods on the sample were 500 nm, 1 µm, 4 µm, 10 µm and 20 µm. The layer reflection is to weak as to be investigated by topography at ID19 (in our scheme). Contrast in the substrate reflection is mainly due to strain caused by the ZnSe lines with 0.7% misfit as compared to the GaAs substrate. The penetration depth of strain into the substrate scales roughly with the period length. Therefore the expected contrast in the layer reflection is certainly less than 5% for the 1 µm period. This means a rather hard test in view of imaging.

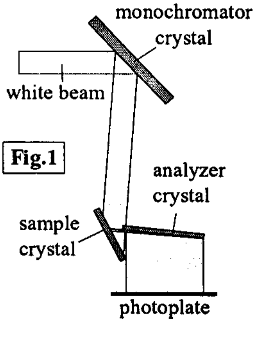

Fig.1

We have chosen a setup as shown schematically in fig.1 using the new double crystal topographic camera at ID19. The Si-(111) monochromator crystal was slightly bent in order to accommodate the sample curvature due to the ZnSe-layer. The analyzer crystal was set on a sample holder we have provided. It is a special surface cut with an angle between surface and (112) netplanes (used for the (224)-reflection) of 42.4°. We have made three sets of experiments with wavelengths of 1.5406 Å, 1.5207 Å and 1.5094 Å corresponding with asymmetry ratios of 40, 80 and 180 - which are equivalent to the magnifications in one dimension.

Several magnifications were used in order to study the dependence of contrast on magnification. Based on general considerations we did expect that at 40-fold magnification the spatial resolution is about at the 1 μm level. Actually, comparing topographs taken with the same density of the photoplates we could detect the 1 μm period only for 80- and 180-fold magnification (figs.2b and 2c). Incidentally, one photoplate was extremely overexposed at 40-fold magnification. This proved advantageous, because the 1 μm period could be observed (fig.2a). Obviously, the conditions did improve the sensitivity to minor intensity variations tremendously. Nevertheless, this 40-fold magnification seems to be some threshold for the resolution of 1000 line pairs per millimeter - actually, in the diffracted beam the period is even slightly below 1 μm (870 nm) due to projection.

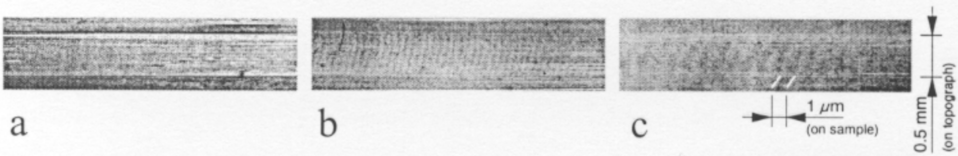

Fig. 2: *Line structure with 1 μm period magnified one-dimensional (a) 34-fold, (b) 80-fold and (c) 180-fold*

Investigation of structures with 4 μm shows a significant improvement with increasing magnifications. At higher magnification some details of diffraction contrast are resolved which are definitely invisible at lower magnification (compare figs. 3a to 3c).

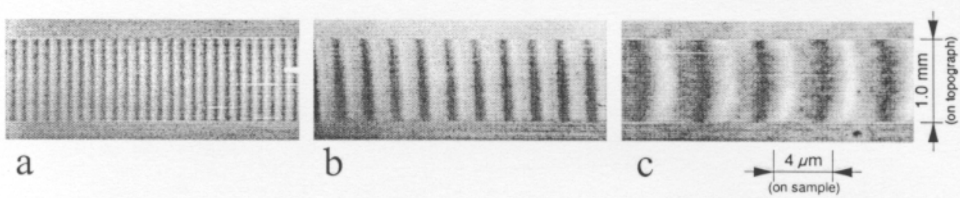

Fig. 3: *Line structure with 4 μm period magnified one-dimensional (a) 34-fold, (b) 80-fold and (c) 180-fold*

The structures of different period cover on the sample fields of 250 to 500 μm length (in diffraction plane) and 500 to 1500 μm width. In figs. 2 and 3 the contrast lines are bent. This curvature is different from field to field and directly shows deviations from straight lines.

Exposure times scale with magnification. This demonstrates that this type of magnification is related with minor intensity losses only.

We have started calculations in order to simulate contrasts including magnification. There are some simple considerations regarding spatial resolution and its relation with asymmetric diffraction, however, a more systematic theoretical approach is required.

We greatly appreciate the excellent support by the staff of ID19, especially by Jürgen Härtwig.