ESRF	**Experiment title:** Depth resolved strain analysis at a two dimensional lateral nanostrutures defined by ion implantation	**Experiment number:** SI-840
Beamline: ID 10B	**Date of experiment:** from: 27.11.2002 to: 03.12.2002	**Date of report:** 15.02.2003
Shifts: 18	**Local contact(s):** O. Konovalov	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

J. Grenzer*, T. Panzner* and U.Pietsch

Institut of Physics, University of Potsdam, Am Neuen Palais 10, 14415 Potsdam, Germany

Report:

We report on the study of a two dimensional dot lattice structure which was created into a GaAs (001)-oriented substrate using a $10^{14} cm^{-2}$ dense Ga^+ focused ion beam with a diameter of about $50nm$ and an energy of $100keV$. The fabricated 2D-lattice structure has a period of $200 \times 200nm^2$ with dots of almost circular shape of an area of about $100nm^2$. The whole implanted area has a size of $0.8 \times 0.8mm^2$ and consists of 16 implantations fields each of $200 \times 200\mu m^2$ size. Two samples were investigated. At sample **A** the implantation was done normal to the sample surface, i.e. the beam is penetrating parallel to the vertical lattice planes (channelling), whereas at sample **B** the implantation was performed 7 degree off with respect to the surface normal tilted towards the {110} direction.

We studied the strain distribution of the implanted samples by means of X-ray grazing-incidence diffraction using the multi-purpose eight-circle diffractometer at $ID10B$. Two symmetry equivalent in-plane reflections, the (220) and the $(2\bar{2}0)$ were measured at two different incidence angles (above and below the critical angle) for each sample. At the first reflection a strain sensitive scan is running along the [110] direction and for the second one along the $[1\bar{1}0]$ direction [1],[2].

The diffraction experiments were carried out in the reciprocal space. We used a coordinate system rotated 45 degree around the (001) surface normal and a tetragonal unit cell ($a_T = b_T = \frac{a_0}{\sqrt{2}}; c_T = a_0$). Therefore the cubic (220) reflection corresponds now to the (200) reflection in the new coordinate system.

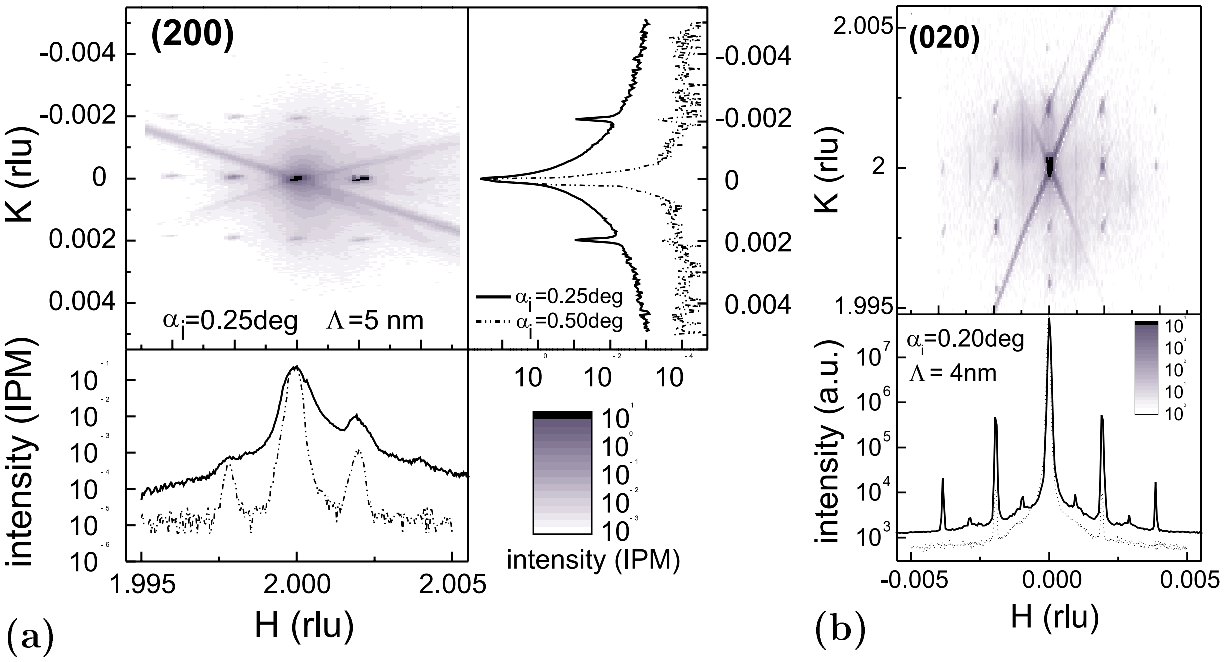

Figure 1: Diffraction patterns of sample **A** (a) and **B** (b). The line scans in figure 1a show scans for two different incidence angles cross the central peak, that one in figure 1b compares identical scans made for sample **A** (dotted line) and **B** (straight line).

Fig.1 shows two reciprocal space maps collected close to the (200) reflection for sample **A** (fig. 1a) and close to the $(0\overline{2}0)$ for sample **B** (fig. 1b). The satellite reflections are clearly displayed being arranged along the H and K directions. Their different shape reflects the different experimental resolution in lateral and transverse scanning directions. The corresponding symmetry equivalent reflections (not shown here) of both samples show similar diffraction pattern which differ only from those shown in Fig.1 by the different (rotated) resolution functions. The fact, that peaks are visible in both maps, the transverse and longitudinal ones, can be explained by the appearance of a periodic damage as well as a periodic strain field. The line scans in figure 1a show clearly the existence of a residual compressive strain and the existence of a thin damaged top layer (increase of diffuse scattering).

The average strain $\frac{\Delta a}{a}$ induced by the ion implantation was calculated from the shift of the envelope over the satellite peaks with respect to the Bragg peak maximum. For sample **A** it amounts to $-4 \cdot 10^{-4}$ near the surface ($\alpha_i = 0.2°$) and decreases to $-2 \cdot 10^{-4}$ in bulk ($\alpha_i = 0.7°$). For sample **B** we found an almost depth independent average strain of about $-10 \cdot 10^{-4}$ ($\alpha_i = 0.15°...0.9°$).

In fig. 1b an additional periodical structure can be identified: A line between the dot lattice peaks along the K direction has appeared, its period in the H direction is the same as the lattice spacing. This behaviour was found only in sample **B** and can be attributed to a different interaction of the implanted ions with the host lattice. This effect disappears for sample **A** where the implantation was done in channelling direction.

We would like to acknowledge Dr. B. Köhler, IZFG Dresden, for providing the samples and O.Konovalov for the support during the measurements.

References

[1] J. Grenzer, U. Pietsch, U. Zeimer, ESRF Report SI-787 (2002).

[2] J. Grenzer, N. Darowski, U. Pietsch, A. Daniel, S. Rennon, J.P. Reithmaier, and A. Forchel, *Appl.Phys.Lett.* **77**, 4277 (2000).