ROBL-CRG	**Experiment title:** **Investigation of the shape of the chemical composition profile in InGaAs/GaAs heterostructures**	**Experiment number**: 20-02-49 EU M07
Beamline: BM 20	**Date of experiment**: from: 22/09/01 to: 25/09/01	**Date of report**: 12/12/01
Shifts: 9	**Local contact(s)**: Dr. Norbert Schell (schell@esrf.fr)	*Received at ROBL:* 12.02.01

Names and affiliations of applicants (* indicates experimentalists):

Dr. Jerzy Sass, ITME, Warsaw, Poland; e-mail: sass_j@sp.itme.edu.pl
M. Sc. Krystyna Mazur, ITME, Warsaw, Poland; e-mail: mazur_k@sp.itme.edu.pl

Report:

Investigation of the chemical composition profile in InGaAs/GaAs heterostructures

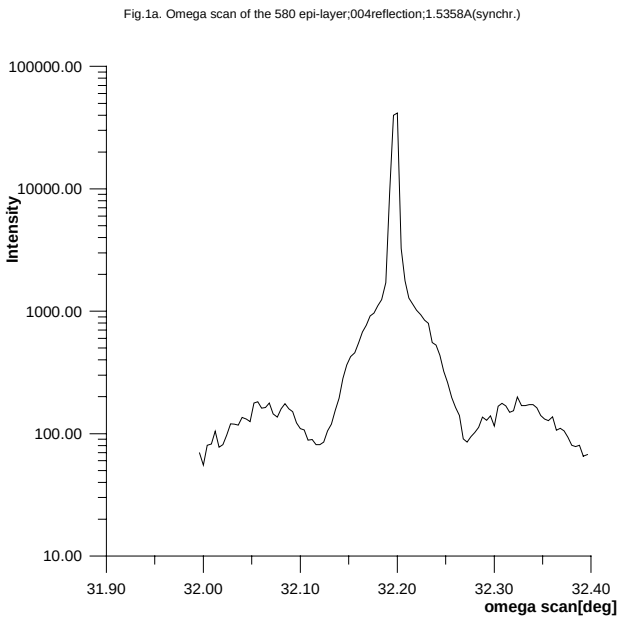
The investigations of the laser structure active layer $In_{0.13}Ga_{0.87}As/GaAs$ were performed with samples with the same chemical composition but a range of layer thicknesses to estimate the range of the metastable equilibrium state. The value of the lattice misfit is equal to $\Delta a/a = 9.3 \times 10^{-3}$ which corresponds to a critical thickness of t_c = 200Å. The layer thicknesses in the range of 80-1000 Å (above and below the critical thickness) were investigated by means of high resolution x-ray diffractometry with synchrotron radiation (λ = 1.5358 Å) and in combination with a conventional x-ray source (λ = 1.5405Å). All of the epitaxial layers were produced in ITME. The coplanar high-angle $\theta/2\theta$-scans were performed for substrate and layer reflections. Additionally, the ω-scans (scan perpendicular to the diffraction plane) and reciprocal space mapping in the vicinity of the 004 layer node were done. The strain relaxation and the layer thickness were determined from $\theta/2\theta$-scans, and the distribution of diffuse scattering related to misfit dislocation was measured by means of reciprocal space maps. The diffuse scattering intensity depends on the strain field, the microstructural arrangement and the density of the defects.

It was necessary to use the synchrotron radiation for the epitaxial layers with the thickness below 580 Å to measure the diffuse scattering. The experimental results are presented in Table I.

Table I:
Experimental results : θ/2θ data of the laser structure active layer $In_{0.13}Ga_{0.87}As/GaAs$

No	sample	thickness	Δθ synchr	layer thickn.(interf. fring.)
		[Å]	[deg]	
1	str2364	80	-	bufor thickn.1837Å
2	str2363	300	0.685	layer thickn.342Å
3	str2355	580	0.683	layer thickn.582Å
4	str2364a	800	0.612	relaxation

The diffuse scattering connected to the misfit dislocation is observed for the layer thickness exceeding 300 Å (Table I). But the main relaxation process connected with the shift of layer reflection starts at an epi-layer thickness of 800 Å. An example of the diffraction pattern of the metastable state is presented in Fig.1. In this figure one can see the diffuse spot characteristic for a small dislocation density ($\rho d \leq 1$) where ρ is the linear dislocation density and d the layer thickness [1]. Besides the diffuse spots in the reciprocal space map, also the thickness fringes are visible. As the dislocation density increases (the long range order is not retained), the layer reflection continuously transforms to an anisotropic Gaussian extended in a direction perpendicular to the diffraction vector and a layer peak shift is observed (see Table I, No 4). Our results are in agreement with the calculations and simulations presented in [1].



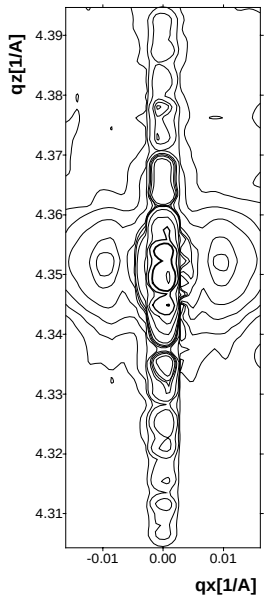


Fig.1b. Reciprocal space map of the 580A epi-layer;004reflection; 1.5358A(synchr.)

References

[1] V.M. Kaganer *et al.*, Phys.Rev.B, Vol.55, No. 3 (1997) 1793-1810.