Nuclear Instruments and Methods in Physics Research A261 (1987) 257–259
North-Holland, Amsterdam

X-RAY TOPOGRAPHY OF $A^{III}B^{V}$ SEMICONDUCTOR EPITAXIAL STRUCTURES ON THE VEPP-4 SR BEAM

G.N. KULIPANOV, Yu.M. LITVINOV, S.N. MAZURENKO, M.A. MIKHAILOV, V.E. PANCHENKO and A.A. VASENKOV

Institute of Nuclear Physics, 630090, Novosibirsk, USSR

The results are presented of X-ray topography exposures of $A^{III}B^{V}$ semiconductor autoepitaxial structures and single crystals on the VEPP-4 white SR beam in Laue reflection.

Exposures of strongly absorbing single crystals and epitaxial structures of the $A^{III}B^{V}$ semiconductors in Laue reflection have been made on the experimental station Topography and Diffractometry ([1]) on the VEPP-4 storage ring white SR beam. The aim of the work was to ascertain the influence of doping on the structural perfection of the crystals as well as the role of the inheritance of defects in the substrata by epitaxial layers grown on them. Of course, the defects acquired by the structures in the process of growing of them were also of interest.

A silicon-doped gallium arsenide single crystal (electron conduction), grown by the oriented crystallization technique with a carrier concentration of 2×10^{18} cm^{-3}, had a dislocation density of about 10^3 cm^{-2}. On this substrate (about 350 μm thickness) an autoepitaxial structure $n\text{–}n^{+b}\text{–}n^{+}$ was grown using the chloride process: an arsenide-gallium epitaxial film 0.15–0.5 μm thick (n); a buffer layer between the epitaxial film (n) and the substratum (n^{+}) (having an additional doping to remove the lack of conformity in the lattice parameter) (n^{+b}). The thickness of the buffer layer was 2.5 μm. After the epitaxial structure had been created, half of its area was etched away to the substrate. Thus, the possibility was ensured of visualizing the defect structure of both parts of the crystal with one exposure when the white SR beam was directed at them simultaneously. During the exposure the (100) plane of cut of the wafer was placed perpendicularly to the incident white SR beam. In fig. 1 topographs of three different Laue reflections (the etching boundary in the figure is vertical and is not observable) show that when growing the epitaxial layers no complications of the dislocation structure occur. Precipitates are also visible on the topographs. The posterior etching also confirmed the absence of dislocations brought into the epitaxial-growth process ([2]).

Under identical conditions the exposure of another

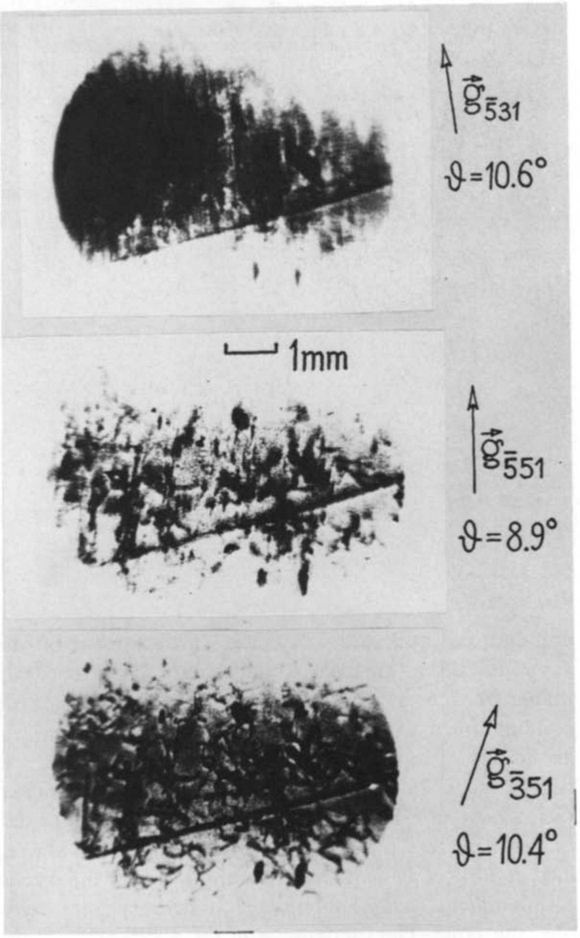

Fig. 1. Topographs (obtained from one exposure) of the arsenide-gallium autoepitaxial structure (silicon-doped substrate).

0168-9002/87/$03.50 © Elsevier Science Publishers B.V.
(North-Holland Physics Publishing Division)

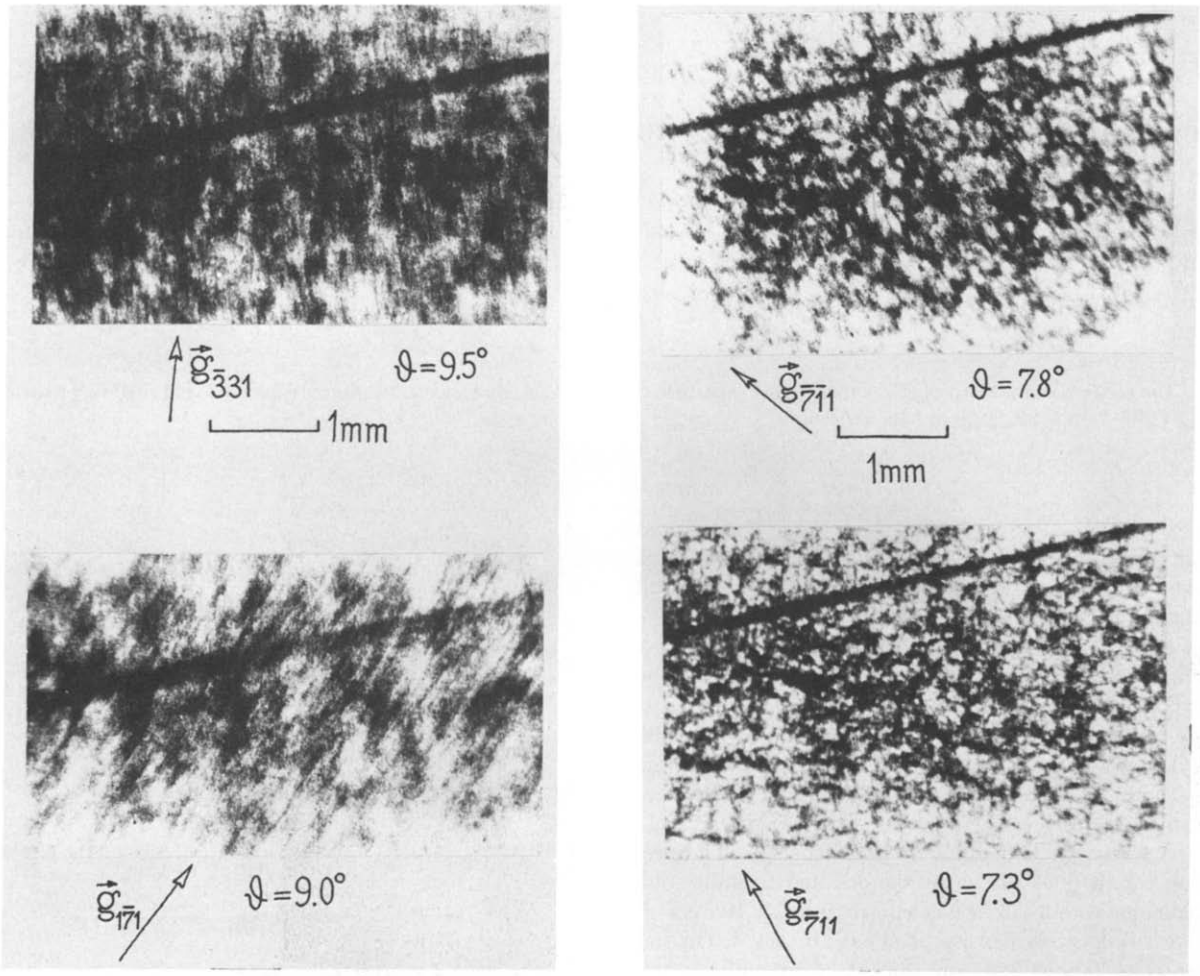

Fig. 2. Topographs (obtained from one exposure) of the arsenide-gallium autoepitaxial structure (tellurium-doped substrate).

autoepitaxial structure was made. It was grown on an arsenide-gallium substrate which was cut along the (100) plane from a tellurium-doped bulk crystal (electron conduction; a carrier concentration of 2×10^{18} cm^{-3}; an initial dislocation density of about 10^5 cm^{-2}, a cellular distribution structure) grown by the Czochralski technique (AGCT). The epitaxial structure grown in the chloride process was identical to that described above. The etching of half of the structure area and the orientation of the etching boundary under exposure were also the same. The topographs in fig. 2 demonstrate an entire inheritage of the cellular structure of the dislocation distribution.

Tellurium as a doping additive was also used in an indium phosphide single crystal (electron conduction, IPET): 2×10^{18} tellurium atoms/cm^3. The bulk crystal was grown by Czochralski's pulling technique in the direction of the [111] axis, and then a (100) wafer of 400 μm thickness was cut from it. The cut was prepared for epitaxial growth. During the exposure the wafer was placed perpendicularly to the SR beam. The topographs in fig. 3, corresponding to different Laue reflections, visualize in different ways the growth bands (no dislocations are observed) and the dislocations in Borrmann contrast (in the absence of the images of growth bands). A superimposition of the images also occurs. The difference in the contrast of the images of these two types of defects on different reflections is in agreement with the conditions of image visualization as formulated in ref. [3].

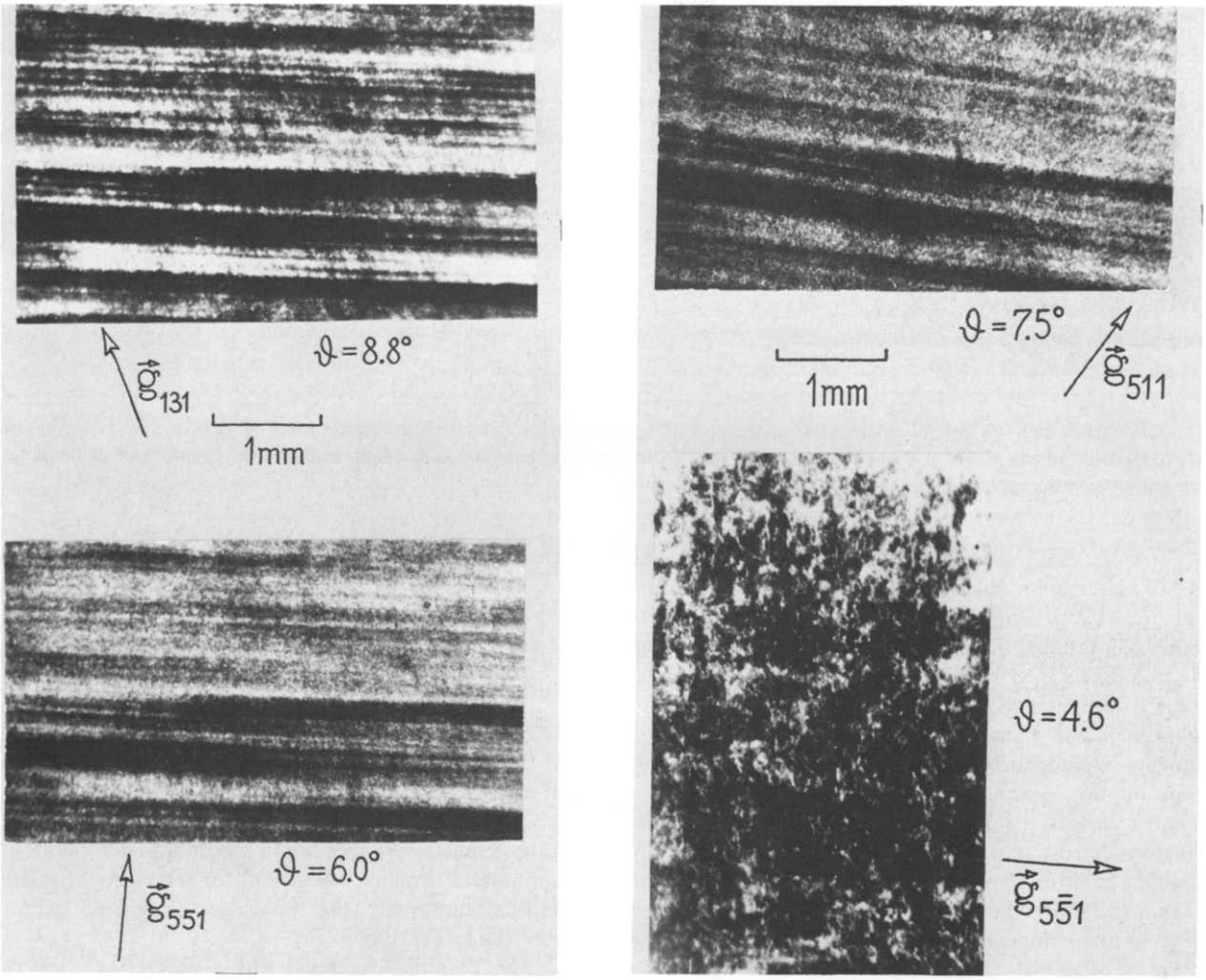

Fig. 3. Topographs (obtained from one exposure) of the indium-phosphide tellurium-doped single crystal.

References

[1] J. Kub, V.E. Panchenko and M. Polcarová, preprint INP 85-108, Novosibirsk (1985); Sov. Zh. Tech. Fiz. in press; these Proceedings (SR '86, Novosibirsk) Nucl. Instr. and Meth. A261 (1987) 233.

[2] A.A. Vasenkov, G.N. Kulipanov, Yu.M. Litvinov, S.N. Mazurenko, M.A. Mikhailov and V.E Panchenko, Abstracts of the Proc. of the 6th National Conf. on Crystal Growth, Tsakhkadzor, Yerevan (September, 1985) vol. 1 (1985) 22.

[3] J. Kuběna and V. Holý. Czech. J. Phys. B33 (1983) 1315.