Direct Observation of zero-ordered defects in GaAs Single Crystal (III).

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Introduction

A system using (+,+) monolithic monochromator (MM) [1] which has been developed to measure the lattice spacing of GaAs single crystal with precision of $2x10^{-7}$ seem promising. That could have provided the fixed and quite stable wavelength in a long term. We have developed several kinds of MM's that can give us a fixed exit beam position provides convenience to setting the whole X-ray optics and to changing to another MM for other d-spacing measurement.

Here, we introduce a wavelength-selective monochromator and system that developed for high-precision lattice spacing measurements. Using this system for lattice spacing measurements of vertical boat-grown (VBG) GaAs single crystals, we were able to measure various specimens with high boron concentrations.

Manuscript preparation

High-precision lattice-spacing measurements were made for the specimens using the system constructed at the BL3C2 experimental station at the Photon Factory, based on the wavelength-selective silicon monolithic (+, -, -,+) channel-cut monochromator, which we developed. Horizontal axis goniometers were required for the vertical incidence. A monochromatic beam, with a central wavelength of λ= 0.1396563 nm, becomes parallel to an incident beam after four time reflections of (2-4-2), (-242), (511) and (-5-1-1) planes of the crystal (Fig.1). An X-ray beam, approximately 1mm×1mm, locates the surface of a sample crystal.

Using this system, precise lattice-spacing measurements of the VBG GaAs single crystals were carried out by the Bond method. Thirty small diced and polished (001) specimens (about 1 cm×1 cm in size) were glued onto a substrate on a precision goniometer stage. The lattice spacing of diced specimens with such dimensions appear not to be influenced by the residual strain of a crystal, but only by impurities and/or point defects. The Bragg angle of the GaAs 0,0,8 reflection is 81.14 degrees.

A computer program was developed to allow us to measure automatically more than 30 different samples within a single run. A full width at half maximum of the rocking curves of a couple of (800) GaAs diffraction are 17 – 20 arc-sec. The standard deviations for the measurements of one sample were estimated by $\Delta a/a=4\times10^{-8}$.

The lattice spacing of thirty silicon doped (up to 6.95×10^{18} cm^{-3}) specimens which cut from VBG GaAs single crystals were measured. A dependence of the lattice spacing on the total silicon concentration was not found. Among the relationship between lattice spacing and boron concentration in the crystals, an anomalous reduction in the lattice spacing was found below a boron concentration of 1×10^{19} cm^{-3}. The reduction at below 3.5×10^{18} cm^{-3} (a solid line) is similar in part of that observed in a previous study[2], in which the reduction rate was about 2 times larger than the predicted rate for the boron concentration derived from Vegard's law. This reduction appears to originate in defects in the $B_{Ga}V_{As}$ complex defects.

Furthermore, another 4 inclined distributions (the dashed lines) were found at intervals. We assume that these are 4 mixed states of the $B_{Ga}V_{As}$ complex and substitutional B [3].

References

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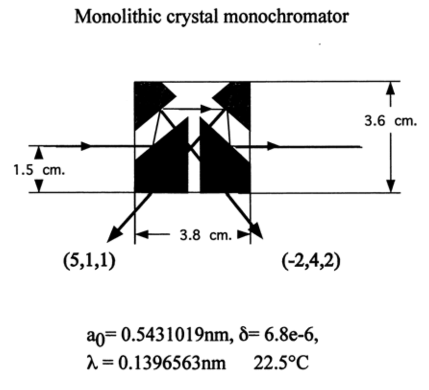

Fig. 1. Wavelength selective silicon monolithic (+,-,-,+) channel-cut monochromator (MM)

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