

Lattice Distortion near InGaP Compound Semiconductor Surface due to Surface Treatment of Bias Sputtering

Takashi EMOTO¹, Yasunori YOSHIDA², Koichi AKIMOTO^{*2}, Ayahiko ICHIMIYA², Satoshi KIKUCHI³, Kazuo ITAGAKI³, and Hideo NAMITA⁴

¹Toyota National College of Technology, 2-1 Eisei-cho, Toyota 471-8525, Japan

²Dept. of Quantum Eng., Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan

³Tsukuba Plant, Mitsubishi Chemical Corp., 1000 Higashimamiana, Ushiku, Ibaraki 300-1295, Japan

⁴Tsukuba Laboratory, CACs. Inc., 8-3-1 Chuo, Ami-machi, Ibaraki 300-0332, Japan

Introduction

III-V compound semiconductors are the basis of semiconductor lasers and optoelectronic devices. In device technology, bias sputtering on a semiconductor surface is often used as a surface cleaning technique. For a compound semiconductor, this technique might generate a compositional fluctuation near the surface and introduces a strain field to the surface.

The aim of this study is to know affections of bias sputtering as a surface cleaning technique to a strain field near an InGaP surface by the surface-sensitive X-ray diffraction.

Results and Discussion

The samples were prepared as mentioned below. Firstly, a 0.5- μm $\text{Al}_{0.7}\text{Ga}_{0.3}\text{As}$ layer and then a 0.5- μm $\text{In}_{0.48}\text{Ga}_{0.52}\text{P}$ layer were deposited on GaAs(001) substrate by using a metal organic chemical vapor deposition (MOCVD) method. Secondly, the resulting grown InGaP surface was cleaned by bias sputtering (Ar ion sputtering). Finally, an AlO_x layer was deposited on the surface at 573 K by a sputtering method using Al_2O_3 target materials. Four samples with different bias voltage for surface cleaning (0 V, 15 V, 43 V, and 77 V) were prepared.

An extremely asymmetric InGaP 113 reflection of the sample was measured to observe strain field. The X-rays impinged on the sample surface at a grazing angle ($\sim 0.2^\circ$). The wavelength of the X-rays used in this measurement was about 0.145 nm.

Fig. 1 shows the measured rocking curves of the InGaP 113 reflection from the $\text{AlO}_x/\text{InGaP}$ interfaces at the four bias voltages used in the surface cleaning. The measured curves consist of a main peak as well as broad sub peaks to the right of this main peak. The intensity of the main peak depended on the bias voltage; except for a bias voltage of 43 V, the intensity decreased with increasing bias voltage. The highest peak intensity occurred for a bias voltage of 43 V.

Fig. 2 shows the calculated rocking curves using dynamical theory of X-ray diffraction for three different strains of topmost layer. In this calculation, the (001) atomic spacing was assumed to close to d_0 from $d_0(1+\varepsilon)$ as the depth reaches to 20 nm from the surface, if d_0 is the

(001) atomic spacing at bulk. Comparison between Fig. 1 and Fig. 2 reveals that, in general, bias sputtering introduced a tensile strain to a compound semiconductor surface. However, when the bias voltage was 43 V, a compressive strain was introduced. A possible reason for this compressive strain is removing of surface contaminations.

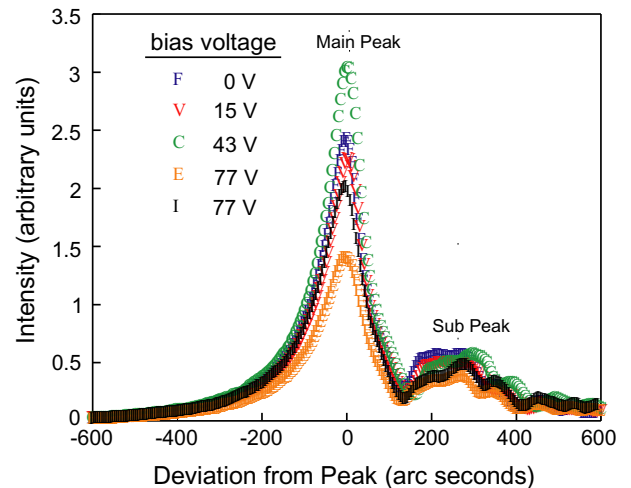


Fig. 1 Measured rocking curves of InGaP113 reflection.

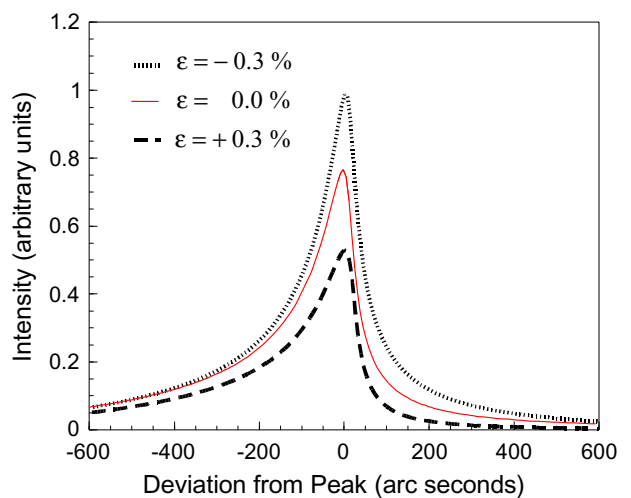


Fig. 2 Calculated rocking curves assuming a strain.

*akimoto@nucc.cc.nagoya-u.ac.jp