

Surface structure of GaP(001)(2x4) and (2x1) studied by photoelectron spectroscopy and photoelectron diffraction

Masaru SHIMOMURA*¹, Shinya ITAGAKI¹, Norikazu KADOTANI¹, Yusuke IKEJIMA²,
Shozo KONO², Yasuo FUKUDA¹

¹RIE, Shizuoka Univ., Johoku, Hamamatsu 432-8011, Japan

²IMRAM, Tohoku Univ., Katahira, Aoba-ku, Sendai 980-8577, Japan

Introduction

Recently, the structure of a (001) surface of phosphorus based III-V semiconductors has been a subject of interest since the reconstruction of the III-group-rich (2x4) surfaces cannot be interpreted as a simple missing row dimer structure which is seen such on GaAs(001) (2x4) or (4x2) surfaces [1]. The structure of a P-rich InP(001) (2x1)/(2x2) surface which is observed during MOVPE growth is also one of the interesting issue because of the difficulty in interpretation of zigzag rows in the STM images[2]. The GaP(001)-(2x1) surface was reported to have the same structure based on the STM data [3].

In this study, photoelectron spectroscopy (PES) and photoelectron diffraction (PED) were used to investigate the structure of GaP(001)(2x4) and (2x1) surfaces.

Experimental procedure

The PES and PED experiments have been carried out on an undulator beamline, BL-13C. An UHV chamber attached to the beamline was equipped with a high-resolution analyzer (VG, CLAM4) and a motor controlled manipulator. The PED measurement was performed in an angle-scan mode with a fixed photon-energy. In this report, the detection angle is denoted with the polar angle of θ and the azimuthal angle of ϕ .

An n-type GaP(001) wafer was used as the substrate. The chemically etched substrate was introduced to the UHV system. Then, the sample was cleaned by ion bombardment and annealing (IBA) treatments. After the several cycles of the IBA treatments, sharp (2x4) LEED spots were observed. The P-rich (2x1) surface was obtained by t-butyl phosphine (TBP) exposure at substrate temperature of 350 °C onto the (2x4) surface.

Results and discussion

Figure 1 shows high-resolution Ga 3d and P 2p spectra of (2x4) and (2x1) surfaces with the curve fitted components. In addition to the bulk component a component at lower binding energy (S1) and that at higher (S2) are needed in order to fit the Ga3d spectrum of the (2x4) surface (Fig. 1a). Only one surface component is necessary for the P 2p spectrum (Fig. 1b). These results are in good agreement with the result reported so far [4]. We have measured the PED pattern of the each component in Fig. 1a and b. In the pattern of the S1 component, highly intense feature at the $\phi = 0^\circ$

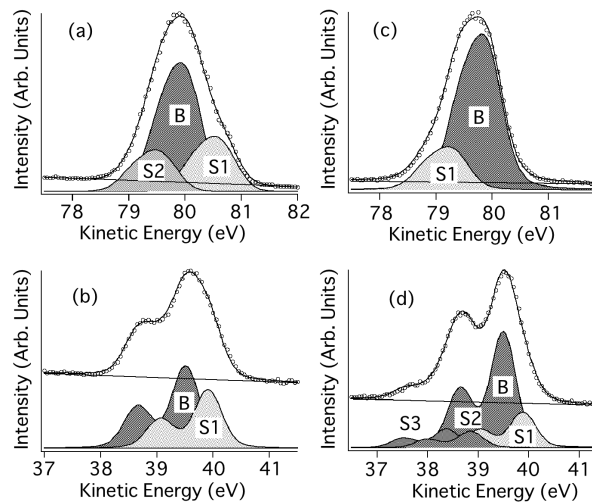


Fig. 1. Photoelectron spectra and their curve fittings of Ga 3d (a and c) and P 2p (b and d) for the GaP(001)(2x4)(a and b) and (2x1)(c and d) surfaces. All spectra were measured at polar angle of 80° .

direction (Ga dangling bond direction of ideally cleaved (001) surface, i.e. x4 direction) and the surface parallel direction was characterized. On the other hand, intensity along the $\phi = 90^\circ$ direction (x2 direction) was low for all polar angles. Although simulation based on a multiple-scattering theory is necessary to identify the component, as one of the intuitive interpretation, nearest neighbor atoms may exist along the x4 direction near surface parallel. In the mixed dimer model [1], which is one of the key model proposed so far, Ga-Ga bonds exist along the x4 direction. The S1 component may be connected to these Ga atoms. Because the PED pattern of the component S2 is rather complicated, the simulation would be necessary to discuss the origin. The PED pattern of S1 of P 2p has highly intense feature at $\phi = 45^\circ$ which resembles with the bulk pattern.

The Ga 3d and P 2p spectra of the (2x1) surface can be fitted by one and three surface components, respectively (Fig.1c,d). The details of the spectra and their PED patterns will be discussed elsewhere.

References

- [1] W.G. Schmidt et al., Surf.Sci. 409, 474 (1998).
- [2] L. Li et al., Phys.Rev.Lett. 82, 1879 (1999).
- [3] N. Sanada et al., Surf.Sci. 419, 120 (1999).
- [4] X. Wallart, Surf.Sci. 506, 203 (2002).

* romshimo@rie.shizuoka.ac.jp