

Photoemission study of Sn films grown on an InSb(111)A surface

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Introduction

Thin films grown on III-V compound semiconductors are quite interesting systems, due to their possibilities of application such as high electron mobility transistors and semiconductor laser devices. Sn film grown on InSb surfaces is one of such systems. In contrast to bulk Sn, which is known to show a semiconducting α phase with a diamond structure below 13.2 °C and a metallic β phase with a tetragonal structure above this temperature, Sn film grown on an InSb(111) surface was reported to have an α phase even at room temperature [1,2]. Although the origin of this difference was proposed to result from a strong chemical bonding between Sn and In atoms at the interface [2], there is no strong evidence to confirm this mechanism so far. Since the understanding of the initial growth process of an α -Sn film is essential to comprehend the origin of the presence of an α phase even above 13.2 °C, we have investigated the process using high-resolution core-level spectroscopy.

Experimental details

The high-resolution photoemission measurements were performed at beamline BL-1C at the Photon Factory of the High Energy Accelerator Research Organization, Tsukuba, Japan. An undoped InSb(111)A sample was cleaned by repeating Ar ion sputtering (500 eV) and annealing at 370 °C until a sharp 2x2 LEED pattern was observed. Sn adsorption was performed using an effusion cell. All measurements were performed at room temperature.

Results and discussion

Figure 1 shows the Sn coverage-dependent In 4d core level spectra. The spectrum of the InSb(111)A clean surface is displayed in (a), and the Sn coverages are 0.25, 1.0, and 2.5 monolayer (ML) in (b)-(d). In order to obtain information about the In 4d components that contribute to the spectral shape, we have analyzed the spectra by a standard least-squares-fitting method using spin-orbit split Voigt functions. The solid lines overlapping the data points (open circles) are the fitting results. Each component is indicated by different hatching. The number of components and their binding energies were confirmed by measuring the spectra using different photon energies and different photoelectron emission angles. The In 4d core-level spectrum of the InSb(111) clean surface is well

reproduced using two components, B and S1. After the 0.25 ML Sn adsorption, the intensity of S1 decreases, and two new components (S2 and S3) appear. At higher Sn coverages, the intensities of both the S2 and S3 components increase together with the decrease in intensity of S1. Taking the electronegativities of In, Sn, and Sb into account, the In-Sn bonding should be less ionic than the In-Sb bonding, and the charge state of In atoms bonded to Sn atoms should be more negative than the charge state of In atoms in the bulk phase. This means that the binding energy of the 4d component of In atoms bonded to Sn should be lower than that of the bulk component within the initial state effect, and we therefore attribute the S2 component to In atoms that bond directly to Sn atoms at the interface. The observation of S2 at 0.25 ML indicates that Sn atoms do not adsorb preferably on the In-vacancy sites of the InSb(111)A structure as suggested in the literature [2,3]. Further, the observation of the Sn-Sb and Sn-In bondings in the Sn 4d spectra at a Sn coverage of 0.25 ML supports that Sn atoms adsorb randomly on the InSb(111)A surface at the initial growth process.

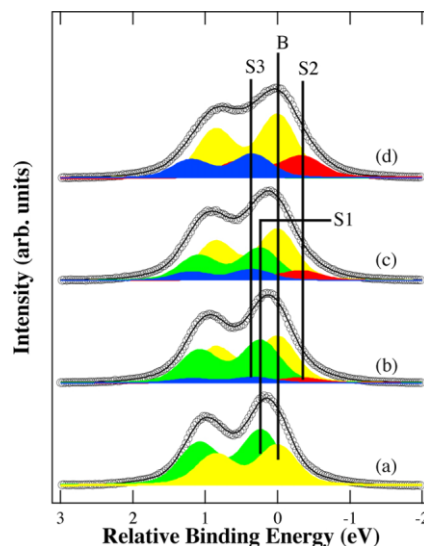


Figure 1; Sn coverage-dependent In 4d core-level spectra

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