

Electronic Structure of H-Terminated Silicon Surfaces [H-Si(111)] Studied by Two-Photon Photoemission

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Investigating electronic states localized at the surfaces allows us to understand elementary processes of chemical reactions and the mechanisms of charge transfer at the surfaces. In particular, understanding the electronic structure of semiconductor surfaces is very important for surface carrier dynamics. As a prototype of the passivated semiconductor surface, information on the surface properties of a hydrogen-terminated Si(111), abbreviated as H-Si(111), is required from a technological as well as fundamental point of view as an unreconstructed and atomically flat surface.

In this presentation, we demonstrate the capability of two-photon photoemission (2PPE) spectroscopy to probe the surface-state transitions as well as the bulk-state transitions. To date, there has been only one report of experimental evidence for an image-potential state on semiconducting materials, which is a 2PPE experiment on Si(100). Now, we report the detection of an image-potential-state resonance on the H-Si(111). We also show the information on the resonant transitions between the image-potential state and the occupied surface state of the H-Si(111) from the photon-energy dependence [1].

The surface and bulk electronic states of H-Si(111) were studied by 2PPE. With the polarization and emission-angle dependence of the 2PPE spectra, five series of electronic structures for H-Si(111) can be identified. For $h\nu < 4.6$ eV, peak A arises from a surface resonance at ~ 1.01 eV from E_F , and at the photon energy higher than 4.6 eV, peak A indicates photoemission from an intermediate state, corresponding to an image-potential state at 3.61 eV from E_F . Other structures, B, C, and D arise from bulk states, while structure E occurs from an electron-hole excitation process. This work has revealed the surface resonance and the image-potential state on H-Si(111) for the first time.

[1] T. Nakamura, K. Miyajima, N. Hirata, T. Matsumoto, H. Tada, Y. Morikawa, and A. Nakajima, *Applied Physics A* **98**, 735 (2010).