

Photoelectron Spectra Measurement of $\text{Al}_2\text{O}_3(0001)$ Surface with an Electron Shower

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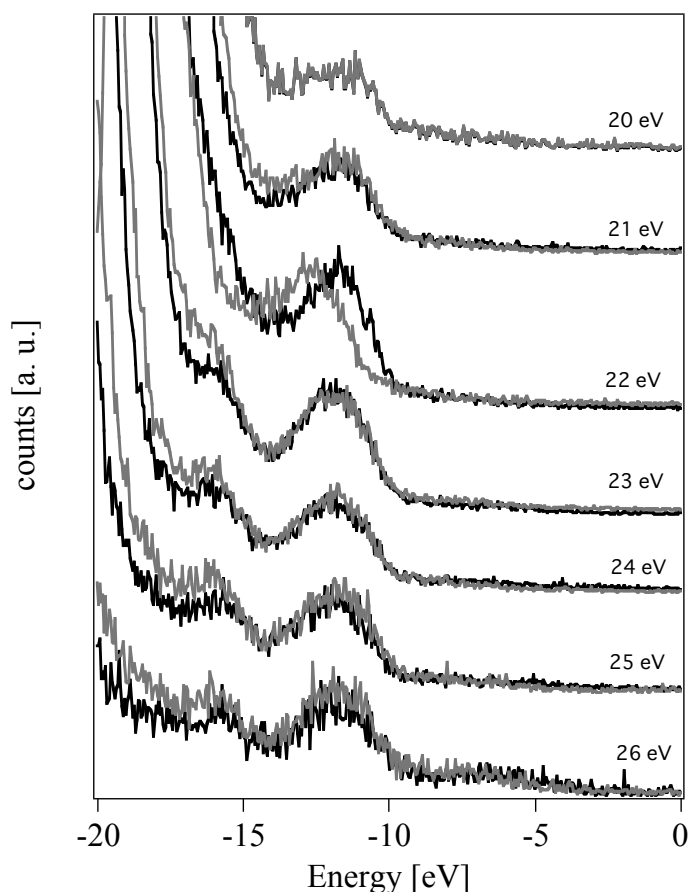
α - Al_2O_3 has been widely utilized as the substrate for GaN thin film. The thin film growth is greatly influenced by the surface structure of the substrate. When we deposit the GaN thin film or other wide-gap semiconductor film, it is frequently required that the substrate temperature is elevated over 1000 °C. Although the stable surface structure of $\text{Al}_2\text{O}_3(0001)$ is the 1×1 structure, the surface structure transforms to the $\sqrt{31}\times\sqrt{31}\pm R9^\circ$ structure (hereafter $\sqrt{31}$ structure) by annealing at about 1000 °C in the vacuum [1-3]. It is theoretically predicted that the $\sqrt{31}$ reconstruction occurs by removing oxygen layers from the surface and forming Al layers[4]. Therefore the change of the electronic structure from the 1×1 structure to the $\sqrt{31}$ structure is very interesting.

We use well-oriented Al_2O_3 (0001) samples, which were supplied by Namiki Precision Jewel Co. Ltd. The samples were cut parallel to the (0001) plane with off angle being $0.15^\circ \pm 0.02^\circ$ along the $\langle 10\bar{1}0 \rangle$ direction and annealed at 1000°C or 1400°C in air. The air-annealed surface shows a clear 1×1 Reflection High Energy Electron Diffraction (RHEED) pattern.

We reported the photoelectron spectra (PES) from the Al_2O_3 (0001) surface where the photo-electrons emitted to the normal direction previously [5]. The PES at photon energies (E_p) below 25 eV show two clear states originate from the Al-O bonding state and the O-2p state [6]. On the other hand, the PES at E_p over 28 eV become noisy and each peak is shifted to unsystematic directions. The random shifts will be caused by a charging up on the insulator surface. Therefore, we tried to measure PES with an electron shower to remove the charging effect.

The electron shower was achieved by emitted electrons from a hot-filament. The filament was made from $\phi 0.15$ mm tungsten wire and can be placed at any distance between a few cm to 20 cm from the sample by using a linear motion manipulator mounted in the PES measurement chamber. When the PES were measured, the filament was set about 10 cm from the sample. The condition of the electron shower is that the filament current is 1.6 A and the applied voltage to the filament is -30 V. Because the PES do not show any appreciable change without the applied voltage. The current density on the sample is not known, precisely, because of the insulator surface.

Figure 1 shows PES from Al_2O_3 (0001) surface, where the photo-electrons emitted to the normal direction, are measured at photon energies (E_p) from 20 eV to 26 eV. Black curves show PES without the electron shower and gray curves show PES with the electron shower (the filament current is 1.6 A , applied voltage is -30 V). The peaks at -12 eV with the electron shower coincide with the peaks without the electron shower except for the peak of $E_p=22$ eV. In the case of the peaks at -16 eV shown in E_p from 23eV to 26 eV, the intensity with the electron shower is higher than that without the electron shower. Except for the spectra at $E_p=22$ eV, it is demonstrated that the electron shower during PES measurement is effective for charging problem of insulator surface. However, the actual electron density supplied to the surface should be determined quantitatively for precise analysis of PES.



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Fig. 1, PES from Al_2O_3 (0001) surface where the photo-electrons emitted to the normal direction are measured at photon energies (E_p) from 20 eV to 26 eV. Black curves show PES without the electron shower and gray curves show PES with the electron shower (the filament current is 1.6 A and applied voltage is -30 V).

References

- [1] J.M. Charig, Appl. Phys. Lett. **10** (1967) 139.
- [2] C. C. Chang, J. App. Phys. **39** (1968) 5570.
- [3] T. M. French and G. A. Somorjai, J. Phys. Chem. **74** (1970)2489.
- [4] G. Renaud et al., Phys. Rev. Lett. **73** (1994)1825.
- [5] Activity Report of Synchrotron Radiation Laboratory 2011.
- [6] R. H. French, J. Am. Ceram. Soc. **73** (1990)477.