Growth of ultrathin InN films on Al-polar AlN and its application to field-effect transistors

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Because InN possesses the lowest electron effective mass and highest electron mobility among III-nitrides, it is expected to be used in high-speed and high-frequency devices. However, the presence of an electron accumulation layer on the surface of InN has made its application to field effect transistors (FETs) difficult. One of the ways to control the electron density of the InN surface is to use a heterointerface with AlN with a giant spontaneous polarization. In this presentation, we will discuss the basic properties of heterojunctions between ultra-thin In-polar InN films and Al-polar AlN. We also discuss the characteristics of FETs using the fabricated InN/AlN heterostructures.

Ultrathin InN thin films are grown on AlN/sapphire templates by sputtering. The AlN templates used were prepared by metalorganic vaper phase epitaxy or hydride vapor phase epitaxy. The films were characterized by atomic force microscopy, X-ray diffraction, and Hall effect measurements. After investigating the basic properties, InN FETs were fabricated. the thickness of the InN channel layer was 10 nm ALD-HfO_2 deposited at 200 °C was used as the gate dielectrics.

Figure 1 shows AFM images of InN films with various thickness grown at 450 °C. It was found that islands were formed when the film thickness exceeded 1 nm. The surface morphology of the 2 nm thick InN films grown at substrate temperatures of 400–500 °C was compared. AFM observations revealed that the height of the islands formed on the InN surface in the early stages of growth decreased with increasing growth temperature, leading to the flat surfaces. This indicates that the use of InN films grown at around 500 °C is essential for fabricating FETs on AlN.

The output characteristics of the InN/AlN-FET fabricated at 450 and 500 °C were compared. The device fabricated at 450 °C was not successfully operated probably due to the rough InN/AlN interface. On the other hand, the drain current of the FET fabricated at 500 °C has been successfully modulated by applying a gate voltage. The relationship between the structural perfection of InN films and the device characteristics will be also discussed.

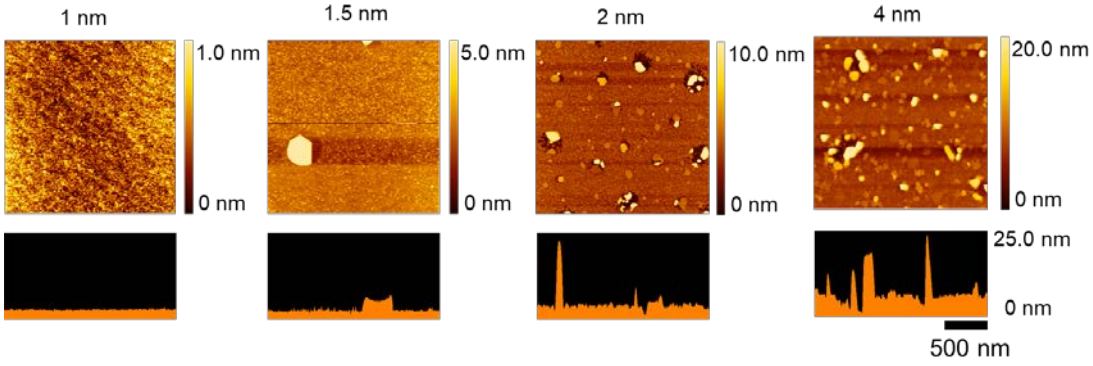

Fig.1 AFM images of ultrathin InN films grown on Al-polar AlN at 450 °C.

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