Field-effect transistors of ultrathin InN grown on AlN

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InN has the smallest electron effective mass and the highest electron mobility among III-nitride semiconductors. For these great properties, InN has been considered as a promising material for high-speed or high-frequency devices. However, application of InN to field-effect transistors (FETs) has been difficult due to the presence of electron accumulation layer at the surface of InN [1]. For control of the electron density in the accumulation layer, the use of hetero interface with AlN, which has the largest spontaneous polarization (−0.100 C/m2), is possibly attractive. In this presentation, we will discuss the basic characteristics of the heterojunctions between ultrathin In-polar InN films and AlN. We will also discuss the characteristics of FETs based on the developed InN/AlN heterostructures.

Ultrathin InN films were grown on Al-polar AlN/sapphire templates by sputtering. The AlN templates were prepared by MOCVD or HVPE. The ultra-thin InN films were characterized by the use of atomic force microscopy, X-ray diffraction, and Hall-effect measurements. After investigation of the basic properties, InN filed-effect transistors were fabricated. Thickness of the InN channel layer was below 10 nm, and ALD-HfO_2 deposited at 200 °C was used as a gate dielectric layer.

The surface morphologies of 2-nm-thick InN films grown at substrate temperatures ranging from 400 to 500 °C were investigated by AFM. The AFM observation revealed that the height of islands that were formed on the InN surface at the initial stage of the growth decreased with the increase in the growth temperature, leading to formation of flat surfaces. It was found that the use of InN film grown at around 500 °C is indispensable to fabricate FETs on AlN. The schematic illustration of InN/AlN-FETs is shown in Fig. 1. Fig. 2 shows the output characteristics of an InN/AlN FET. The drain current of the FET was successfully modulated by applying the gate voltage. Dependence of the transistor characteristics on the growth temperature and film thickness of InN will be also discussed.

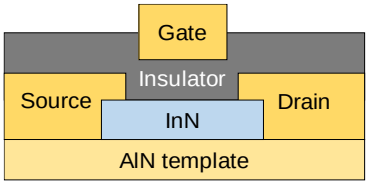

Fig.1 The schematic illustration of fabricated FETs.

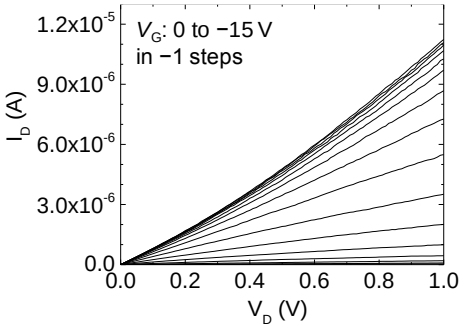

Fig. 2 The output characteristics curve of ultra-thin InN-based FET.

References

[1] D. Jeong *et al.*, The 66th JSAP Spring Meeting, 11p-W541-13 (2019).

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