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Formation of a thin nitrided GaAs layer

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Nitridation technique has been receiving much attention for the formation of a thin nitrided buffer layer on which high quality nitride films can be formed[1]. Particularly, gallium nitride (GaN) has been considered as a promising material for blue-and ultraviolet-emitting devices. It can also be used for in situ formed and stable passivation layers for selective growth of GaAs[2]. In this work, formation of a thin nitrided layer is investigated. Nitrogen electron cyclotron resonance(ECR)-plasma is employed for the formation of thin nitrided layer.

The plasma source used in this work is a compact ECR plasma gun[3] which is specifically designed to enhance control, and to provide in-situ monitoring of plasma parameters during plasma-assisted processing. Microwave power of 100-200 W was used to excite the plasma which was emitted from an orifice of 25 mm in diameter. The substrate were positioned 15 cm away from the orifice of plasma source. Prior to nitridation is performed, the surface of n-type (001)GaAs was exposed to hydrogen plasma for 20 min at 300 °C in order to eliminate a native oxide formed on GaAs surface. Change from ring to streak in RHEED pattern can be obtained through the irradiation of hydrogen plasma, indicating a clean surface. Nitridation was carried out for 5-40 min at RT-600 °C in a ECR plasma-assisted molecular beam epitaxy system. Typical chamber pressure was 7.5×10^{-4} Torr during the nitridations at N_2 flow rate of 10 sccm.

We observed the changes of RHEED pattern before and after the nitridation on GaAs substrate. RHEED pattern is abruptly changed from streak to halo/or,ring within several minutes after the irradiation of nitrogen plasma, implying an amorphous-like state. The nitrided layer was analyzed by SIMS(secondary ion mass spectroscopy) measurement. Fig. 1 shows a SIMS depth profile for several ions in nitridated layer which is treated at 450 °C for 40 min. For comparison, the profiles of GaN on sapphire and un-nitrided GaAs are shown together. As can be seen from Fig. 1, the nitrided layer is composed of Ga+N as well as As elememts, indicating the assignment of the GaAsN. By comparing the depth profiles of Ga+N ions in the nitrided sample and un-nitrided sample, a typical nitrided layer was determined to be approximately 30 nm in depth. SIMS profiles provide enhance that a nitride layer of GaAsN can be formed on the surface of GaAs by the irradiation of a nitrogen ECR plasma.

Fig. 2 shows that the PL spectra of nitrided GaAs with different substrate temperature during the nitridation. From the PL measurement, we observed two new peaks at 1.358 eV and 1.326 eV for the nitrided sample at 600 °C which are assigned as a band to band transition of GaAsN layer and defects associated with V_{As}, respectively as shown in Fig. 2(b). On the other hand, the GaAsN-related peak would not be generated at the low nitridation temperature as shown in Fig. 2(a). This means that the nitridation can not be accomplished enough to form a GaAsN layer at the low nitridation temperature. So, it is crucial for the applications to form a GaAsN layer with optimizing conditions of nitridation temperature.

In summary, the nitridation process results in the formation of GaAsN with a defect such as V_{As} with increasing the nitridation temperature. Therefore the nitride layer formed by the irradiation of nitrogen ECR-plasma provides a simple and controllable means of producing GaAsN.

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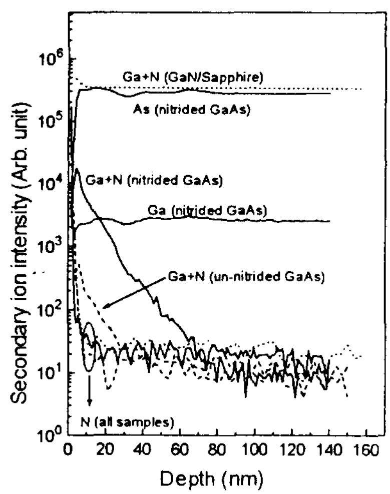

Fig. 1. SIMS depth profile for nitridated layer.

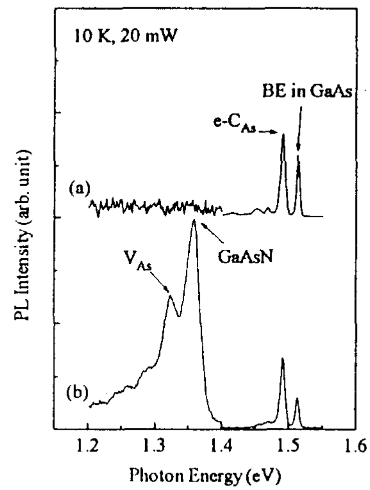

Fig. 2. PL spectra of nitrided GaAs layer with (a) T_{sub} = RT (b) T_{sub} = 600 °C.