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Pt/Al $_{0.33}$Ga $_{0.67}$N Schottky Diode with an Interlayer Buffer

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1. Introduction

Due to the wide, direct bandgap and other superior characteristics, the AlGaN system is regarded as one of the best promising materials in the application of the UV opto-electronics. Research groups have been studying the nitride semiconductors for the LDs, LEDs, and photo-detectors in UV band. As the aluminum composition increases in the AlGaN thin films, there are difficulties in obtaining the high quality and crack-free AlGaN layer due to the strain of lattice and thermal mismatch.

In this work, we used the low temperature (LT)-AlGaN interlayer between AlGaN and GaN layer to reduce the crack density [1], and fabricated the Pt Schottky diode on the AlGaN layer for the application of the solar-blind UV photo-detector.

2. Device Fabrication and Characterization

To fabricate the Pt/$Al_{0.33}Ga_{0.67}$N schottky photo-diode with the epi-layer structure, GaN buffer (350 Å)/n$^+$-GaN (2 μm)/AlGaN interlayer (150 Å)/AlGaN(0.5 μm) was grown on sapphire substrates by MOCVD and the schematic layer is shown in Fig. 1. As an active layer, we used AlGaN layer with the thickness of 0.5 μm, whose Al mole fraction was 33 %.

Ohmic metallization of Ti/Al/Ni/Au layers was carried out after selective mesa etching down to the n$^+$-GaN by using e-beam evaporator. The contact resistivity was ~ 10^{-4} Ω·cm^2 after annealing at 500 °C for 1 min in the N_2 ambient. Then, the 70 Å thick Pt Schottky contact was deposited on the AlGaN top layer. Before forming the electrode, we deposited 1000 Å thick Si_3N_4 in order to passivate between the two electrodes. We finally formed a bonding pad by depositing Au with a thickness of 2000 Å [2,3]. All the metallizations were carried out by employing the lift-off process.

By the insertion of the AlGaN interlayer, we could obtain the good quality and crack free AlGaN epi-layer. It was due to the reduction of the thermal and lattice mismatch between AlGaN and GaN layer. The photodiode with the interlayer had the leakage current of 500 nA/cm^2 at –5 V, which showed two orders of magnitude lower than that of the diode without the inter-layer (Fig.2). The result shows that the AlGaN interlayer was very important to decrease the background dark current in the UV photo-detector under reverse biased operation.

The spectral responsivity was measured using Xe-lamp, whose peak value was 0.15 A/W at 280 nm in a 500 μm device (Fig. 3). The UV/visible extinction ratio was 1.5×10^{-4} in the band edge. The photocurrent at the –5 V reverse bias was increased one order and the leakage current was also increased two orders of magnitude near the current edge, respectively. The reason was the diffusion of the generated electron-hole pairs from the n$^+$-GaN layer.

3. Conclusions

We fabricated and characterized the solar-blind photo -diode using the unintentionally doped $Al_{0.33}Ga_{0.67}$N layer, which was grown by MOCVD. We demonstrated the AlGaN interlayer is playing an important role in decreasing the crack effect in the AlGaN layer and enhance the electrical and UV detecting properties in the Schottky type photo-detector. The fabricated photodiode has the dark current of 509 nA/cm^2 at –5 V. The cutoff of wavelength and peak responsivity was measured at 310 nm and 0.15 A/W at 280 nm, respectively. The UV/visible extinction ratio was 1.5×10^{-4} in the band edge, which is one of the highest values in Pt/AlGaN photo-detector.

References

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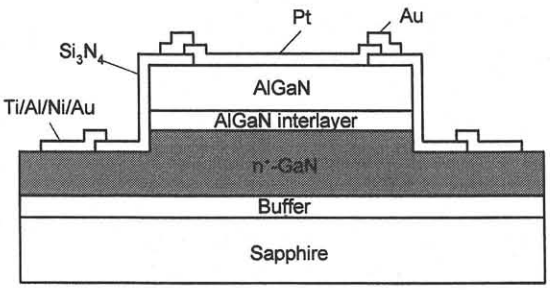

Fig. 1. Schematic cross-section of the fabricated device.

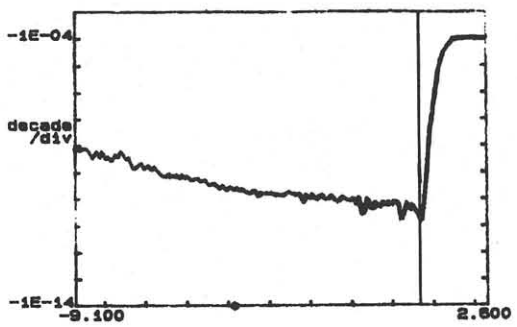

Fig. 2. I-V characteristics of Pt/$Al_{0.33}Ga_{0.67}N$ Schottky diodes with AlGaN interlayer.

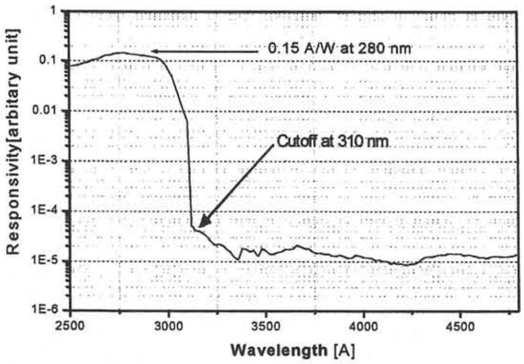

Fig.3. Spectral responsivity of the fabricated Pt/AlGaN photodiode.