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Characterization of GaN Schottky barrier photodiodes with a low-temperature growth GaN cap layer

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Abstract

In the past few years, various types of GaN-based photodetectors have been proposed, such as p-n junction photodiodes (PDs), p-i-n PDs, p-π-n PDs, Schottky barrier PDs and metal-semiconductor-metal (MSM) PDs. Compared with p-n junction PDs, the fabrication process of Schottky barrier PDs is much easier. The response speed of Schottky barrier PDs is also faster due to the limitation of minority-carrier storage problem in p-n junction PDs. However, leakage current in Schottky barrier PDs is also higher due to the large thermionic emission current in Schottky barrier PDs, as compared to the diffusion current in p-n junction PDs for a given built-in voltage. To reduce the leakage current in Schottky barrier PDs, it is necessary to achieve a high Schottky barrier height at the metal/semiconductor interface. For example, various metals and transparent conducting oxide films have been deposited on GaN to achieve high performance Schottky barrier PDs. In addition to the choice of contact metals, leakage current of Schottky barrier PDs also depends strongly on the properties of the topmost semiconductor layer.

In this study, by using organometallic vapor phase epitaxy (OMVPE), we have prepared i-GaN/low-temperature growth (LTG) GaN/Ni/Au (sample A) and i-GaN/Ni/Au (sample B) Schottky barrier UV PDs. Figure 1 shows dark I-V characteristics of the GaN Schottky barrier PDs. Under reverse bias, it was found that the dark current was near a constant of around 1×10^{-10}A for sample A. In contrast, dark current of sample B was much larger, and increased rapidly as the reverse bias increased. Figure 2(a) and 2(b) show spectral response of sample A and sample B, respectively. The cutoff occurred at around 365 nm (the absorption edge of GaN) for both samples and a much larger photocurrent to dark current contrast ratio by introducing a LTG GaN on top of the conventional nitride-based UV PDs. With incident light wavelength of 350 nm and a –1 V reverse bias, the measured responsivity was around 0.1 A/W and 0.37 A/W for sample A and sample B, respectively.

Furthermore, it was found that the responsivity of sample A is less bias dependent. In contrast, the much stronger bias dependent responsivity of sample B suggests that there might exist some internal gain in this particular Schottky barrier PDs, even at low biases. More detailed results will be reported.

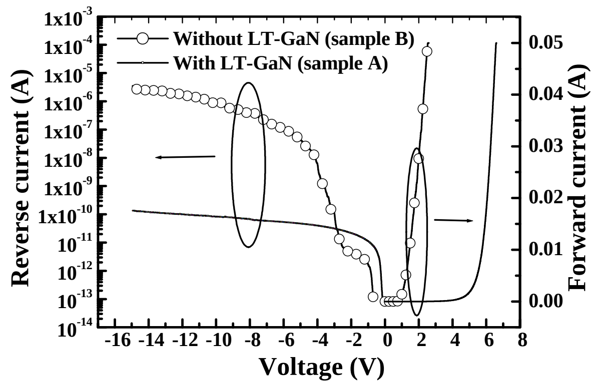

Figure 1 I-V curves taken in dark for sample A and sample B

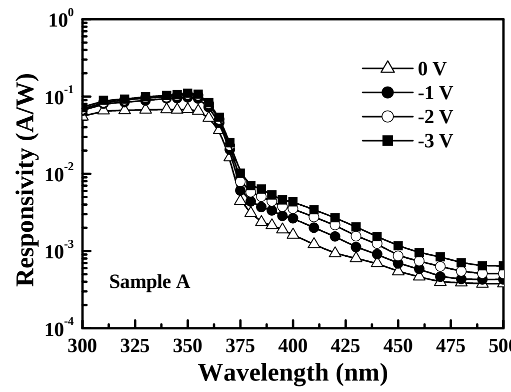

Figure 2 (a) Spectral responsivity of sample A.

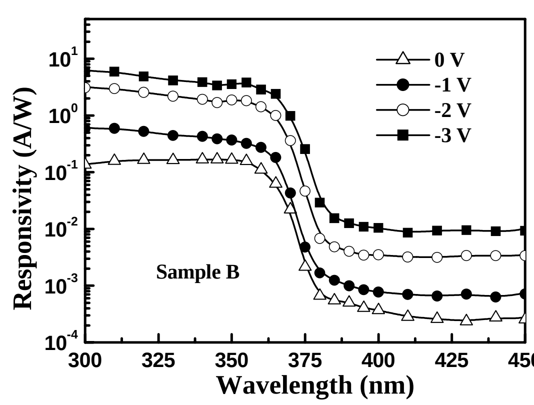

Figure 2 (b) Spectral responsivity of sample B.