# Fabrication and characterization of UV MSM and p-i-n photodiode

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The III-V nitrides are ideal choices for use in solar-blind ultraviolet photodetection due to their large bandgap energy. The applications for these nitride devices include missile plume detection, flame sensing, ozone monitors, laser detectors and pollution monitoring. There are several reports on nitride-based metal-semiconductor-metal (MSM) and p-i-n photodiodes in the literature.[1,2] However, due to a poor p-type doping technology and threading dislocations in the films, the photodiodes demonstrated to date often suffer from large leakage currents, a slow response time, low quantum efficiency and a broad spectral cutoff.[3]

In this work, we demonstrate the fabrication and characterization of a very low dark current UV MSM photodiode fabricated with undoped GaN epitaxial layers using Pd as the Schottky contact metal, and a $Al_{1-x}Ga_xN$/GaN heterostructure p-i-n photodiode. The advantages and limitations of these devices to achieve solar-blind detection will be discussed.

A low-pressure metalorganic chemical vapor deposition technique was used for growing the individual device layers on c-plane sapphire substrate. All device processing was completed using standard semiconductor processing techniques which included photolithography, chemically assisted ion beam etching and metallizations to provide Schottky and ohmic contacts. For the spectral responsivity studies, a Xe arc lamp was used as an optical source and the wavelengths were selected by a monochromator.

Palladium and platinum were chosen as the Schottky metals because of its comparatively high work function. The electrical properties, $q\phi_B$, and n value of Schottky contact metals were determined by the I-V method in terms of the thermionic emission model. Typical I-V characteristic of Pd and Pt contacts on u-GaN are shown in Fig. 1. We found that the Pd Schottky contact had superior properties to the other one. The Pd Schottky contact barrier is as high as 0.82±0.02 eV and the n value is 1.22±0.05.

MSM photodiodes, based on two interdigitated Pd Schottky contacts which is depicted in Fig. 2., present a low dark current and a high breakdown voltage. The results for a typical device are shown in Fig. 3. The I-V curves are taken in the dark and under illumination. We obtained a very low dark current of 4.8 pA at a reverse bias of 5 V. Fig. 4. shows the spectral response of the same devices. The cutoff wavelength is 365 nm, which is corresponding to the absorption edge of GaN, and the response is nearly constant in the wavelength range between 300 and 365 nm.

For p-i-n PD that has a structure of p-AlGaN/i-GaN/n-GaN, the spectral response is also shown in Fig. 4. It showed the same cutoff wavelength, but the intensity was decreased near 343 nm due to of the increased absorption by the AlGaN cladding layer. From this point, we can estimated an effective mole fraction of Al to be 0.86 %. More detailed results will be presented with optimized device design.

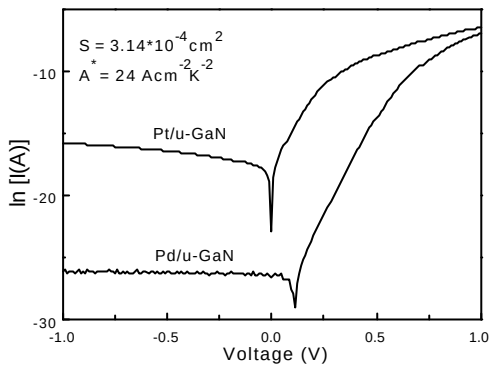


Fig. 1. A typical I-V characteristic of Pd/u-GaN Schottky contacts in a semilog plot.

Fig. 2. Top view of MSM device showing interdigitated geometry. Finger width is 2 m, length 200 m, and pitch is 5 m.

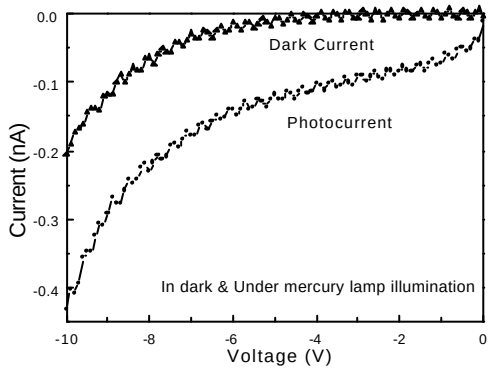


Fig. 3. I-V characteristics of the Pd/u-GaN MSM photo detectors taken in dark and under mercury lamp illumication.

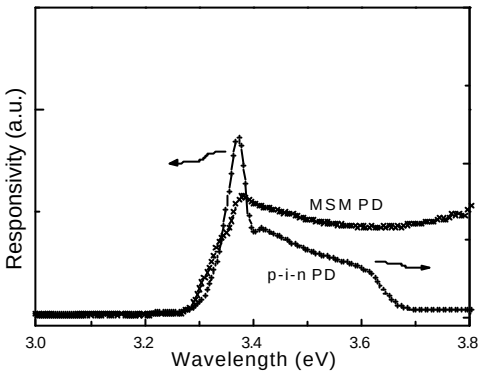


Fig. 4. Zero-bias spectral response of p-i-n, MSM photodiodes

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