High-performance back-illuminated solar-blind AlGaN photodetectors grown by metalorganic chemical vapor deposition

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Abstract

In this work, we report the growth, fabrication and characterization of back-illuminated solar-blind AlGaN metal-semiconductor-metal photodetectors. The dark current of 40µm×40µm devices is lower than the instrument measurement limitation of 20fA for the bias <100V. The external quantum efficiency is as high as 48% and the spectral response shows a sharp band edge drop-off at approximately 280nm.

A variety of ultraviolet (UV) photodetectors based on GaN/AlGaN compound semiconductors have been extensively studied recently.[1] This research has been driven primarily by military applications such as missile tracking, which require solar-blind UV photodetectors with a long-wavelength cutoff wavelength (λ_c) at 280nm. In order to facilitate flip-chip bonding of UV photodetector arrays to read-out integrated circuits, back illumination is preferred. To date, numerous materials approaches and device structures have been reported. Among the device structures, the metal-semiconductor-metal (MSM) photodetector is a good candidate for this application. First, it is easy to achieve good Schottky contacts on wide-bandgap AlGaN material. Secondly, the MSM approach avoids the difficulties in obtaining high *p*-type doping and good ohmic contacts on *p*-type AlGaN which are necessary for *p-i-n* photodiodes. Also, since the devices are back-illuminated, there is no shadowing from the inter-digitated metal contact fingers. Finally, the low capacitance of the MSM will not compromise the response speed when the detector is connected with a high impedance amplifier.

We report here the performance of back-illuminated solar-blind MSM photodetectors. The device dark current is lower than 20fA, the instrument measurement limitation, for bias voltages ≤100V. The external quantum efficiency is as high as 48%. The spectral response shows a solar blind cutoff wavelength at 280nm. Both the current-voltage characteristic and the spectral response at different biases indicate that there is no photoconductive gain.

The device structure consists of AlGaN epitaxial layers grown on double polished c-plane (0001) sapphire substrates by low pressure MOCVD. First, an AlN buffer layer was grown. The second grown layer was a 0.8 µm-thick $Al_{0.6}Ga_{0.4}N$ "window" layer. Then, a 10nm transition region with the Al mole fraction graded from 60% to 45% was grown to decrease the interface strain. Finally, a 0.2 µm-thick $Al_{0.45}Ga_{0.55}N$ active layer was grown. Device mesas were defined by reactive ion etching (RIE). Evaporated layers of 50Å titanium and 800Å platinum were deposited as metal contacts and 1000Å SiO_2 was deposited by PECVD as a surface passivation layer.

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References

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