MOCVD Growth of InAlN/GaN Heterostructures on Si Substrate for UV Photodiode Application

Binh Tinh Tran[1], Edward Yi Chang[1]*, Hong Quan Nguyen[1], Kartika Chandra Sahoo[2], Chen Chen Chung[1], Chi Lang Nguyen[1], Quang Ho Luc[1], and Huy Binh Do[1]

[1]Department of Materials Science and Engineering, National Chiao Tung University, 1001 University Road, Hsinchu 300, Taiwan
[2]Taiwan Semiconductor Manufacturing Co., Ltd., Hsinchu, Taiwan

*Corresponding author: edc@mail.nctu.edu.tw

$In_xAl_{1-x}N$ alloys with 17-18% indium composition are becoming popular in research due to their natural wide bandgap (i.e., 0.6 to 6.2 eV) and lattice matching GaN [1, 2]. $In_xAl_{1-x}N$ alloys are very attractive for high electron mobility transistors (HEMTs), light emitting diodes (LEDs), solar cells and ultraviolet photodiodes (UVPD) applications [3-9] due to a wide spectrum of wavelength available by using ternary alloys. Besides, the $In_xAl_{1-x}N$-based devices can operate at high temperatures and have a long lifetime. Recently, $In_xAl_{1-x}N$ has been widely studied and applied to various semiconductor devices. However, most reported research used sapphire substrate for growing $In_xAl_{1-x}N$ alloys. A few studies used Si substrate due to the challenges of growing $In_xAl_{1-x}N$ film on Si substrate, which exhibits an obvious lattice mismatch. High quality GaN buffer is one effective method used to obtain a high quality $In_xGa_{1-x}N$ [10], and in this study, it will be continuously used to improve the $In_xAl_{1-x}N$ film on Si substrate using metal organic chemical vapor deposition (MOCVD) reactor.

In this study, we report on the growth of high quality $In_xAl_{1-x}N$/GaN heterostructures on Si substrate by MOCVD with various indium compositions. The lattice-matched $In_{0.176}Al_{0.838}N$/GaN structure shows a smooth surface with good crystalline quality. In addition, the ultraviolet photodiode device fabricated based on this structure shows excellent device characteristics with a low leakage current of 0.12 μA, and a high spectral response. It has good quantum efficiency of 94 mA/W and 44% at 265 nm.

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