Epitaxial growth of nonpolar GaN on Si (100) for light emitting diode and power device application

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Non polar GaN has been focused at the beginning of GaN LED. As the presently used GaN (0001) plane is the polar surface and due to the "Stark Effect", the light emitting efficiency is suppressed by internal electric filed because it reduces the recombination of electrons and holes. To enhance the recombination, the most desirable idea was to use non polar plane where the internal electric field and bias direction is orthogonal. As the substrate for GaN LED, the sapphire of (0001) plane has been adopted because it has hexagonal structure and is durable in high temperature growth. The price of the substrate, however is rather expensive compared with Si. Actually some GaN LED is fabricated on Si(111) to replace Sapphire (0001). The both surfaces have hexagonal orientation and does not provide non polar plane. Therefore the ideal template for GaN LED is non polar GaN growth on Si (100), where the cubic structure is expected to provide non polar plane.

Nonpolar (11-20) oriented GaN films were grown epitaxially by sputtering on Si(001) using MnS as buffer layers[1]. X-ray diffraction pole figures showed an epitaxial relationship of (11-20) GaN // MnS(001) // Si(001). On this GaN as a template, at first p-type GaN layer of 200nm was grown by MOCVD at 1200 C. Then, an i-ZnO and n-type ZnO were grown subsequently by pulsed laser deposition to make p-i-n diode structure as shown in Fig.1. A near band-edge emission from ZnO was observed at 378 nm in photoluminescence measurements. Electroluminescence of nonpolar n-ZnO/i-ZnO/p-GaN LEDs displayed UV emission at 390 nm under forward and reverse bias (Fig.2(a) and Fig.2(b)).

Successful growth of nonpolar n-ZnO/i-ZnO/p-GaN heteroepitaxial on Si provides an attractive solution for integrating nonpolar GaN and ZnO-based optoelectronic devices with Si substrates for various applications such as higher efficient LED or GaN based power device, which is required for power saving electronics.



Fig.1: schematic illusration of the LED fabriated on non polar GaN templete grown on Si (100) substrate.



Fig.2(a) : light emitting from the LED fabricated on Si(10



Fig.2(b) : Spectrum of the UV light from the LED fabricated on Si(100). As a gold electrode is u ed, light emission is observed at the edge of the electrode.

Reference:

[1] N.Nguyen et al "Epitaxial growth of nonpolar ZnO and n-ZnO/i-ZnO/p-GaN heterostructure on Si(001) for ultraviolet light emitting diodes", *Appl. Phys. Express* 7 062102 (2014).

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