Strong visible light emission from zinc-blende InGaN/GaN pn junction on Silicon substrate

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This paper describes the optical possibility of zinc-blende GaN crystals grown by metal organic chemical vapor deposition (MOCVD) technique. A markedly promising result has been obtained.

Recently, a strong emitting blue LED has been much required, however Stark effect[1] due to piezo efficiency of hexagonal structure makes detrimental results by limiting carrier recombination. In order to eliminate the Stark effect, we have developed the growth of zinc-blende GaN single crystals on Si substrates.

Recently, we have successfully grown zinc-blende GaN by MOCVD on Si substrates using n type BP crystals as a buffer crystal in our laboratory[2,3]. The photoluminescence (PL) results of preliminary grown GaN crystal is shown in Fig.1. The peak of zinc-blende GaN can be seen clearly. We couldn't find any peak from hexagonal GaN. The cross sectional view of zinc-blende GaN on buffer crystal is given in Fig.2. A somewhat flat GaN has been obtained on BP/Si substrates. As a preliminary study to determine the feasibility of zinc-blende type crystals, we have grown InGaN crystals on GaN. An InGaN crystal has been successfully grown on GaN layers, however, the In content is still small in this case. After that, the p-type GaN has been grown by Mg doping. In this case we have not grown yet the reflector barrier to increase the carrier recombination at the quantum well. We have measured the electric current through a p-n junction. The electric current went through vertically from the p-type GaN toward the backside of the Si substrate. The electrodes used were mixed Ni-Au alloy on the p-type GaN surface of the specimens. The preliminary fabricated fundamental p-n junction demonstrates that the forward-current exponentially increased at around 2.4V. A striking result has been obtained. A strong light has been emitted just at the increasing point of the forward current. We strongly believe that the zinc-blende GaN related materials are one of the most promising materials in optical usage. In addition this material system is all diamond structure including zinc-blende structure, so it is easy to cleavage along (110) face to fabricate mirror structure like the GaAs related materials. In this meeting, we mainly give a presentation of p-n junction and light emission from zinc-blende GaN diodes.

The key point of this study is the use of BP crystals as a buffer crystal on Si. It absorbs the large lattice mismatched strain with Si near the interface. The mismatched dislocations are generated within 150nm from the BP and Si interface. The conductive type is easily controllable by suppressing carbon incorporation and impurity doping during the epitaxial growth. The lattice mismatch between the BP crystal and the zinc-blende GaN is within 1%. So, it is possible to obtain GaN and InGaN crystals directly on BP/Si substrates.

In this meeting, the possibilities of zinc-blende GaN will be discussed in terms of emitting light analyses, PL measurement, X-ray measurement, FE-SEM analyses, and p-n junction properties. To study the structure around depletion region, capacitance measurement with reverse bias will be also discussed.

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References

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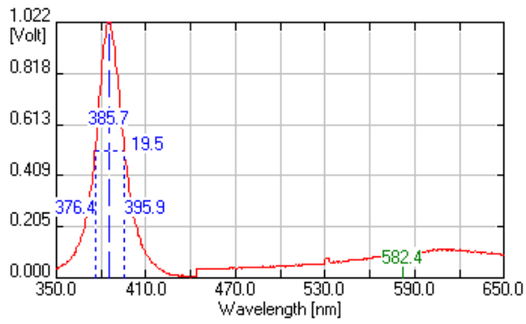

Fig.1 PL spectra of zinc-blende GaN on Si(100)

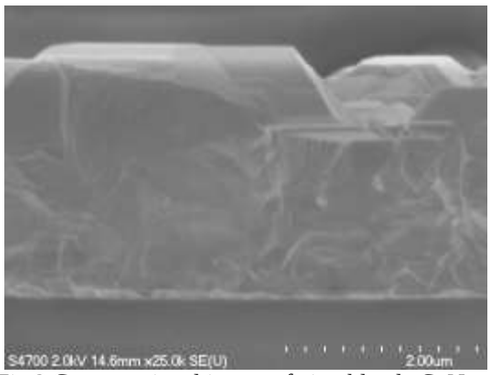

Fig.2 Cross sectional image of zinc-blende GaN on Si(100) with buffer layer