Comparison of the optical properties in InGaN/GaN quantum well structures grown on (0001) and ($11\bar{2}0$) sapphire substrates

T.Wang[1] J.Bai[2] and S.Sakai[1,2]
[1]Satellite Venture Business Laboratory
[2]Department of Electrical and Electronic Engineering,
the University of Tokushima, Minaji-josanjima, Tokushima 770-8506, Japan
E-mail: taowang@svbl.tokushima-u.ac.jp

Abstract

Although there are many reports on the optical investigation of InGaN/GaN quantum well structures, the emission mechanisms of this structure are still not fully understood. Furthermore, almost all of InGaN/GaN-based opto-electrical devices are fabricated on (0001) sapphire substrate. Generally, the orientation substrate has an influence on the properties of semiconductore devices. Recently, a theoretical study shows that the growth of InGaN/GaN quantum well structure on (11-20) sapphire substrate can improve the optical propertites of InGaN/GaN quantum well structures[1]. In addition, it is greatly helpful for the cleaving to grow InGaN/GaN-based optical devices grown on (11-20) sapphire substrate, the cleaving is a very important issue in the fabrication of GaN-based devices on sapphire substrates. Therefore, it is necessary to study the optical properties of InGaN/GaN quantum well structure grown on (11-20) sapphire substrates.

Temperature dependent photoluminescence (PL) measurements are performed on InGaN/GaN multiple-quantum-well (MQW) structures with 2.5nm well thickness grown on (0001) and **(**11-20) sapphire substrates as shown in Figure 1. Transimission electron microscopy indicates that the substrate orientation does not affect the growth rate. Deatailed X-ray diffraction and photoluminescence measurements shows that the Indium content decreases on (11-20) saphhire substrate compared with that on (0001) substrate (10% Indium on (0001) and a lower Indium on (11-20) under the identical growth conditions). The exciton localization effect is investigated with regards to the orientation of substrates. In figure 1, on the (0001) substrate, the emission energy decreases monotonically with increasing temperature from 10k to room temperature, which means that there is no distinguished localization effect. However, on the (11-20) substrate, the emission energy shows a temperature-induced blue-shift in the temperature over 70K, which is typical characteristic of exciton localization effect. Based on the band tail model, the temperature-dependent emission energy is fitted as shown in Figure 2, in which the σ value that indicates the degree of the localization effect[2] is obtained. Obviously, in spite of the lower Indium content on (11-20) sapphire substrate, the σ vlaue is much larger than that on (0001) sapphire substrate, which means that the (11-20) substrate can enhance the localization effect greatly. The excitation-power dependent PL measurement indicates that there is no any blue-shift with increasing excitation-power as shown in Figure 3, which means that the quantum confine Stark effect (QCSE) can be ignored for such a low Indium content. Therefore, the difference between the emission energy on (0001) and (11-20) can not be attributed to QCSE, but to the difference of Indium content, which agrees with the X-ray diffraction results.

Since the growing of InGaN/GaN-based optical devices on (11-20) sapphire substrate is great helpful for the cleaving and a good advatange for the enhancement of localization effect, the presented result in this paper should be highly emphasized.

References:

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2. P.G. Eliseev, et al APL. **71**, 569 (1997)

Figure 1

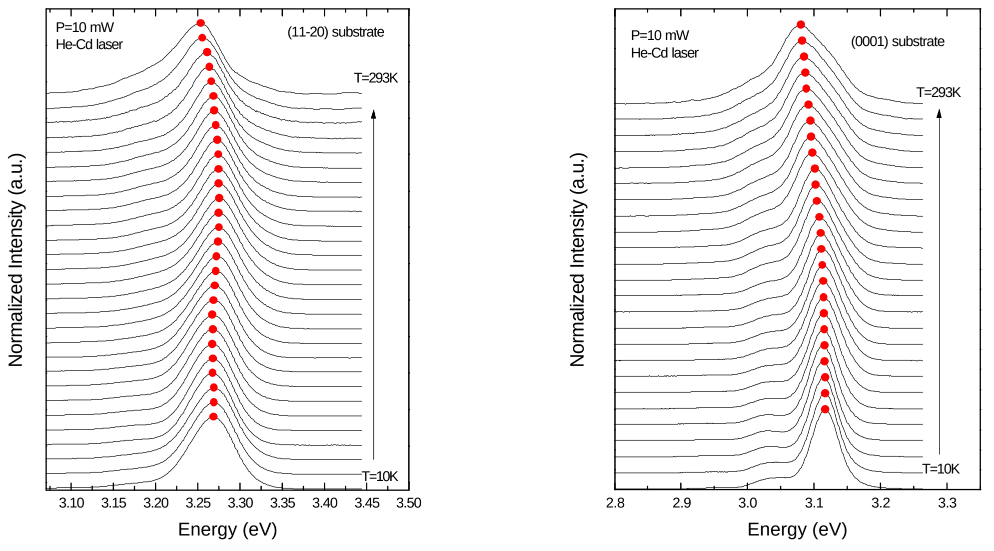

Figure 2

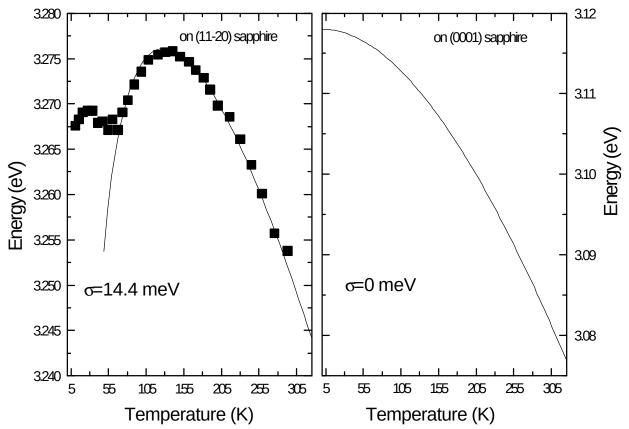

Figure 3