Local structural study around In atom in $m$-$\text{In}_{0.06}\text{Ga}_{0.94}$N by EXAFS

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Introduction

$\text{In}_{x}\text{Ga}_{1-x}$N is a key material in high-brightness blue and green light-emitting diodes (LEDs) and purplish-blue laser diodes. In order to make the emission mechanism clear in $\text{In}_{x}\text{Ga}_{1-x}$N-based light-emitting devices, it is important to clarify the local structure around In atoms in active layers. Extended x-ray absorption fine structure (EXAFS) is a powerful tool in investigating local structures in thin layers composed of two or more elements.

For single quantum well (SQW) $\text{In}_{x}\text{Ga}_{1-x}$N film, EXAFS study has been successfully performed and it was suggested that the aggregation of In along to $c$-axes is important for the high quantum efficiency of LED [1]. Recently, $m$- or $a$-plane (as non polarized plane) $\text{In}_{x}\text{Ga}_{1-x}$N specimen has been developed in order to obtain the higher efficiency without the effect of the electromagnetic field. In this report we measured In $K$-edge EXAFS for $m$-$\text{In}_{x}\text{Ga}_{1-x}$N film for two arrangements: the electric field of incident X-ray is parallel and perpendicular to $m$-plane of the sample.

Experimental and Data analyses

300 nm $\text{In}_{x}\text{Ga}_{1-x}$N film was deposited by MOVPE on GaN buffer layer/GaN substrate by HVPE method. The sample structure is shown in Fig.1.

![Fig. 1 Schematic structure of $m$-$\text{In}_{x}\text{Ga}_{1-x}$N film](image)

X-ray absorption measurements were made at beam line of NW10A at Photon Factory, KEK. Data were collected with a double-crystal monochromator using Si(311) crystals. Indium $K$-fluorescence emission was measured using a 19-element Ge solid-state detector. Data analyses was performed using XANADU code [2] and FEFF8.01 code [3].

Results and discussion

Figure 2 shows the $k^2\chi(k)$ spectra for $m$-$\text{In}_{x}\text{Ga}_{1-x}$N film for two directions. The data quality is fairly good $k < 12\text{A}^{-1}$ and we found the clear difference between two directions. Figure 3 shows the Fourier transforms of the EXAFS data shown in Fig. 2.

![Fig. 2 $k^2\chi(k)$ spectra for $\text{In}_{x}\text{Ga}_{1-x}$N film](image)

![Fig. 3 Fourier transforms for $\text{In}_{x}\text{Ga}_{1-x}$N film](image)

First peak around 1.8A corresponds to In-N atomic pair and the second one around 3 A to In-Ga and In-In. It is not clear the reason why the first peaks are different between them. For the second peak detailed analyses performed by the curve-fitting analyses. The results are summarised in Table 1 and 2. For $c$-axes direction, it is noted that no In-In contribution is observed. This interesting result should be ascertained by further investigation.

<table>
<thead>
<tr>
<th>$r$/Å</th>
<th>$N$</th>
<th>$\sigma$/Å</th>
</tr>
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<tbody>
<tr>
<td>In-Ga</td>
<td>3.21</td>
<td>9.0 0.07</td>
</tr>
<tr>
<td>In-In</td>
<td>3.43</td>
<td>3.0 0.04</td>
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Table 2: EXAFS parameters of $m$-$\text{In}_{x}\text{Ga}_{1-x}$N film for $a$-axes

<table>
<thead>
<tr>
<th>$r$/Å</th>
<th>$N$</th>
<th>$\sigma$/Å</th>
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</thead>
<tbody>
<tr>
<td>In-Ga</td>
<td>3.18</td>
<td>12 0.09</td>
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</table>

References


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