Materials Science

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Local structural study around In atom in *m*-$In_{0.06}Ga_{0.94}N$ by EXAFS

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Introduction

$In_xGa_{1-x}N$ 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 InGaN-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) InGaN film, EXAFS study has been successfully performed and it was suggested that the aggregation of In atom along to *c*-axes is important for the high quantum efficiency of LED [1]. Recently, *m*- or *a*-plane (as non polarized plane) InGaN 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*-InGaN 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 $In_{0.06}Ga_{0.94}N$ film was deposited by MOVPE on GaN buffer layer/GaN substrate by HVPE method. The sample structure is shown in Fig.1.

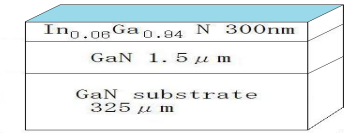

Fig. 1 Schematic structure of *m*-$In_{0.06}Ga_{0.94}N$ film

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 $k\chi(k)$ spectra for *m*-$In_{0.06}Ga_{0.94}N$ film for two directions. The data quality is fairly good $k < 12A^{-1}$ and we found the clear difference between two directions. Figure 3 shows the Fourier transforms of the EXAFS data shown in Fig. 2.

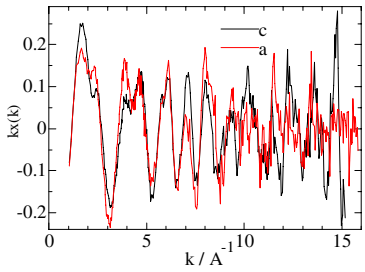

Fig. 2 $k\chi(k)$ spectra for $In_{0.06}Ga_{0.94}N$ film

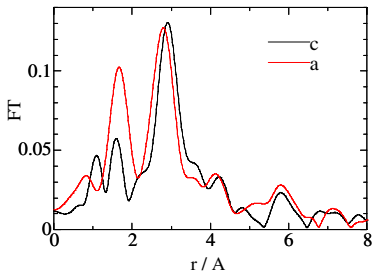

Fig. 3 Fourier transforms for $In_{0.06}Ga_{0.94}N$ film

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 1: EXAFS parameters of *m*-$In_{0.06}Ga_{0.94}N$ film for *c*-axes

	r / A	N	σ / A
In-Ga	3.21	9.0	0.07
In-In	3.43	3.0	0.04

Table 2: EXAFS parameters of *m*-$In_{0.06}Ga_{0.94}N$ film for *a*-axes

	r / A	N	σ / A
In-Ga	3.18	12	0.09

References

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