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Fluorescence EXAFS analysis of local structures around Er atoms doped in GaAs by low-temperature molecular beam epitaxy

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Introduction

Er-doped III-V semiconductors have been attracting much interest due to sharp and temperature-stable intra-4f-shell luminescence at 1.54 μm, which corresponds to the minimum transmission loss in the silica-based optical fibers [1]. Therefore, the Er-doped semiconductors have been extensively studied in recent years [2,3]. Recently, we have grown GaAs:Er by low-temperature molecular beam epitaxy (LT-MBE) [4]. It has been found that the photoluminescence (PL) emission of the GaAs:Er grown by LT-MBE depends strongly on the growth temperature. Since the electronic states of Er are perturbed by the crystal field around Er atoms, it is essentially important to study the local structures around Er atoms for understanding and controlling the luminescent properties of Er atoms in semiconductors.

In the present work, Er-doped GaAs (GaAs:Er) grown by LT-MBE is investigated by fluorescence EXAFS measurements.

Experimental

Two Er-doped GaAs samples were prepared by the MBE on undoped GaAs (001) substrates. Er concentrations were measured by SIMS. Fluorecence EXAFS measurements were performed at beam line BL12C at KEK-PF

Results and discussion

Figure 1 shows the Fourier transformed Er L_{III}-edge $k\chi(k)$ EXAFS spectra for GaAs:Er and the theoretical EXAFS spectra for substitutional Er on the Ga-site in the GaAs lattice and interstitial Er on Td-site in the GaAs lattice. The peak structure in the range 2-3Å is due to the first coordination shell around Er. The position of the peak for the GaAs:Er grown at 400 °C (#B) shifts toward the longer radial distance side than that for the GaAs:Er grown at 590 °C (#A). Curve-fitting results for the EXAFS spectra showed that majority of Er atoms in the sample #A substituted Ga-site in the GaAs lattice, but in the sample #B were interstitial in Td-site in the GaAs lattice. Photoluminescence measurements showed that in the sample #B luminescence peak corresponding to the $^4I_{13/2} \rightarrow {}^4I_{15/2}$ transition in Er^{3+} was observed at 1.54 μm, and in the sample #A it almost diminished. Therefore, it is expected that the difference in the local structure around Er atoms doped in GaAs causes the change of the PL intensity.

References

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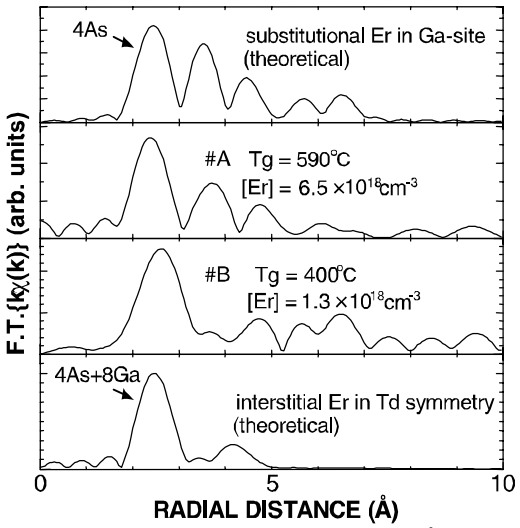

Fig.1: Fourier transform of Er L_{III}-edge $k^3\chi(k)$ EXAFS for GaAs:Er and the theoretical EXAFS spectra for substitutional Er on the Ga-site in GaAs and interstitial Er on Td-site in GaAs.

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