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X-RAY TOPOGRAPHY AND PHOTOLUMINESCENCE (PL) AT GaAs/AlGaAs MBE AND LPE HETEROJUNCTION MATERIALS

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MBE and LPE heterojunction epitaxial GaAs/AlGaAs layers are studied by both X-ray and photoluminescence (PL) to profile the uniformity, defects and dislocations, and stress distribution for the material research.

GaAs/AlGaAs heterojunction materials are greatly improved by the use of different growth technologies, such as MBE, MOCVD and LPE, for the optoelectronic applications. The purpose of this paper is to report the recent research results of X-ray topography and PL measurement on the MBE and LPE growth GaAs/AlGaAs multilayers.

Heterojunction GaAs/AlGaAs epilayers are grown by general MBE and LPE technoloby. Among them there are MBE growth single quantum well layers with or without superlattice buffer layers, LPE double heterojunction wafers, and LPE AlGaAs waveguides. X-ray topography and measurements are carried out by the use of scanning type double crystal X-ray goniometer, D/MAX-rA Rigaku. The X-ray difffraction rocking curves in (511) and (422) directions are recorded in (+, -) setting[1]. The X-ray topography image is taken in the slopest point of the rocking curves of substrate and epilayers, respectivily, with Fuji 1X film[2]. PL is measured by the Laser Raman Spectrameter, JY-T80, at 11K and a grating spectrameter at 77K to measure the excitons related luminescence[3].

Fig. 1 shows the PL intensity profile of exciton transition at 77K, and X-ray topography image of LPE GaAs/AlGaAs waveguide which is of low optical loss and uniformity. The X-ray topography image is the (311) diffraction image which shows the stress distribution of both substrate and epilayers. Where, high PL intensity

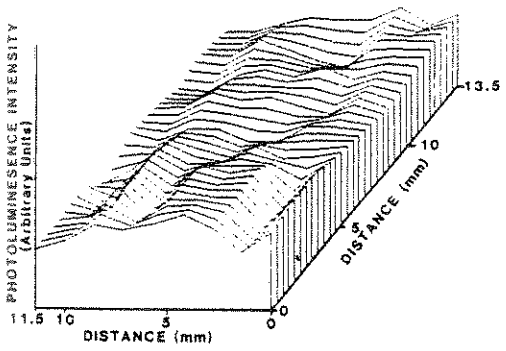
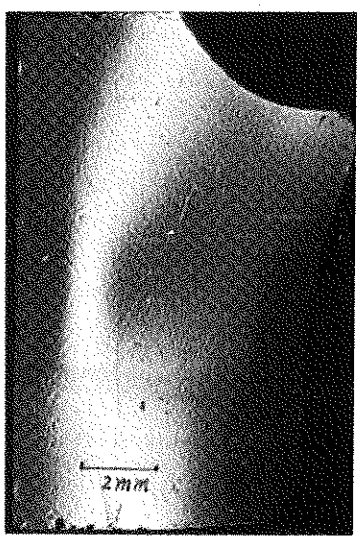


FIGURE 1
The PL intensity profile(at 77K) at 726.8 to 729.6nm and (311) x-ray topography image of waveguide Ly-121.



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responses to the low stress, shown as the white area of the contrast image, in the wafer.

Fig. 2 shows the X-ray topography image of MBE167 sample which was grown at 580°C without superlattice buffer layers. Along the directions of [110] and [$\bar{1}$10], cross dislocations can be observed in most of the wafer. However, with the same substrate condition, there are no obvious dislocation observed in MBE177 which was grown at 680°C with same structure as MBE167, except inserting a series superlattice buffer layers between substrate and epilayers. In MBE177, density dislocations can be epilayers. In MBE177, density dislocations can be seen only in the edges or corner of the sample, which may come from the substrate damage. The PL intensity of MBE177 is about 10^2 times higher than that of MBE167. Also the high energy transiitions resulted from the 500Å single well can be seen clearly in the sample MBE177.

Both X-ray and PL methodes are used to study the uniformity of epilayer thickness, Al composition of AlGaAs layer, defects and dislocations, and stress distribution to find the improvement from the insert of a series of GaAs/AlGaAs superlattice buffer layers between substrate and epilayers in MBE process. The advantage effects can be concluded to the improvement of the hetero-interface by superlattice layers which may block the defects from substrate to epilayers in the epitaxial process[4].

From the observation noted above, we can conclude that: 1. X-ray and PL are both very useful in diagnosis of the heterojunction GaAs/AlGaAs epilayers without sample damage. 2. The MBE heterojunction layers can be improved on the uniformity of thickness and Al composition, defects and dislocations, and PL properties by the insert of a series superlattice buffer layers between substrate and epilayers.

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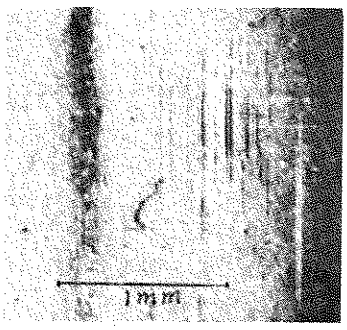

FIGURE 2
(422) x-ray topography image of MBE167.

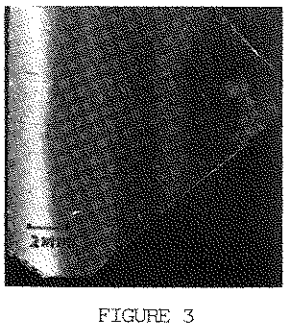

FIGURE 3
(422) x-ray topography image of MBE177.