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Gas Species Comparison of Fast Atom Beam Irradiation to Photoluminescence Properties of GaInAs/InP layers for Surface Activated Bonding

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1. Introduction

Hydrophilic bonding or plasma activated bonding (PAB) [1,2] are usually used for hybrid wafer bonding. However, to achieve high bonding strength, annealing temperature of higher than 150°C, resulting in the thermal stress caused by the difference between thermal expansion coefficients of bonded wafers, and long cooling time are required. To deal with the mentioned problems, surface activated bonding (SAB) based on fast atom beam (FAB) [3] was proposed in recent years, which can realize wafer bonding at room temperature. In our previous report, we reported the influence of Ar-FAB to photoluminescence properties of GaInAs/InP wafers [4]. In this report, we assessed the influence by other gases N_2 and Xe.

2. Experiment Results

In this experiment, depth dependence of wafer damage after FAB irradiation was evaluated by photoluminescence (PL) intensity degradation. Only one wafer put on lower side of the SAB equipment is irradiated by FAB. The layer structure of the evaluated wafer is shown in Fig. 1. The wafer consists of 4 GaInAs quantum wells (QWs) with different thickness (emit at different wavelength) separated with 200-nm InP. Fig. 2 shows the normalized PL intensity of 3-nm thick GaInAs (50-nm quantum well depth) as a function of irradiation time for Ar-FAB, Xe-FAB, and N_2-FAB sources at different FAB currents. PL intensity was decreased by FAB irradiation even the irradiation time was short. The degradation is smaller at lower FAB current at the same irradiation time. This means low FAB current should be utilized in wafer bonding in order to keep PL property, although too low current cannot make activated surface and bond the wafers. Fig. 3 shows quantum well depth dependence of normalized PL intensities under the irradiation time and current of 10 sec. and 5 mA, respectively. It was found that normalized PL intensity kept >80% at 450-nm quantum well depth under low current and short irradiation time for three FAB sources. Meanwhile, Xe-FAB resulted in the less degradation under the same FAB conditions (current and irradiation time) compared with Ar-FAB and N_2-FAB. One of the explanation may be related to that the atomic mass of Xe is bigger than those of Ar and N. For the future plan, we need to investigate more FAB sources, such as Kr and Ne to figure out the reason of the degradation of normalized PL intensity and choose the most suitable FAB sources for InP/Si wafer bonding.

Fig. 1. Layer structure used in assessment of optical property.

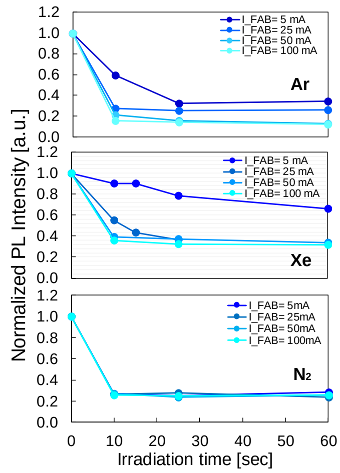

Fig. 2. Normalized PL intensity at quantum well depth 50nm.

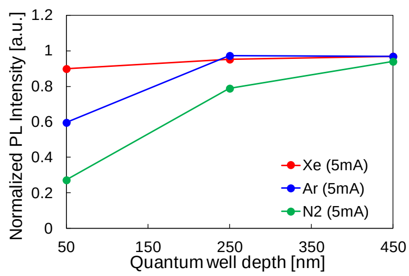

Fig. 3. Normalized PL intensity as a function of quantum well depth (FAB irradiation time: 10 sec).

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