Investigation of InP/Si bonding condition for suppressing degradation of Photoluminescence property using Surface Activated Bonding

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1. Introduction

To deal with thermal stress and long cooling time introduced by conventional wafer bonding technology, such as hydrophilic bonding and plasma activated bonding (PAB) [1,2], 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, in order to suppress damage introduced by Ar-FAB irradiation to wafer, we reported the influence of irradiation to photoluminescence (PL) properties of GaInAs/InP wafers by various FAB sources and figured out that Xe-FAB has the lowest damage to PL intensity [4]. In this report, we measured bonding strength of InP/Si bonding conducted by Xe-FAB and compared with the result under the same bonding condition conducted by Ar-FAB.

2. Experiment Results

Fig. 1 shows a schematic image of SAB process flow using FAB. Initial wafers are mounted on fixtures in a vacuum chamber and fast atom beam is irradiated to the wafers. Then, the wafers are immediately pressed without any annealing. The structure of the wafer used in FAB irradiation experiment is shown in Fig.2. The wafer consists of 4 GaInAs quantum wells (QWs) with different thickness (emit at different wavelength) separated with 200-nm InP. Fig. 3 shows the normalized PL intensity of 3-nm and 5-nm thick GaInAs (50-nm and 250-nm quantum well depth) as a function of FAB current for Ar-FAB, Xe-FAB sources when FAB irradiation time was 10 sec. It was found that under the same FAB irradiation condition, sample irradiated by Xe-FAB has lower PL intensity degradation even at 50-nm quantum well depth. Moreover, at 250-nm quantum well depth, PL intensity of sample irradiated by Xe-FAB is kept over 90%. Fig. 4 shows FAB current dependence of InP/Si bonding strength by Xe-FAB and Ar-FAB. It indicates that Ar has stronger bonding strength comparing with Xe. However, PL showed opposite behavior. Actually, based on previous research, it is possible to conduct hybrid laser process when wafer bonding strength is over 0.5 MPa [2]. Therefore, Xe-FAB should be the choice for enough bonding strength of hybrid laser process as well as maintaining low damage to PL intensity of wafer.

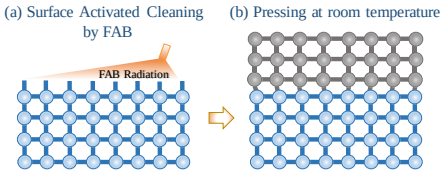

Fig. 1. Surface activated bonding using FAB.

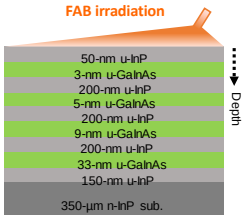

Fig. 2. Wafer structure.

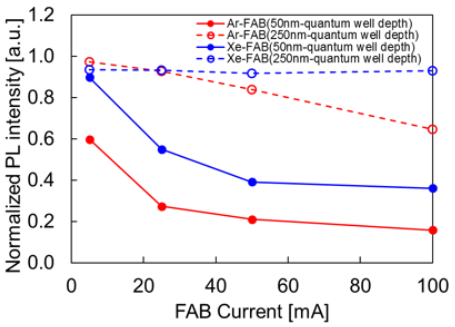

Fig. 3. FAB Current dependence of Normalized PL intensity at 50 nm and 250 nm-quantum well by Xe and Ar-FAB (FAB irradiation time: 10 sec).

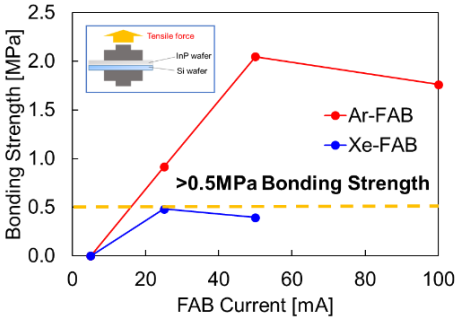

Fig. 4. FAB Current dependence of InP/Si Bonding Strength by Xe and Ar-FAB (FAB irradiation time: 10 sec).

Acknowledgment

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