Investigation of Photoluminescence property of InP/SOI wafer after bonding experiment using Surface Activated Bonding based on Fast Atom Beam

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1. Introduction

In order to reduce thermal stress introduced into hybrid wafer bonding [1,2], surface activated bonding (SAB) based on fast atom beam (FAB) [3] was proposed, which can achieve bonded wafer at room temperature. In our previous report, in order to maintain semiconductor crystal quality through FAB irradiation, 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. Beyond that, InP/Si wafer bonding by Xe-FAB is realized which has enough bonding strength to be introduced into hybrid laser fabrication process [4]. In this report, PL intensity after InP/SOI wafer bonding process is investigated.

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 bonding conditions are summarized in Table 1. Under Xe-FAB irradiation current: 35 mA and irradiation time: 10sec, the bonding strength is over 0.5 MPa, which means Xe-FAB can be the choice for enough bonding strength of hybrid laser process as well as maintaining low damage to PL intensity of wafer. For Si or SOI wafers, Ar-FAB can be used since Si is more rigid than InP-based materials. InP/SOI wafer bonding is conducted to investigate PL intensity variation after bonding experiment. Fig. 2 shows layer structure of epitaxial grown wafer (epi wafer) used in InP/SOI wafer bonding experiment. Fig. 3 (a) shows surface image of InP epi/SOI wafer after removal of InP substrate by 100% HCl. As shown in the figure, there is no obvious void and peeling except the positions of hillocks the original epi wafer had. Fig. 3 (b) shows the PL intensity mapping of InP epi/SOI wafer after removal of InP substrate. It is shown than a uniform III-V layer is bonded on SOI substrate by Xe-FAB.

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References

[1] A. W. Fang, *et al.*, *Opt. Express* **14**, 9203 (2006).
[2] Y. Hayashi, *et al.*, *JJAP* **55**, 082701 (2016).
[3] H. Takagi, *et al.*, *Appl. Phys. Lett*, **68**, 2222 (1996).
[4] Y. Wang, *et al.*, ***66th*** *JSAP spring meeting*, 10a-W331-10 (2019).

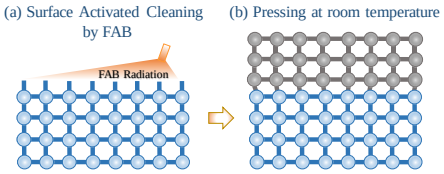

Fig. 1. Surface activated bonding using FAB.

Table 1. Bonding conditions

Wafer	Si	InP epi
FAB source	Ar	Xe
Irradiation Current	50 mA	35 mA
Irradiation time	90 sec.	10 sec.
Pressure	400 kg	
Pressing time	300 sec.	

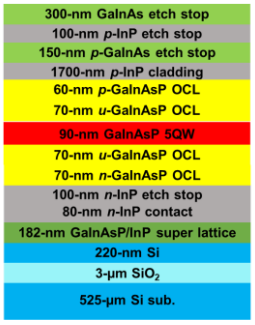

Fig. 2. Layer structure of epitaxial grown wafer after removal of InP substrate.

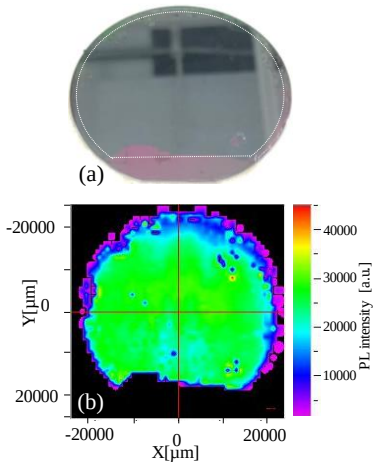

Fig. 3. (a) InP/SOI wafer after removal of InP substrate (b) PL intensity mapping of InP/SOI wafer.