Investigation of bonding strength between (InP, Si)/SiO_2 and Si by Surface Activated Bonding based on Fast Atom Beam assisted by Si nano-film

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1.Introduction

Semiconductor membrane lasers are promising light source for on-chip interconnection on LSI [1]. However, relatively large thermal resistance due to low thermal conductivity of bottom insulator is one of the problems to be solved and direct bonding with minimum SiO2 thickness should be realized. In recent years, surface activated bonding based on fast atom beam was proposed [2], which can realize wafer bonding at room temperature. However, oxides like SiO_2 are not suitable material to this method in a general condition. Therefore, to solve this problem, the Si nano-film layer was used [3]. In this report, physical bonding strength after Si or InP to SiO_2 wafer bonding process is investigated.

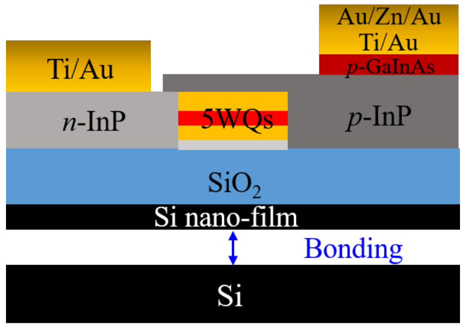

Fig. 1 Schematic of membrane laser based on direst bonding

2. Experimental results

Fig. 1 shows the schematic of a membrane laser based on surface activated direct bonding technology. This bonding using a Si nano-film as a middle layer to bond Si and SiO_2.

Fig. 2 shows the details of bonding process. 2-inch Si or InP wafers with SiO_2 deposited by PECVD were prepared. The thickness of SiO_2 layer was about 300 nm. First, a target Si wafer as the sputtering source was set on the bottom of the chamber, and the Si/SiO_2 or the InP/SiO_2 wafer was set on the top of the high vacuum chamber. Then, the target Si wafer was irradiated by Ar fast atom beam under the conditions of Ar flow: 30 sccm, Current: 100 mA, and Voltage: 1.5 kV. By this irradiation, Si nano-film was deposited on the surface of top wafer (SiO_2). After that, the target Si wafer was exchanged with a new 2-inch Si wafer. Then, only the bottom Si wafer was irradiated by Ar fast atom beam under the conditions of Ar flow: 30 sccm, Current: 50 mA, and Voltage: 1.2 kV, and Irradiation time: 90 sec. Finally, the top and bottom wafer were brought into contact without any heat for 5 min.

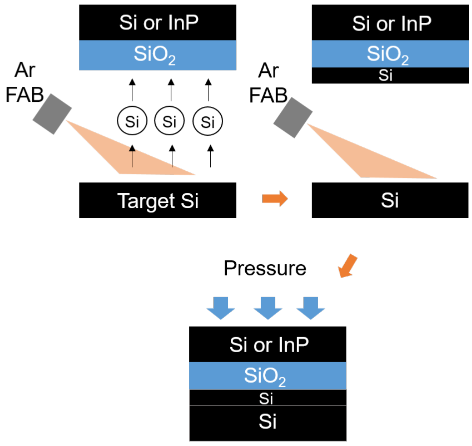

Fig. 2 Si-SiO_2 surface activated bonding process using a Si nano-film

Fig. 3 shows the result of the bonding strength by a pulling test. The parameters of the experiments were sputtering time and load during the bonding. It reveals that the bonding strength increases as the sputtering time increases. Also the load value has a great impact to the bonding strength. On the conditions of the sputtering time of 15 min and the load of 500 kgf load, the measurement system (max: 5000N) could not separate two bonded wafer, which means the strength is more than 5000N corresponding to 2.47MPa for Si/SiO_2-Si 2-inch wafer. In the case of InP/SiO_2-Si, bonding strength was 0.96 MPa, which is lower than that of Si/SiO_2-Si under the same condition. Although this value is high enough to fabricate the lasers on Si [4], we are investigating the reasons of this difference.

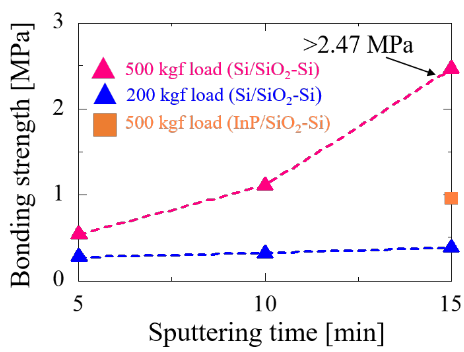

Fig. 3 Bonding strength dependence on sputtering time and load value

Acknowledgments

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Reference

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