Investigation of stress dependence on bonding strength for III-V/Si chip-on-wafer by plasma activated bonding

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1. Introduction

A large-scale photonic integrated circuit based on Si-photonics has several advantages [1]. III-V semiconductors with different bandgap and chip sizes should be also integrated with Si to obtain optical gain function by using the Chip-on-Wafer (CoW) bonding technology [2, 3]. In our previous work, we reported the bonding weight dependence for CoW plasma activated bonding (PAB) [4]. This time we report stress dependence on the bonding strength for CoW by PAB.

2. Experiment and results

As the previous report, uniform photoluminescence intensity mapping for the CoW could not be obtained, especially at the corners of chips, compared with the 2-inch wafer bonding [3]. So, we deduced that this is attributed to the chip bow of InP-based chips. For this investigation, we diced InP-based wafers with different bow (applied by stresses) to small chips (2 mm × 2mm). Fig. 1 shows the bonded structure consisting of an InP-based chip and a Si substrate. At the superlattice layer, two kinds of semiconductor GaInAsP (7 nm) and InP (6 nm) are grown alternately 14 times to form a periodic structure on an InP wafer, and the flow rate of gallium precursor was varied, which changed the composition of GaInAsP to apply stress due to strain to chips. After deposition, wafer stress was calculated from change in the radius of wafer bow at the same position using bowing measurement, and average stress over the entire scan is shown in Fig. 2. After InP-based chips bonding on a Si wafer, the die-shear examination for the experiment of stress dependence was carried out as shown in Fig. 3. Applying tensile stress allowed better bonding strength, as compared with compressive stress samples. The maximum bonding strength of ~24 MPa was obtained with higher yield. In conclusion, we demonstrated that the optimization of chip stress is very useful for the enhancement of bonding strength in III-V/Si CoW by PAB.

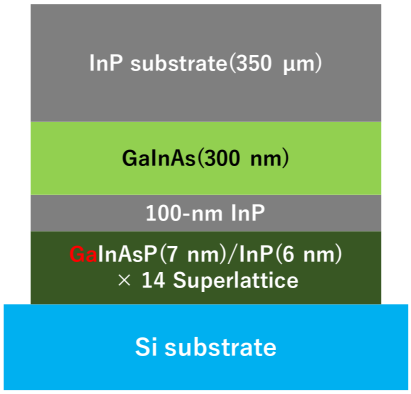

Fig. 1 Cross-sectional image of the bonded structure used for the experiment of stress dependence.

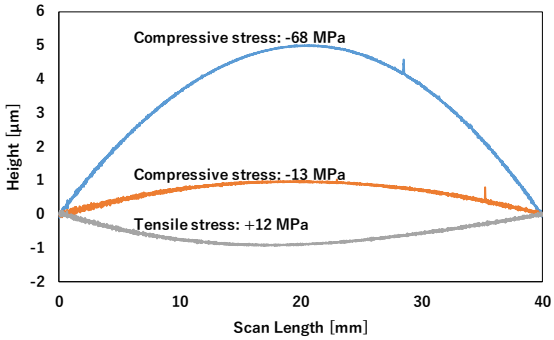

Fig. 2 Result of change in the radius of wafer curvature after the deposition of InP-based layers.

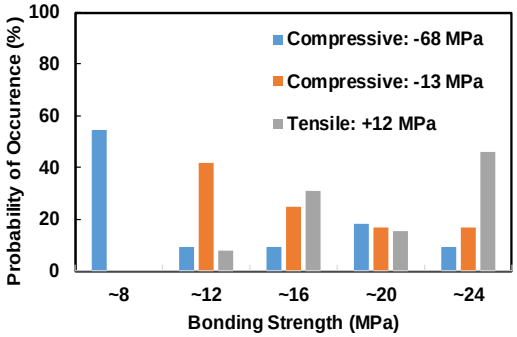

Fig. 3. Results of die shear examination for substrates as a function of different stress values.

Acknowledgment

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