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# Bonding and Debonding of Si/Glass based on SAB Method Combined with Hydrophilic Treatment

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**Abstract**

**In the fabrication process of electronics such as thin film transistor (TFT), the temporary bonding technique is an important issue for handling thin and fragile substrates. In the previews study, a new room temperature temporary bonding technology for glass to glass bonding was proposed based on the surface activated bonding (SAB) using the Si intermediate layer combined with hydrophilic treatment. However, the interaction between Si and glass surfaces was not clear. In this work, we investigated the effect of the Si intermediate layer and the hydrophilicity on the bond strength by Si/glass bonding. The bond strength of Si/Glass decreases after heating using the proposed process, while the bond strength generally increases when glass and Si substrates are bonded by the conventional thermal compression bonding.**

## 1. Introduction

Temporary wafer bonding is a key technology for fabrication of thin electronic devices because thin substrates are easily damaged in high temperature transistor process. Especially thin glass substrates need to be bonded on carrier glass substrates and debonded after high temperature process of TFT at 450 °C, which means that decrease of the bond strength after heating is necessary. However, the conventional bonding method such as thermal compression bonding is not suitable for the temporary bonding because the bond strength increases by heat treatment. To address this issue, we proposed the bonding and debonding of glass/glass for handling of thin glass substrates in the previews studies [1–3]. The thin glass substrate is bonded onto the career glass by the Si intermediate layer with less 10 nm thickness that is deposited on the only one side of a pair of the glass substrates. It has been also reported that the bond strength decreases after heating at 450 °C because the deposited Si layer reacts with the absorbed water on the glass surface, resulting in appearance of the interfacial voids induced by $H_2$.

However the bonding of Si and glass substrates, which is comparable to the bonding between the deposited Si layer and the glass surface by the proposed process, generally gets strong by heating because the $H_2$-induced voids diffuse into $SiO_2$ [4].

Therefore, in this study, we investigated the effect of the Si intermediate layer and the hydrophilicity on the bond strength to clarify the comparison between the boning of bulk Si/glass and the deposited Si/glass.

## 2. Method

Non-alkali glass 4 inch wafers and Si 4 inch wafers were bonded at room temperature. We conducted the bonding under three conditions based on the proposed method [2]; process 1: The Si layers are deposited by Ar ion beam sputtering on the both side of Si and glass substrates in vacuum chamber. After that, the bonding surfaces were brought into contact and bonded. process 2: The Si layer was deposited on the only Si surface, and then bonded in vacuum chamber. process 3: First, the Si layer was formed by sputtering on the only Si surface. After that, both Si and glass substrates were exposed to $N_2$ gas to form OH groups on the surfaces. After the exposure, the both substrates were introduces into the vacuum chamber again, and bonded. The thickness of the Si layer is under 10 nm and the bonding load is 5kN.

The bond strength before and after heating at 450 °C is evaluated as an energy release rate by the blade insertion test. The interfacial voids are observed by scanning acoustic tomography (SAT).

## 3. Results

Here we show the bond strength of Si/glass under each condition in Fig.1. The bonded Si and glass by the process 1 shows the high energy release rate of 2.8 J/m$^2$ before heating and the bulk strength after heating resulting in the breakage of the wafer.

The process 2 achieves also shows increase of the bond strength that is 0.6 J/m$^2$ before heating and 1.3 J/m$^2$ after heating. These bond strengths that increases by heat treatment can be considered that the OH groups in the bonding interface decompose and form covalent bonds of Si−O−Si at high temperature.

On the other hand, the bonded Si and glass by the process 3 shows decrease of the bond strength. The energy release rate is 2.5 J/m$^2$ before heating and 0.5 J/m$^2$ after heat-

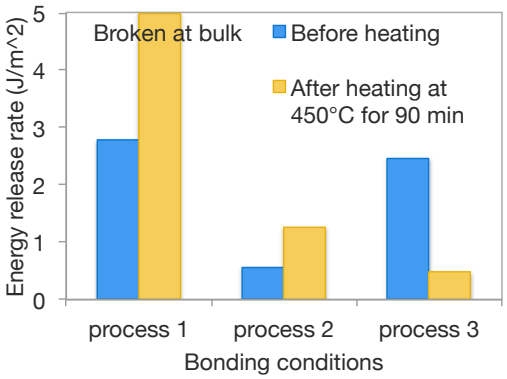


Figure 1: The energy release rate of the bonded interface between the glass and Si substrates by each process. The strength was evaluated by the blade insert test before and after heating at 450 °C for 90 min.

ing, which means that bonding and debonding after heating are achieved in the case of SI/glass. Because the process 3 is same as the proposed bonding process for bonding and debonding of glass/glass, it can be said that the bond strength decreases in the similar reaction to the glass/glass bonding.

We also show the interfacial voids in the bonding interface by the process 3 in Fig.2. The $H_2$-induced voids appear as the interface is heated. This phenomenon is also observed in the case of glass/glass bonding [2]. The SAT observation also indicates the similar interaction in the bonding interface to the glass/glass bonding and debonding.

### 4. Conclusion

In this study, we bonded Si and glass substrates at room temperature using the SAB method combined with hydrophilic treatment. The bond strength of 2.5 J/m$^2$ decreases to 0.5 J/m$^2$ after heat treatment, which indicates that debonding after high temperature process is possible. The effect of the Si intermediate layer and the hydrophilicity on the bond strength is comparable to the bonding of glass/glass.

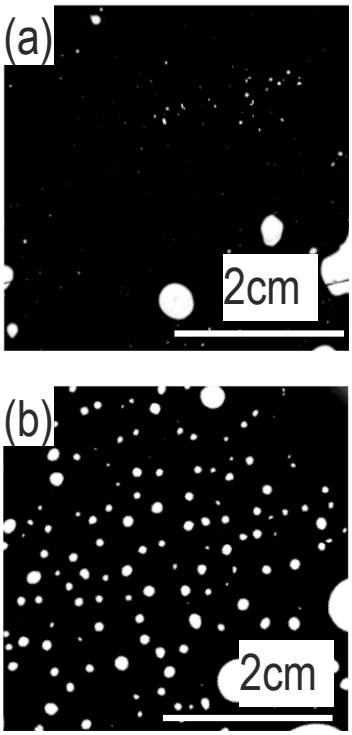


Figure 2: The SAT images of the interfacial voids in the bonding interface by the process 3. The black area is bonded interface and the white spots are the interfacial voids.

## References

[1] K. Takeuchi, M. Fujino, and T. Suga. In *2016 International Conference on Electronics Packaging (ICEP)*, pages 298–301, April 2016.

[2] K. Takeuchi, M. Fujino, and T. Suga. In *2016 IEEE 66th Electronic Components and Technology Conference (ECTC)*, pages 1284–1289, May 2016.

[3] Kai Takeuchi, Masahisa Fujino, and Tadatomo Suga. *ECS Transactions*, 75(9):185–189, 2016.

[4] C. Ventosa, F. Rieutord, L. Libralesso, C. Morales, F. Fournel, and H. Moriceau. *Journal of Applied Physics*, 104(12):123524, 2008.