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Wafer bonding of SiC-SiC and SiC-Si by modified suface activated bonding method

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Abstract

SiC-SiC has been successfully accomplished by modified surface activated bonding with Fe and Si layer. The wafers were almost completely bonded except a few voids. Bonding strength of SiC-SiC is higher than 32MPa. However, the diffusion of Fe at the interface seems occurred during some thermal process. Therefore, modified surface activated bonding with only Si layer was proposed to attempt SiC-Si wafer bonding. The bonded wafer has a few big voids and some small voids, which may be caused by particles in unclean environment. Bonding strength of SiC-Si bonded pair is higher than 14.3 MPa. Many fractures happened in bulk Si. The interfaces of bonded SiC-SiC and SiC-Si have been analyzed by high-resolution transmission electron microscopy.

1. Introduction

SiC has been attracting much attention in power devices field owing to its superior properties like wider band-gap energy, higher electric breakdown field, higher carrier saturation velocity and higher thermal conductivity compared with silicon. These properties can accomplish the devices with smaller size, lower losses, higher operation temperature and frequency, and simpler heat sink. Now many kinds of SiC devices like schottky diodes, bipolar junction transistors, MOSFETs and JFETs have been commercially available [1, 2]. With the further commercial development of SiC devices, SiC-SiC wafer bonding will be indispensable in SiC devices fabrication and integration.

Surface activated bonding (SAB) is a promising method to achieve bonding at room temperature, which has apparent advantages compared with conventional high temperature bonding method [3]. In this paper, we attempt SiC-SiC and SiC-Si wafer bonding by different modified SAB methods.

2. Experiments and results

Materials and bonding process

The SiC wafer we used is 3inch 4H-SiC. Bonding face is Si-face or C-face, which was polished by chemical mechanical method. Si wafer we used is 6inch mirror polished (100) Si. Fig. 1 shows the detailed process of SiC-SiC bonding by modified SAB with Fe and Si layer. Fig. 2 shows the SiC-Si modified SAB with only Si layer.

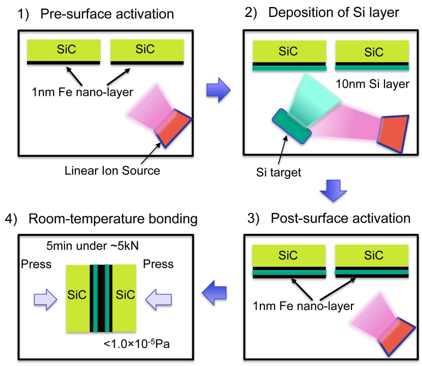


Fig. 1 SiC-SiC bonding by modified SAB with Fe and Si layer.

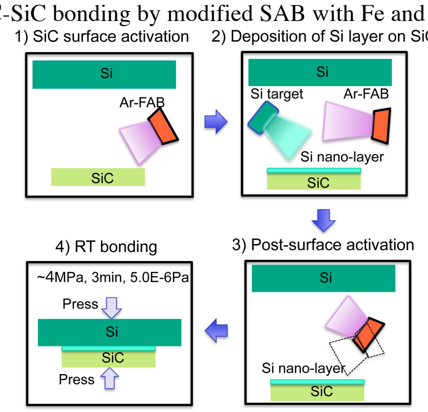


Fig. 2 SiC-Si bonding by modified SAB with Si layer.

Results and discussion

Fig.3 shows the SAM image of bonded SiC-SiC wafer. It was found the wafers were almost completely bonded except a few voids. Bonding strength is higher than 32MPa.

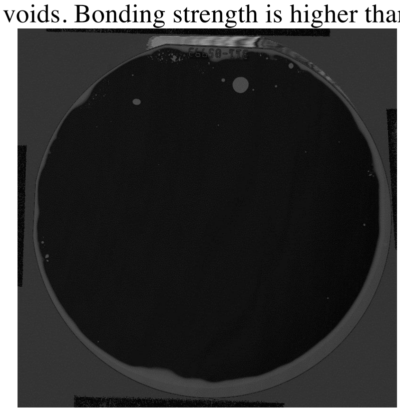


Fig. 3 SAM image of bonded SiC-SiC wafer.

Fig. 4 and 5 show the bonded SiC-SiC interface before and after annealing. A uniform amorphous layer, ~16nm, was found at the interface. After annealing, the interface layer was reduced by half.

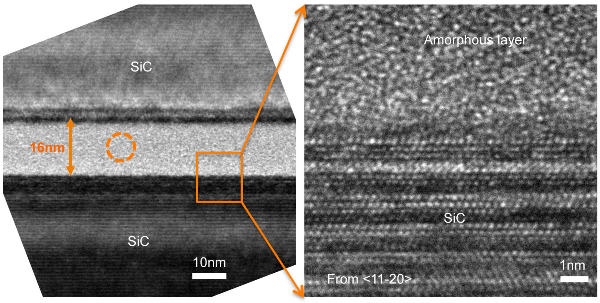


Fig. 4 TEM image of SiC/SiC bonded interface.

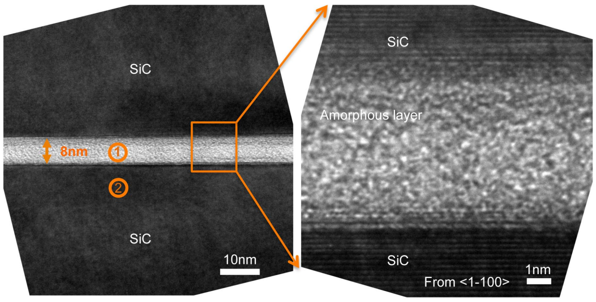
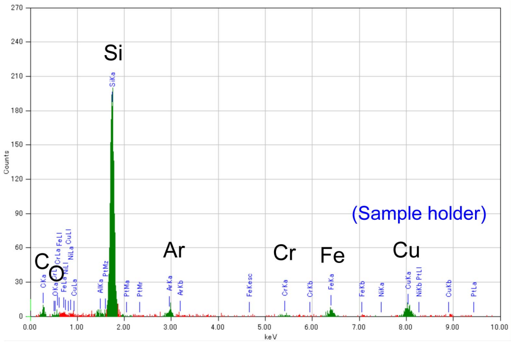
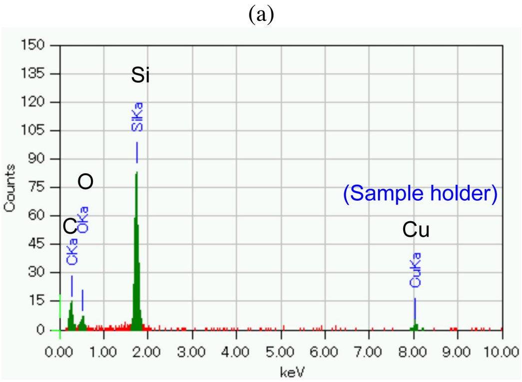


Fig. 5 TEM image of SiC/SiC interface after annealing.

In addition, Fe diffusion happened during annealing from the EDX result, which is shown in Fig. 6. Since Fe diffusion is not desired in some application, we also attempt SiC-Si bonding with only Si layer.



(a)



(b)

Fig. 6 Composition of SiC-SiC interface before (a) and after (b) annealing.

Since Fe diffusion is not desired in some application, we also attempt SiC-Si bonding with only Si layer. Fig. 7 shows the SAM image of bonded SiC-Si wafer. SiC-Si was also almost completely bonded except a few big voids and some small voids, which may be caused by particles in unclean environment. Bonding tensile strength is higher than 14.3MPa and many fractures happened in bulk Si side.

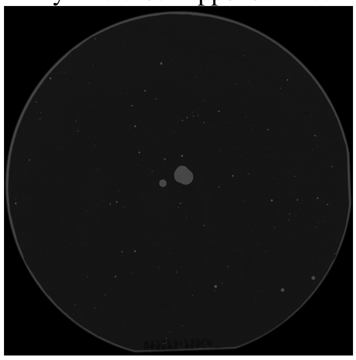


Fig. 7. SAM image of the bonded SiC-Si wafers

The SiC-Si bonded interface was also analyzed by high-resolution transmission electron microscopy, as shown in Fig. 8. An amorphous layer, ~20nm in thick, can be seen at the interface of SiC-Si. This layer should contain the deposited Si layer and FAB caused damage layer.

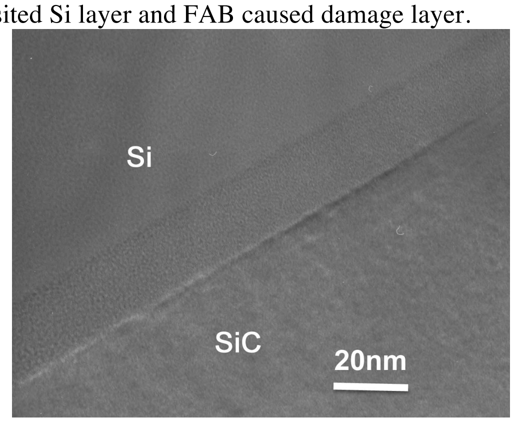


Fig. 8. TEM image of SiC-Si bonded interface.

3. Conclusions

SiC-SiC and SiC-Si wafer bonding has been successfully accomplished by different modified surface activated bonding. Almost the entire wafer can be bonded except some few voids. Bonding strength is close to or higher than bulk Si strength.

Acknowledgements

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References

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Appendix

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