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Characterization of Void in Bonded SOI Wafers by Controlling Coherence Length of Near-Infrared Microscope

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1. Introduction

Silicon on Insulator (SOI) technology has been rapidly developed for high-performance and low-power LSI applications. Silicon direct bonding (SDB) has been mainly used to fabricate SOI wafers. Scanning Acoustic Microscope (SAM) has been employed for the observation of a void in bonded SOI wafers. However, the resolution is not enough to characterize bonded wafers before thinning silicon layer, because the penetration depth for silicon is shorter, as the frequency of the supersonic wave is higher.

In this paper, we report the observation of a void in a SOI wafer before thinning by the microscope using near-infrared light, to which Si is transparent. We also discuss the void shape obtained from the observation image and the cause of the void formation.

2. Experimental

Si(100) wafers were rinsed with O_3 ultrapure water, cleaned with $HF/H_2O_2/H_2O$/surfactant solution under megasonic irradiation, rinsed with O_3 ultrapure water, etched with dilute HF solution, and rinsed with ultrapure water. A thermal oxide layer with a thickness of 200nm was grown on the Si wafer at 1000℃ in wet oxygen gas at an atmospheric pressure. The wafer with the thermal oxide layer and the cleaned wafer were stacked. The stacked wafer was heated for 5min at 1000℃ in nitrogen gas to achieve the wafer bonding. The voids in the bonded wafers were observed by using the near-infrared microscope shown in Fig. 1.

3. Results and Discussion

Figure 2 shows the observation image of a bonded wafer with a patterned oxide film. The circle hole in the oxide film is observed near the center of the image. The contrast of the hole is almost constant. It is considered that the hole is not a void.

The elliptical interference fringes are observed in the bonded wafer with the overall oxide film as shown in Fig. 3. The observed image of the heavy-lined part in Fig.3 (a) is shown in Fig. 3(b). The image observed by using interference filter is shown in Fig. 3(c). The center wavelength of the filter is 1200nm and the spectrum width is 10nm. In Fig. 3(b), the image near the center of the interference fringes is not clear because the contrast of the image is low. On the other hand, the contrast of the images near the center is high in Fig. 3(c), because the coherence length of the light is long compared with the gap of the void. The coherence length is increased by narrowing the spectrum width with the interference filter.

In order to discuss the cause of the void formation, the void shape obtained from the observation image is compared with the deflection curve models of disks under uniformly-distributed load by gas molecules or under concentrated load by a particle as shown in Fig. 4. Figure 5 shows the void shape obtained from observed interference fringes. The void shape is calculated from intervals of brightness and darkness of the interference fringes in Fig.3 (c). The measured void shape is fitted to the deflection curve calculated from the disc under the uniformly-distributed load. Therefore, it can be concluded that the void formation is caused by gas molecules trapped in the bonded interface.

4. Conclusion

The void in bonded wafers before thinning has been observed by the near-infrared microscope. The contrast of interference fringes is improved by controlling the coherence length of the light. This characterization method is useful to investigate the cause of the void formation.

References

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[1] I. Cayrefourcq et al, Ext. Abst. of 2004 Int. Conf. on SSDM, p.774

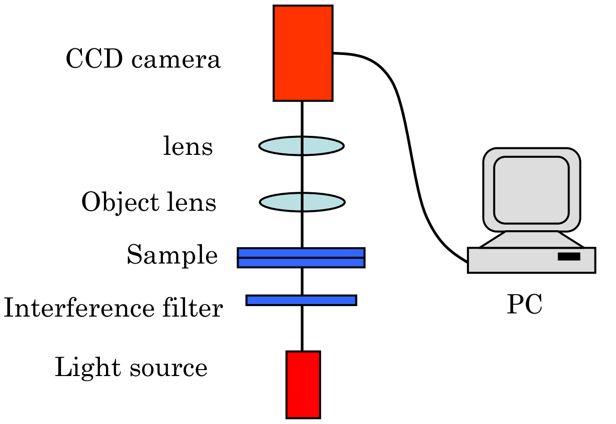


Fig. 1 Schematic view of near-infrared microscope.

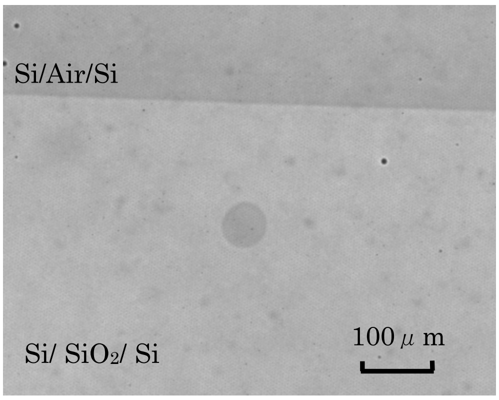


Fig. 2 Near-infrared microscope image of bonded wafers with patterned oxide film.

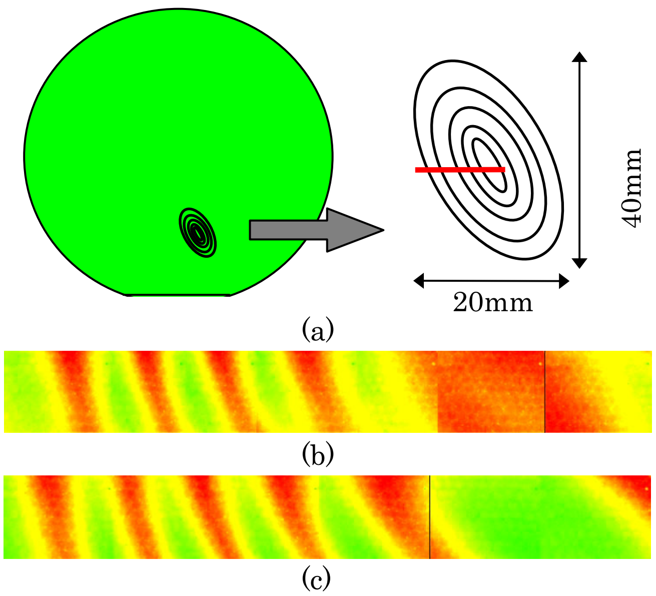
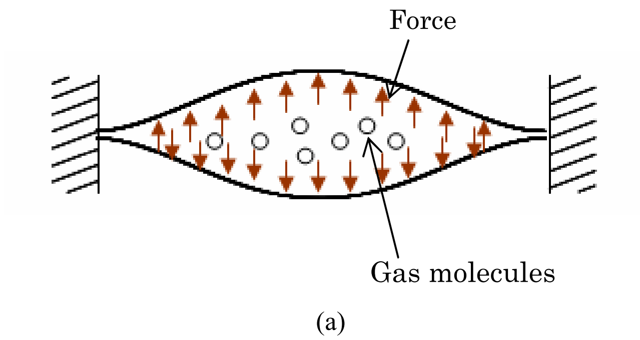


Fig. 3 (a) Illustration and (b) image of observed interference fringes of bonded wafer with overall oxide film by near-infrared microscope, and (c) image of interference fringes observed under using interference filter.



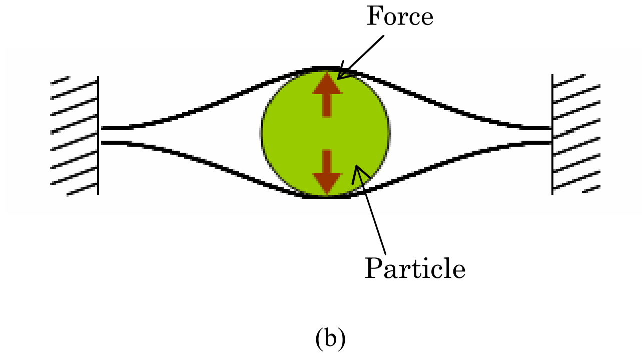


Fig. 4 Deflection curve models of discs clamped at edge (a) under uniformly-distributed load by gas molecules and (b) under concentrated load by particle.

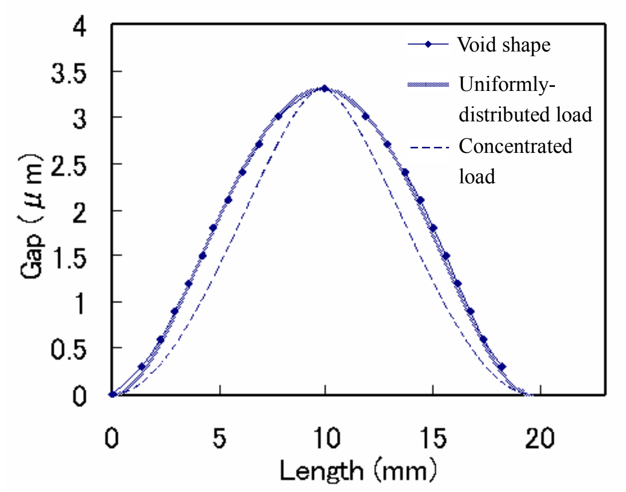


Fig. 5 Void shapes obtained from observed interference fringes and deflection curve of disc clamped at edge under uniformly-distributed load or under concentrated load.