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Detection of Particles on Quarter um Thick or Thinner SOI Wafers

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1. Introduction

Particles of less than 0.2-0.3μm diameter on SOI(Silicon On Insulator) wafers can not be detected successfully in current available particle detection systems, based on the principle of light scattering of particles, using 488nm Ar laser as a probe[1]. This is because of light scattering on surface or haze caused by multi-layer interference effect. In addition, sensitivity of particles on SOI wafers is affected by thickness of SOI layers and BOX(buried oxide) layers because of the reflectivity difference between SOI structures. To overcome these problems, we try to employ shorter wavelength laser than 488nm Ar laser as a probe for detection of particles on SOI wafers. Short wavelength light is expected to reduce the interference effect of multi-layer structures due to the characteristics of smaller penetration depth into silicon[2]. In this study, we examined a 430nm SHG(second harmonic generation) laser as a currently available laser of the shortest wavelength for a particle detection system, compared with a 430nm laser system.

2. Experiments

430nm SHG laser and 488nm Ar laser were used in the same optical configuration of the particle detection system Hitachi Deco LS6500. Measurements were carried out under 2 conditions, normal incidence and oblique incidence of laser light on sample surface. In the case of normal incidence, detection angle was 45° from normal to surface. In the case of oblique incidence, incident light was p-polarized to sample surface and s-polarized light was detected at scattering angle of 75°. Firstly, calibrations were performed by measuring latex spheres of diameters 0.100, 0.157, 0.208μm on FZ(float zone) silicon polished wafers for each laser and each incident condition. Secondly, measurements for SOI wafers of thicknesses of SOI/BOX=0.5μm/0.5μm, 0.2μm /0.5μm, 0.2μm /0.2μm were carried out. Lastly, latex spheres were put on the wafers and measurements were performed for the wafers. Measured samples were PACE'd (plasma assisted chemical etched)SOI wafers made from CZ (Czochralski) wafers.

3. Results and Discussion

Figure 1 shows detected LPD(light point defect) maps of greater than 0.1 μm measured by using 430nm and 488nm lasers. This is an oblique incident case on an SOI wafer of 0.5μm SOI /0.5μm BOX. LPD counts are reduced to a common CZ polished wafer level by using 430nm laser. This is due to reducing interference effect stemmed from reflection at the interface of SOI and BOX. In the case of normal incidence, 430nm gave better results than 488nm, but not enough results. Figure 2 shows the case of SOI/BOX=0.2μm /0.5μm, in which LPD density remained high level, even when using 430nm laser. It is because the penetration depth of 430nm light into silicon is 0.248μm[2] (reduced to 1/e) so that reflected light at the interface through 0.2μm SOI layer reduces to light intensity of 10 %. However, for SOI wafers of 0.2μm SOI and 0.2μm BOX, LPD density was as low as in the case of 0.5μm /0.5μm, as shown in Fig. 3. This case can be explained by the reflectivity of the p-polarized light on the SOI wafer. Figures 4-6 show the reflectivity of p-polarized light of 430nm and 488nm on SOI surfaces of SOI/BOX=0.5μm /0.5μm, 0.2μm /0.5μm, 0.2μm /0.2μm, respectively, calculated from optical constants of Table Ⅰ. As shown in Fig.6, the reflectivity of 430nm light at incident angle of 80° is small enough to reduce the haze level on the measurement. Haze reduction prevents the miscount of particles due to the noise or haze signal. Similarly, in terms of reflectivity of p-polarized 430nm light, it is predicted that suitable BOX thicknesses are 0.2μm, 0.4μm, 0.6μm for 0.1μm SOI. For example, Fig. 7 shows the reflectivity of p-polarized 430nm light dependence on Box thickness around 0.4μm. The reflectivity does not depend on SOI thickness at incident angle of 80°. So the BOX thickness dependence is the same for less than 0.1μm SOI. Furthermore, when using 430 nm laser the deference of particle sensitivity on SOI from that on polished wafers was smaller than using 488nm laser. The identification of the detected LPD's remains future work.

4. Conclusion

It is shown that 430nm laser as a probe for a particle detection system based on the principle of light scattering is effective for detection of particles on thin SOI wafers. Particularly, p-polarized oblique incident light is more effective than normal incidence. This laser was suitable down to SOI structure of 0.2μm SOI layer and 0.2μm BOX layer. In addition, it is predicted that the suitable BOX thicknesses for particle detection using 430nm laser are 0.2μm, 0.4μm, 0.6μm, and so on in SOI wafers of down to less than 0.1μm SOI thickness in terms of the reflectivity.

References

[1]K. Kajiyama et al., Jpn. J. Appl. Phys. 35 (1996) 5937.
[2] G.E.Jellison, Optical Materials, 1 (1991) 41.

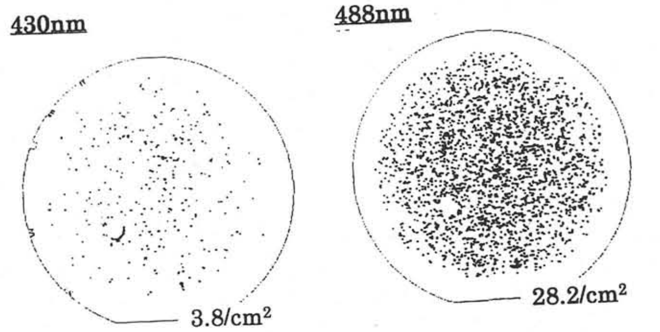

Fig. 1 LPD maps using 430nm and 488nm laser on SOI surface of SOI/BOX=0.5μm /0.5μm. LPD sizes are greater than 0.1μm.

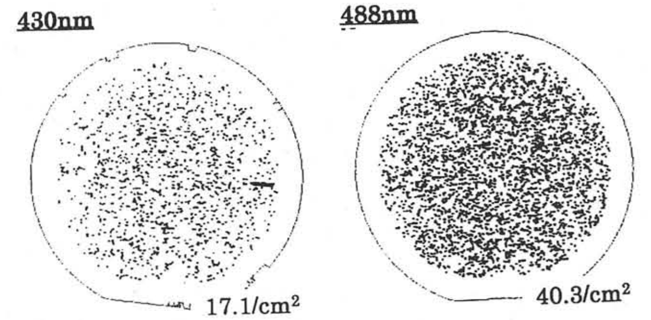

Fig. 2 LPD maps using 430nm and 488nm laser on SOI surface of SOI/BOX=0.2μm /0.5μm. LPD sizes are greater than 0.1μm.

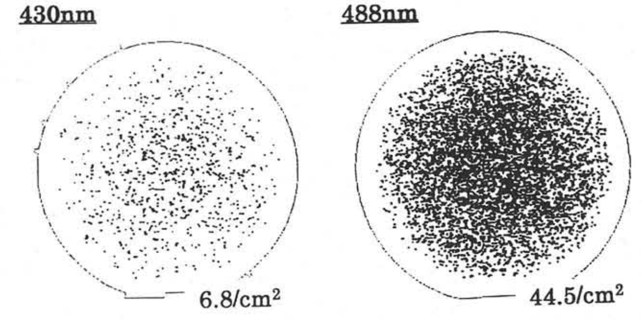

Fig. 3 LPD maps using 430nm and 488nm laser on SOI surface of SOI/BOX=0.2μm /0.2μm. LPD sizes are greater than 0.1μm.

Table I Optical constants of silicon at 430nm and 488nm from ref[2], used for the calculations of the reflectivity of SOI wafers.

Wavelength (nm)	Refractive index	Extinction coefficiency	Penetration depth (μm)
430	4.9218	0.13815	0.248
488	4.3596	0.056654	0.686

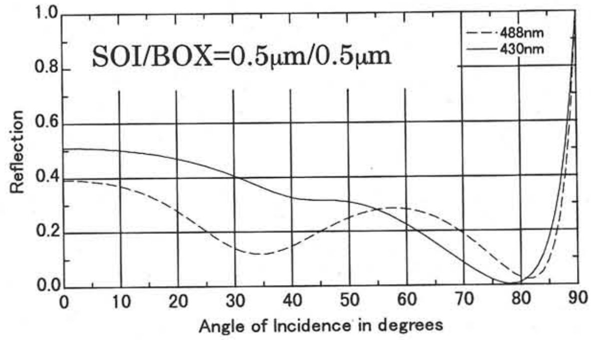

Fig. 4 Calculated reflectivity of p-polarized light of 430nm and 488nm on SOI wafer of 0.5μm SOI /0.5μm BOX.

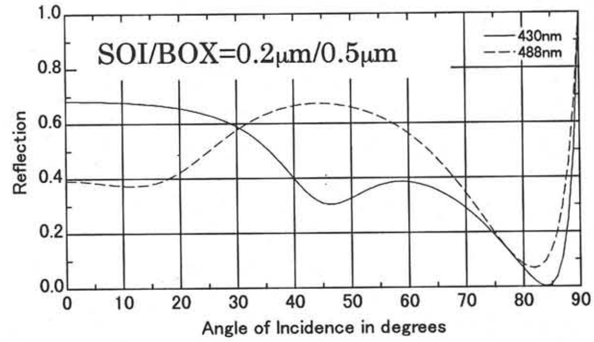

Fig. 5 Calculated reflectivity of p-polarized light of 430nm and 488nm on SOI wafer of 0.2μm SOI /0.5μm BOX.

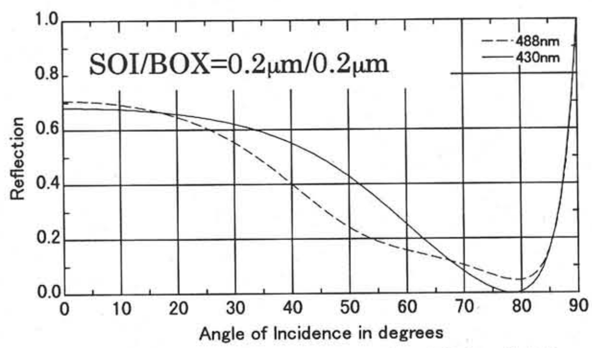

Fig. 6 Calculated reflectivity of p-polarized light of 430nm and 488nm on SOI wafer of 0.2μm SOI /0.2μm BOX.

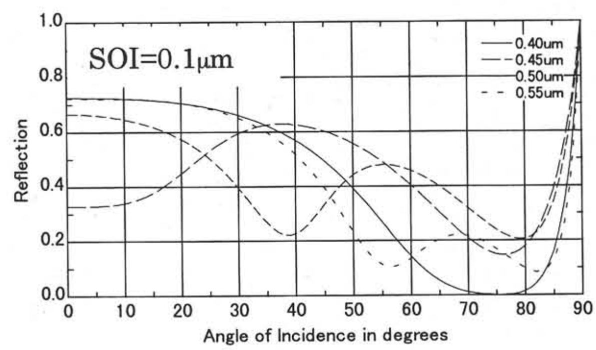

Fig. 7 Dependence of reflectivity of p-polarized 430nm light on thickness of BOX layer of 0.1μm SOI wafer.