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Comparison in Splitting Bonded SOI by Solid and Fluid Wedges (Water and Air Jets)

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1.Introduction

Recently the thinning methods of ***Bonded SOI*** have completely been shifted from grinding off the one of bonded wafers to splitting the pairs. The shift eradicates the material cost issue that two wafers are needed for fabricating one bonded SOI. ***Fluid wedge*** splitting and reusage of the split seed wafers are originated and has been reported[1,2]. Custom-made water jet machine was installed in the production line since last year. ELTRAN® wafers[3] are fabricated as shown in Fig. 1. Double porous Si layers are formed in the seed wafers and epitaxial Si and surface oxide layers are grown on the porous seed wafers in this order. After that, the seed wafers are bonded with handle wafers and split around the interface between the double porous Si layers, resulting in SOI wafers from split handle-side after etching off the porous Si and hydrogen annealing to smooth out[4]. The split seed wafers are repeatedly reused for the next seed wafers. The splitting mechanism is responsible for the interfacial confinement of the lattice-strain within the porous Si layers, not for the applied force or energy possibly to induce the destruction. However the quality is affected by the way to split. In this paper, the comparison in wafer splitting by different methods is reported.

2.Comparison

Key processes in ELTRAN® wafer production are double porous Si layer formation and separation of the bonded pairs within the porous Si layers. The 1st porous layers with low porosity are electrochemically formed in the seed wafer surface followed by the 2nd porous Si with high porosity by increasing the anodic current[2]. The bonded pairs containing the double porous Si layers are split by ***Solid Wedge*** and two kinds of fluid wedges; ***Water-Jet*** and ***Air-Jet***. Each porous Si layer leaving behind on the split wafers serves as protective capsulations. The split surface roughness (TIR:Total Indicator Reading) was measured to be around 163nm(***Solid Wedge***) 116nm(***Water Jet***) and 172nm(***Air Jet***) at the scanning length of 500 μm. The substantial difference can not be observed. As-split surface roughness (over 100 nm TIR) does not degrade the final SOI surface roughness because of extremely high selective etching and hydrogen annealing[4].

Figure 2 shows the side views during splitting the bonded pairs by (a)***Solid Wedge***, (b)***Water-Jet*** and (c)***Air-Jet***. The maximum gap at the bonded wafer edge during splitting by these methods are shown in Fig. 3. Bonded pairs are not deformed in only case of ***Water Jet*** due to both high directivity of the jet stream and the flexibility of the shape. The area applying the external force is as quite small as cross-sectional area of ***Water Jet*** (ϕ~0.1mm). Moreover the flexibility of the shape causes the dispersion of the applied stress and the penetration of the water pressure into split narrow gap. Therefore the opened gap at the bonded edge is measured to be as narrow as ~0.1mm, resulting splitting without warping and damaging the wafers. On the other hand, the gaps by ***Solid Wedge*** and ***Air-Jet*** are evaluated 20 and 5mm, respectively, which are much larger than ***Water Jet*** by two and one orders of magnitude. The causes are as follows. ***Solid Wedge*** has non-flexibility of the shape and applies the concentrated stress at the edge so as to widen the gap. ***Air-Jet*** has less directivity of the jet stream and needs large flow rates. The large distortion of the wafers degrades the controllability of the splitting. As a result, the splitting technique affects the yield as shown in Fig. 2. Actually, the splitting yield in the exclusive case of ***Water Jet*** is evaluated to be continuously **100%** over several hundreds wafers. Such perfect yield has been realized by no-warped splitting in conjunction with the stress control within the double porous Si layers. In contrast, the other methods; ***Solid Wedge*** and ***Air-Jet***, can not provide the high yield even if the porous Si is optimized in the stress. Particularly in case of ***Air-Jet***, the other problem is such that the splitting area and its propagation velocity are out of control, resulting in the lowest yields of 10%

3.Conclusion

The controllability of splitting depends on the methods. Exclusively ***Water-Jet*** can split the bonded pairs with perfect yield because it applies force at confined area without wafer warpage due to both flexibly shaped and collimated jet. Such high controllability is suitable for scaling up of wafer diameter and really contributes to successful fabrication of 300-mm-diametered ELTRAN® wafers by splitting until 2nd generation[1].

References

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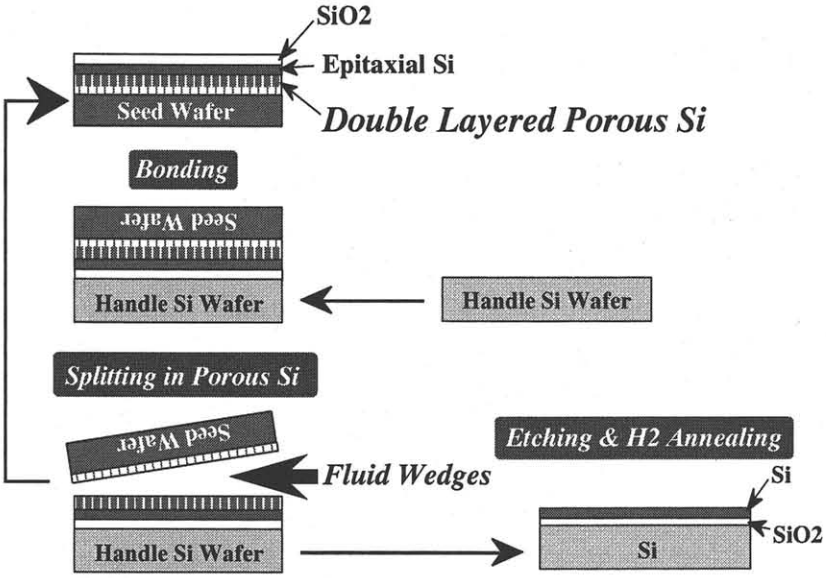
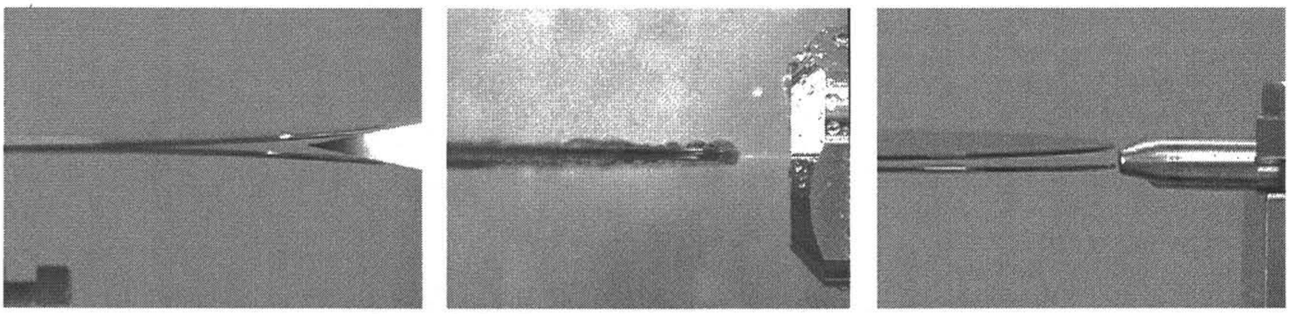


Figure 1. ELTRAN process flow. The Bonded pairs are split by ***Solid Wedge*** and ***Fluid Wedges***.



(a) Solid Wedge (b) Water Jet (c) Air Jet

Figure 2. Side view photographs during splitting of the bonded pairs by a)***Solid Wedge***, b)***Water Jet*** and c)***Air Jet***. Note that ***Water Jet*** can not exclusively warp the wafers.

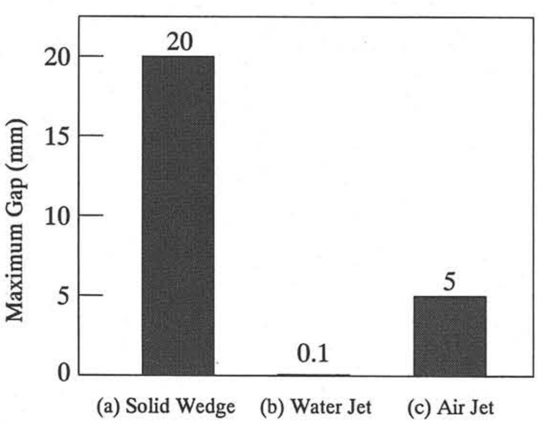


Figure 3. Maximum gaps at the edge during splitting of the bonded pairs by a)***Solid Wedge***, b)***Water Jet*** and c)***Air Jet***.

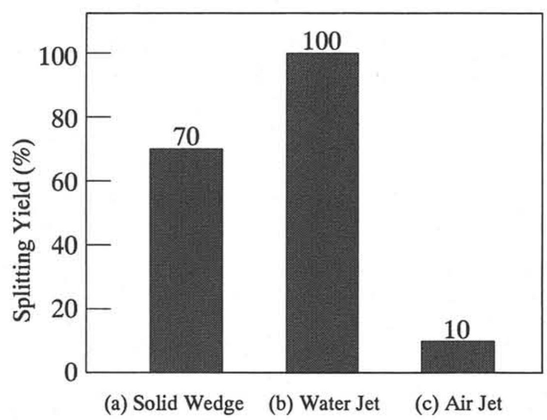


Figure 4. Splitting yields of the bonded pairs by a)***Solid Wedge***, b)***Water Jet*** and c)***Air Jet***. ***Water Jet*** exclusively realizes 100% yield.