Characterization of bonded interface by HF etching method

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SOI (silicon-on-insulator) wafers have replaced the conventional silicon wafers in many electrical and sensor applications. SOI wafers are available with different buried oxide (BOX) and SOI-layer thicknesses. The strength of the bonded interface is usually measured with the crack opening method [1]. However, the use of the crack opening method is rather difficult in cases when one or both of the bonded materials are fragile such as glass or thin wafers, since in these cases the blade insertion usually leads to breaking of one of the wafers instead of crack formation. Another limitation is that the blade needs to have a place for insertion, e.g. opening between two rounded wafers. Therefore, the surface energy is measurable only from the areas near the wafer edges. The crack opening method has also problems in measuring strong bonds [2]. In this work we will present HF-etching of the bond interface as an alternative method to evaluate the bond strength.

To assess this method, we created different bonded interfaces (Si / oxide, oxide / oxide, Si / glass, oxide / glass). The wafer pairs were annealed at 100°C-1100°C. To carry out the etching test we cut grooves on the surface of the bonded wafer using a dicing saw. Subsequently, the samples were etched in 50% HF solution for 10 min. In SOI-structures we measured the etched distance from the groove to the oxide wall (Fig. 1) by using scanning electron microscopy (SEM). In Si / glass structures we measured the width of the “shoulder” (Fig. 2).

For comparison, we measured the effective surface energy with the crack opening method from the SOI samples where the method could be used.
The relation between the surface energy and the etched distance is shown in Fig. 3. In all measured SOI structures the etching occurred faster at the bonded interface than in the other parts of oxide. However, in a case of strong bonding, the difference between etch rates is relatively small (Fig. 1). In Si / glass bonding we found the length of the “shoulder” to decrease with increasing annealing temperature.

In this paper, we demonstrate that the HF etching test can be used to evaluate bond strength in many practical cases where the crack opening method is not applicable.

[1] W. P. Maszara, G. Goetz, A Caviglia, and J. B. McKitterick, J. Appl. Phys., **64,** 4943 (1988).
[2] T. Martini, J. Steinkirchner, and U. Gösele, J. Electrochem. Soc. **144** (1), 354-357 (1997).

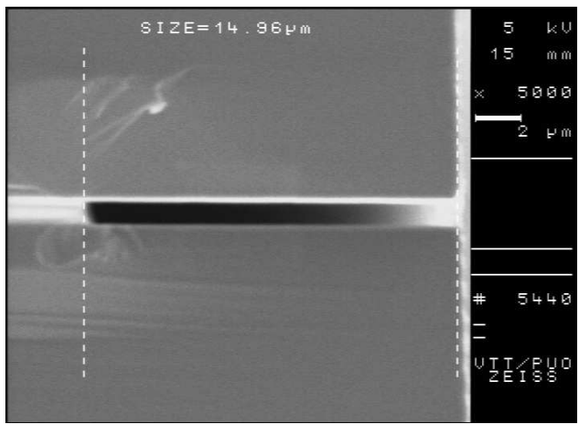

Figure 1. SEM image of the etched 1 µm thick buried oxide. The etched distance is ~15 µm.

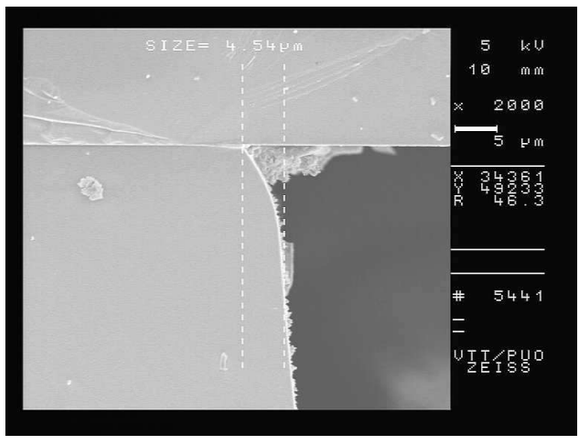

Figure 2. SEM image of the “shoulder” in the plasma activated Si / glass bond. The wafer pair was annealed at 500°C and etched for 10 min in HF. The width of the shoulder is around 4.5 µm.

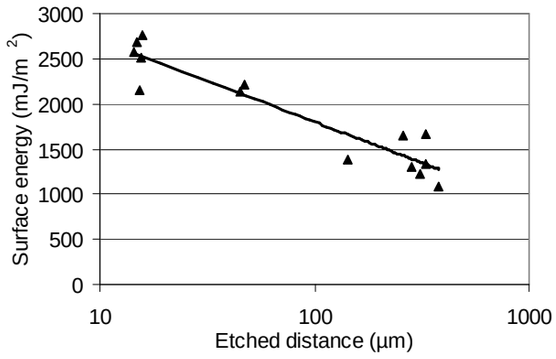

Figure 3. The measured surface energy as a function of the measured etched distance for bonded SOI structures. The etching was carried out for 10 min in 50% HF.