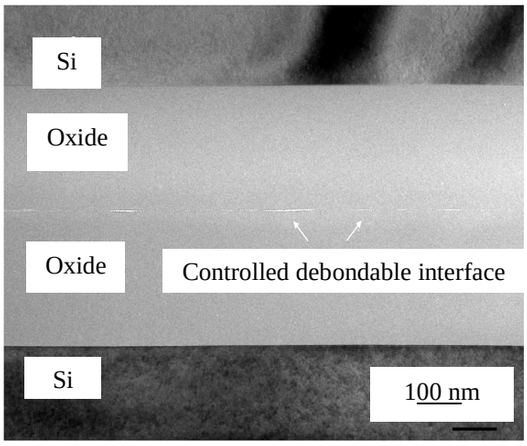
The Bonding Energy Control : An Original Way To Obtain “Debondable Substrates”.

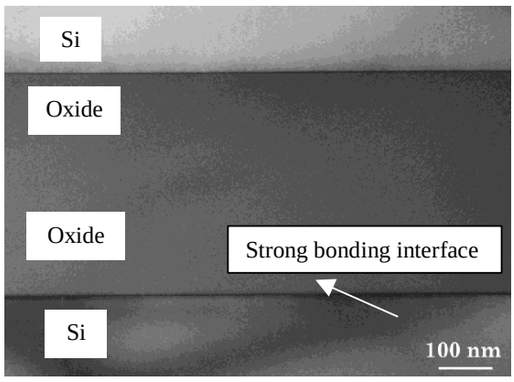
H. Moriceau [(1)], O. Rayssac [(2)], B. Aspar [(1,3)], B Ghyselen[(2)]

1- CEA-DRT - LETI/DTS - CEA/GRE - 17, rue des Martyrs 38 054 GRENOBLE cedex 9 - France
2- SOITEC - Parc technologique des Fontaines Bernin – 38926 CROLLES cedex- France
3- TRACIT - 15, rue des Martyrs - 38000 Grenoble cedex - France

Wafer-bonding is a mature technology used in different processes. For example, today, most of the SOI wafers are manufactured thanks to this technology. Depending on the application, thick or thin SOI layers are suitable and performed by different processes such as SmartCut®, bonding and grinding … The quality of the wafers is now well known. Up to now, high bonding energies have been targeted to obtain SOI structures with very strong and sharp interface even at the bonding interface. For that, the wafers are prepared before bonding in order to get strong hydrophilicity and low surface microroughness. On such wafers high quality devices are obtained.
We propose a new concept based on the control of wafer bonding energy. Such approach gives rise to “debondable substrates”.
In order to control the bonding energy, various parameters have been investigated. First, the modification of the cleaning before bonding has been realized. Cleaning with different hydrophilic levels have been compared. Secondly, surface microroughness has been modified in order to evaluate its impact on the bonding energy. The effect of the surface microroughness can be highlighted by comparing two bonded structures among which only one has its surfaces roughened before bonding. For instance oxidized silicon wafers had been bonded leading to (silicon-oxide-silicon) structures. After 1100°C annealing, controlled debondable interface in the structure where SiO_2 surfaces have been roughened before bonding was put in evidence by TEM observations (Fig.1). Using these two parameters (hydrophilicity, surface microroughness), it is possible to get bonding energy compatible both with the manufacturing process including some high temperature device processes and with further debonding.
We used this concept to perform both thin debondable SOI (using the SmartCut® process) and thick debondable SOI (using bonding and grinding process).
To demonstrate this concept, debondable SOI structures were directly bonded onto a silicon or an oxidized silicon final wafer. These stacked structures were submitted to thermal treatments at high temperature (1100°C) in order to get a strong difference of bonding energy between the first interface (the weak one of the debondable SOI) and the second interface (the strong one with the final wafer). If the bonding energy difference is high enough, the structure can be debonded at the weak interface level and the silicon layer of the debondable SOI structure can be transfered onto the final substrate. More over, after debonding, the silicon substrate of the initial structure can be reclaimed and reused.
It is worth noting that such process is compatible with most of the heterostructures obtained by wafer-bonding.



- a -



-b-

Figure 1 : After 1100°C annealing, TEM observations have put in evidence both a controlled debondable interface (a) in the structure where SiO_2 surfaces have been roughened before bonding and a strong bonding interface (b).

SmartCut® is a trademark of SOITEC