Triple-Stack Anodic Bonding for MEMS Applications

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The field of micro-electro-mechanical systems (MEMS) has been recognized internationally within the last years, although it is rooted in efforts on sensors and actuators fabrication that go back thirty years. Many of the emerging application areas for microelectronics, however, deal with non-electronic host systems, and thus require that parameters such as pressure or flow be measured and converted to electrical signals that can be processed by computers. After the necessary control decisions are made electronically, the resulting electronic signals can than be fed to actuators to control the parameters of the host system.

With automotive applications being the driving force in the last decade of commercial MEMS products, we are now entering a new MEMS manufacturing era with microfluidics, MOEMS (Micro-Opto-Electro-Mechanical-Systems), RF MEMS, non-automotive accelerometers and gyros. The field of applications gets expanded to consumer products and Information Technology (IT).

As MEMS devices are usually three dimensional architectures, the need for new processing techniques appeared.

Wafer bonding is one of the most powerful techniques used for MEMS devices fabrication and packaging. Different wafer bonding approaches are used in the MEMS industry: fusion, adhesive, eutectic, thermocompression bonding are normally used for device fabrication and generation of 3D structures, while anodic bonding is one of the most used wafer level packaging procedures.

Anodic bonding is a very mature technology which was first introduced at the end of 60`s [1] as a method to join metal and glass surfaces. Anodic bonding is used today mainly to bond a silicon wafer to a glass wafer with high content of alkali oxides. The bond occurs under heating conditions in an applied electric field due to the fact that at a certain temperature depending on the glass composition the oxides dissociate and the mobile alkali ions are driven by the electric field into the glass, creating an oxygen rich layer at the silicon-glass interface. The oxygen ions will be driven by the electric field to the silicon surface and will produce oxidation of Si. The resulting bond strength is very high and the process is irreversible.

Certain MEMS applications like accelerometers, gyros and microfluidic devices are using two anodic bonding processes in order to obtain a 3 wafers structure (“triple-stack”). The present paper describes a process developed for the fabrication of triple-stacks using a single anodic bonding step.

The process was performed in a proprietary universal bond chamber which allows controlled heating using two independently controlled heaters (top and bottom), controlled atmosphere (high vacuum or process gases), applied contact force up to 40 kN and voltage up to 2 kV.

The experiments were performed on 100 mm diameter Si and Pyrex wafers using a specially developed setup. Compared with the approach using two anodic bonding steps, the advantages offered by our process are the secure packaging of double side processed wafers with minimum risk by using only half of handling steps and increased throughput.

REFERENCES

[1] G. Wallis and D. Pommerantz, J. Appl. Phys. 40 (1969), 3946.