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Bonding at Micralyne

Wafer bonding is a very important baseline process for silicon-based microsystem or MEMS fabrication. It is a method for creating engineered substrates with single crystalline layers to form three-dimensional structures for capping, sealing and completing micromechanical or microfluidic devices.

Wafer-to-wafer bonding involves attaching multiple wafers or substrates together either permanently or temporarily using any number of adhesive technologies. Production capabilities at Micralyne include bonding silicon-to-silicon, silicon-to-glass, and glass-to-glass substrates.

The wafer bonding process must fulfill four points for it to be used in a complete process flow for a particular MEMS device.

1. The wafer bonding must satisfy device requirements such as bond strength, hermetic sealing of a specific pressure or gas, alignment accuracy, and electrical lead-through duct.

2. The bonding process must fit into the complete technology flow with regard to surface activation without damaging previously structured layers (metal), bond and annealing temperatures, and the bondability of the surfaces (low roughness)

3. The economic aspects of bonding, such as process costs, chip yield (local voids on bonded wafers) and wafer yield (misaligned or mainly non-bonded wafers) are very important in industrial production.

4. The bonding interface has to be reliable with regards to mechanical loads and hermeticity so that the device can withstand subsequent process steps, such as dicing and assembly, and is stable over the required lifetime.

In early July 2006, Micralyne purchased a high precision substrate bonder (SB6e), and a high precision bond aligner (BA6) from SUSS MicroTec.

The SB6e is a semi-automatic, computer-controlled system with both vacuum- and pressure-controlled atmosphere capability featuring an ergonomic load/unload station. The SB6e provides superior post bond alignment accuracy resulting from precision mechanics, uniform force capability and leading temperature control. When matched with the SUSS BA6 bond aligner, they offer enabling capabilities for MEMS, 3-D interconnect, and opto-electronic projects.

The SB6e and BA6 support all types of bond processes including anodic bonding, eutectic bonding, glass frit bonding, fusion bonding (post bond annealing required),

and thermo-compression.

Parameters of the SB6e bonder include:

- Chamber pressure 5.5e-05mbar in 5min
- Both chucks temperature uniformity +/-3%
- Both chucks temperature accuracy +/-5C
- For anodic bonding, post bond alignment +/-5um
- For fusion bonding, post bond alignment +/-2.5um

With any process in MEMS development, bonding has its own challenges. One such obstacle is the development of robust criteria for bondability. There is a certain amount of conflicting information in the literature today on how to achieve acceptable bonding. Some confusion exists due to different measurement standards for bonding and a lack of a standardized set of metrology methods needed for a rational comparison of processes for wafer-to-wafer bonding.

Other challenges include:

- The characterization of stresses in bonded structures
- Long-term reliability of wafer-to-wafer bonds
- The development of techniques for bonding of dissimilar materials

Based on our experience at Micralyne, we have developed many protocols that improve the effectiveness of bonding operations. These include cleaning the wafer surface to remove particles and contaminants from substrates prior to bonding - this is extremely critical to achieve good bond quality. The cleaning is not only required at pre-bond cleaning but also throughout the whole fabrication process before bonding occurs. As well, precise alignment is another key element to achieving high accuracy wafer bonding.

In summary, controlling thermal stresses and optimizing the bond strength are the greatest challenges in this field. If mastered, however, advanced bonding capabilities open up a wide range of new potential MEMS devices and structures.

Please contact us if you would like to learn more about **Micralyne's bonding capabilities.**

- Charlene Chen, Process Engineer -