MIXED-SIGNAL FOUNDRY EXPERTS

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SENSORSYSTEME 2010

Aspects of Bonding Processed CMOS Wafers

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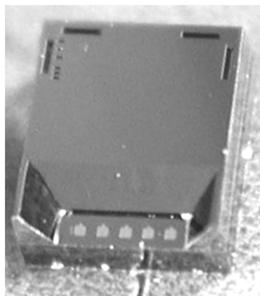
Outline

1. CMOS Wafer Bonding
2. General Aspects, Requirements and Limitations
3. Application Example
4. Conclusions

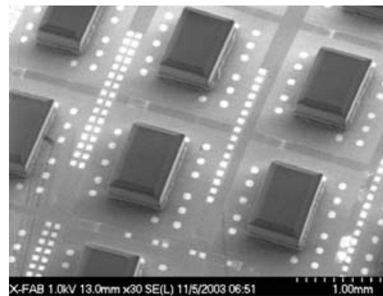
CMOS Wafer Bonding

CMOS Wafer bonding is…

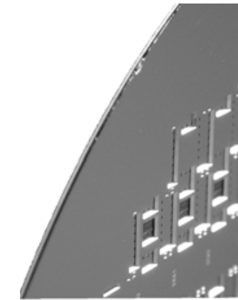
- required to realize Microsystems with advanced functionality of integrated circuits
- typically done as a post process when CMOS or CMOS-like MEMS wafers are finished
- a real challenge due to the limitation that the electrical parameters of the CMOS wafers must not be influenced by the bonding process



Capped acceleration sensor



Optical windows bonded on CMOS



Wafer level capped gyroscopes

General Aspects, Requirements and Limitations

The general requirements are...

- mechanical strength
- gas-hermeticity
- reliability

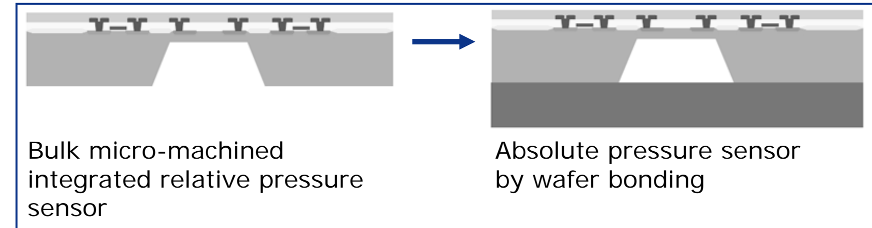
If CMOS processed wafers are bonded...

- any post-processing of CMOS wafers, micromachining or wafer bonding, must not change the characteristics of the CMOS elements.
  - Avoidance of...
    - temperatures >450°C
    - high thermal time budget
    - aggressive acid based wet chemical treatment
    - electrical discharges during bonding/plasma treatment
    - introduction of mobile ions into the CMOS structures
    - changing mechanical stress characteristics
    - parasitic effects, such as parasitic capacities, short ICs e.g.

Application Example: Realization of an integrated absolute pressure sensor

Application Example:

An available 1.0 µm CMOS process for lateral integration of bulk micromachined relative pressure sensor should be completed by wafer bonding to realise an integrated absolute pressure sensor.



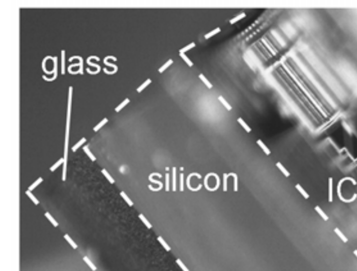
Bulk micro-machined integrated relative pressure sensor

Absolute pressure sensor by wafer bonding

A CMOS-compatible bonding process is required. Evaluation of different bonding processes:

Bond Process:	Low-Temperature Direct Bonding	Glass Frit Bonding	Anodic Bonding
Advantages:	+ no special bonding layer + no special wafer material (silicon) + direct bonding silicon to silicon + very cheap process (short time at bonder, batch anneal)	+ safe, universal bond process + less influence of the bond surface quality + active sealing and bonding due to glass frit	+ safe bond process + bonding process driven by strong electrical field, high bonding force + typical high process yield
Disadvantages:	- critical process due to surface quality and particles - infrared inspection for process monitoring required	- screen printing required - expensive process due to glass frit, screen printing, long bonding time	- high voltages for bonding required, - thermal mismatch of glass and silicon - long bonding time due to bonding temperature
Base Wafer:	blank silicon wafer	silicon with screen printed glass paste	blank glass wafer Borofloat®33

Anodic bonding is the most suitable bonding technique for this application because of the high process stability, excellent bonding results (yield, strength, reliability) and the absence of any influence on the CMOS parameters.



Anodic bonded integrated absolute pressure sensor chip.

Conclusions

It can be concluded that…

- bonding of CMOS processed wafers is possible, if the bonding process and resulting interaction with the CMOS parameters is well known

- comparative studies help to find the most suitable wafer bonding process for different applications

- CMOS wafer bonding is the key for increased system integration