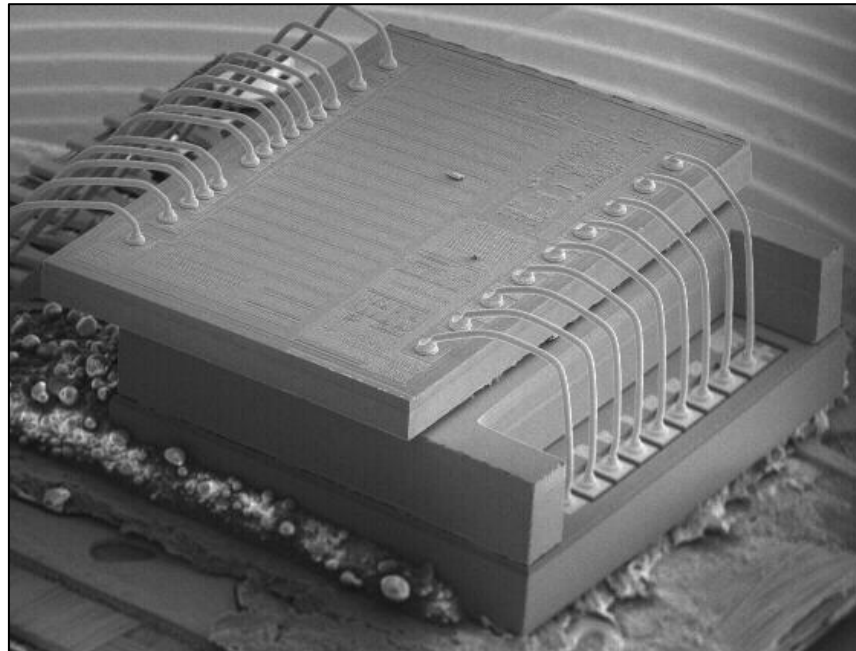


Reverse Costing analysis



STMicroelectronics LIS3DH / Apple A2L Triple-Axis MEMS Accelerometer

March 2011 - Version 1

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- LIS3DH Overview:

Cristallo:

Ultra-Low-Power and High Performance Accelerometer

Higher flexibility at lower current



100X Lower Power

Courtesy of STMicroelectronics



Advanced power management

- Wide supply voltage down to 1.8V
- Ultra low current

High versatility

- Extended FS range (2/4/8/16g)
- Multiple configurable interrupt sources

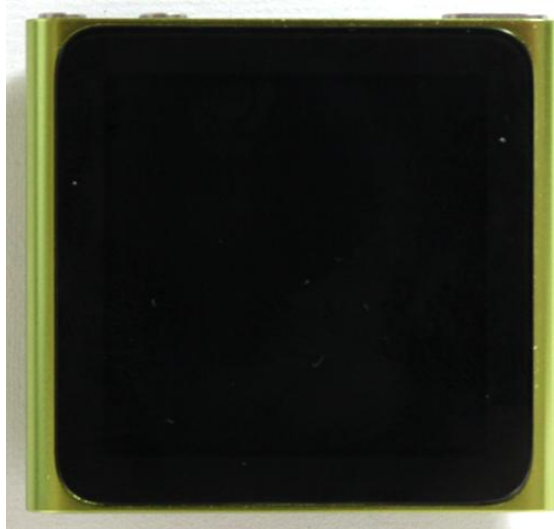
Embedded features

- Programmable FIFO (32 levels)
- 3 auxiliary ADC channels

- The LIS3DH is the official reference of the 3-Axis accelerometer integrated in the Apple iPod nano 6G, and labeled "A2L".



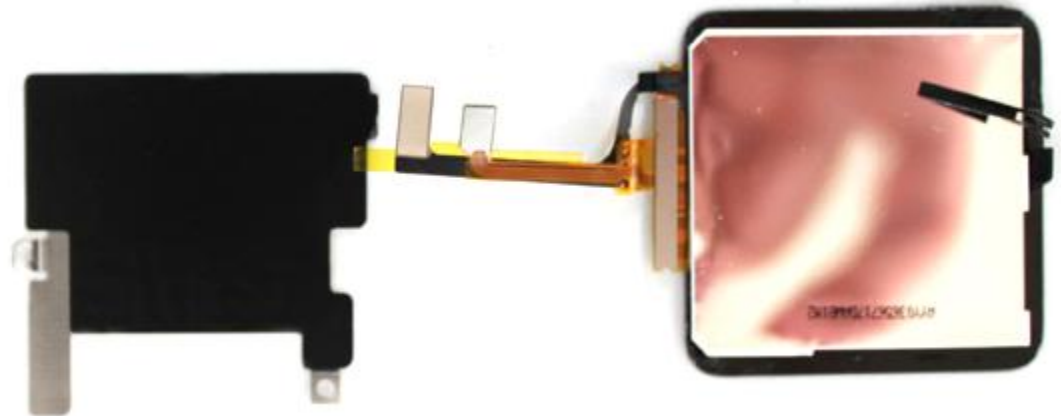
iPod nano 6G



Front view



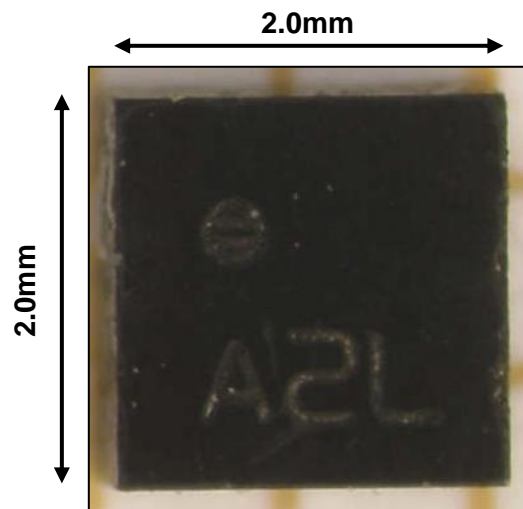
Back view



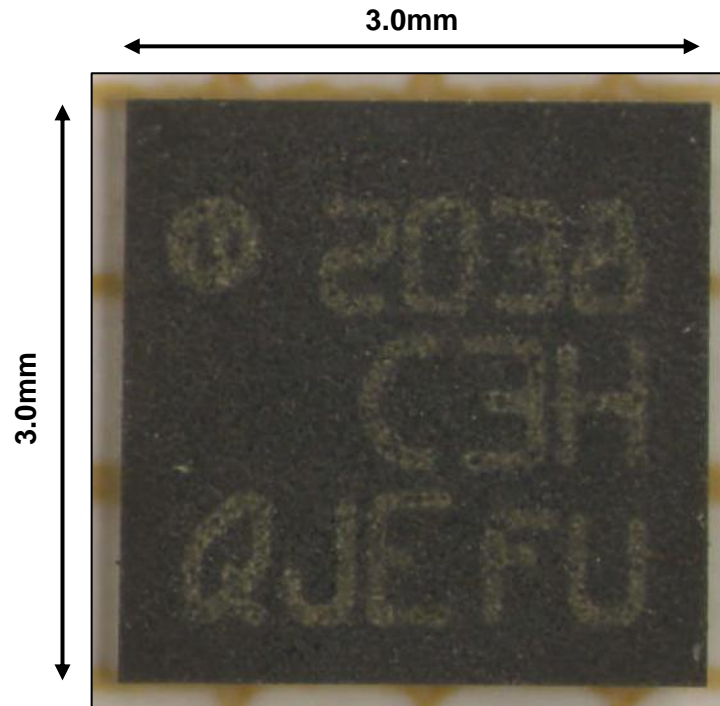
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Two references are analyzed:

- ✓ **STMicro LIS3DH: 3.0x3.0x1.0mm Package**
 - **STMicroelectronics standard component**
 - **Package Marking: C3H**
- ✓ **Apple A2L: 2.0x2.0x1.0mm Package**
 - **Apple iPod Nano 6G component**
 - **Package Marking: A2L**

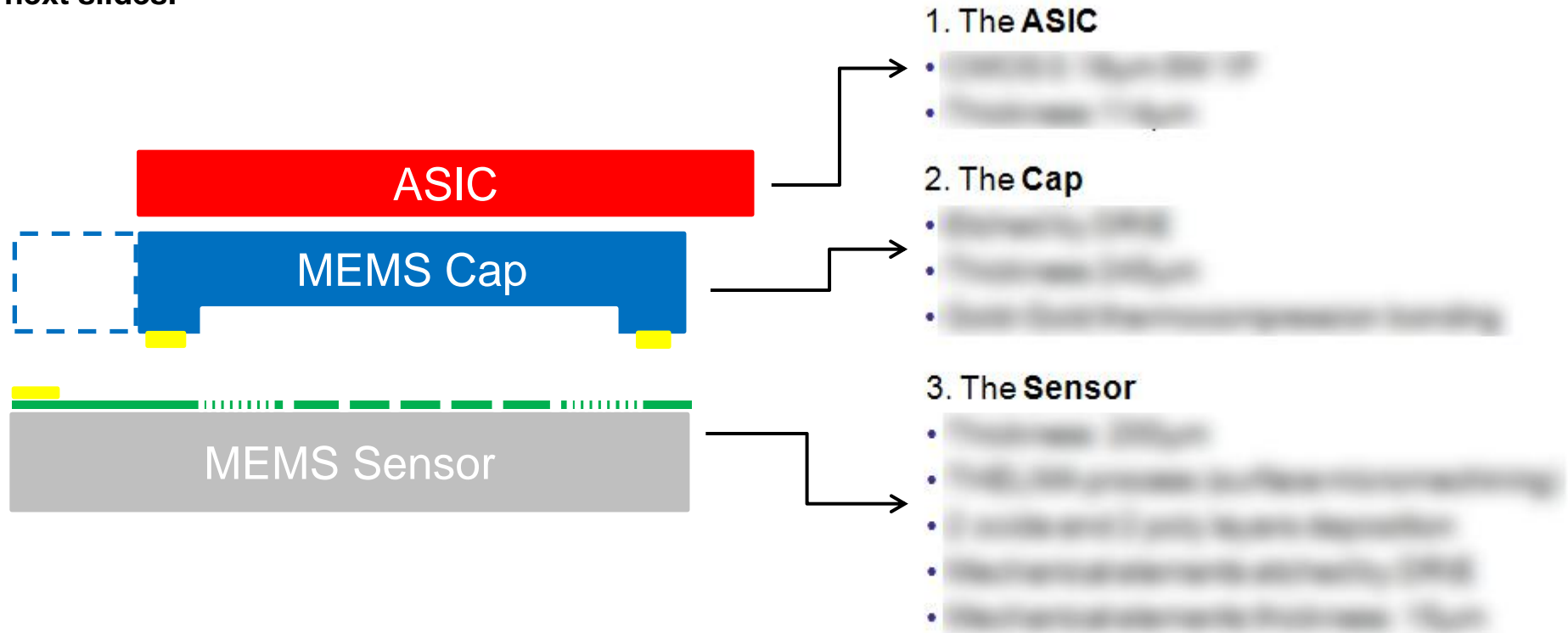


A2L

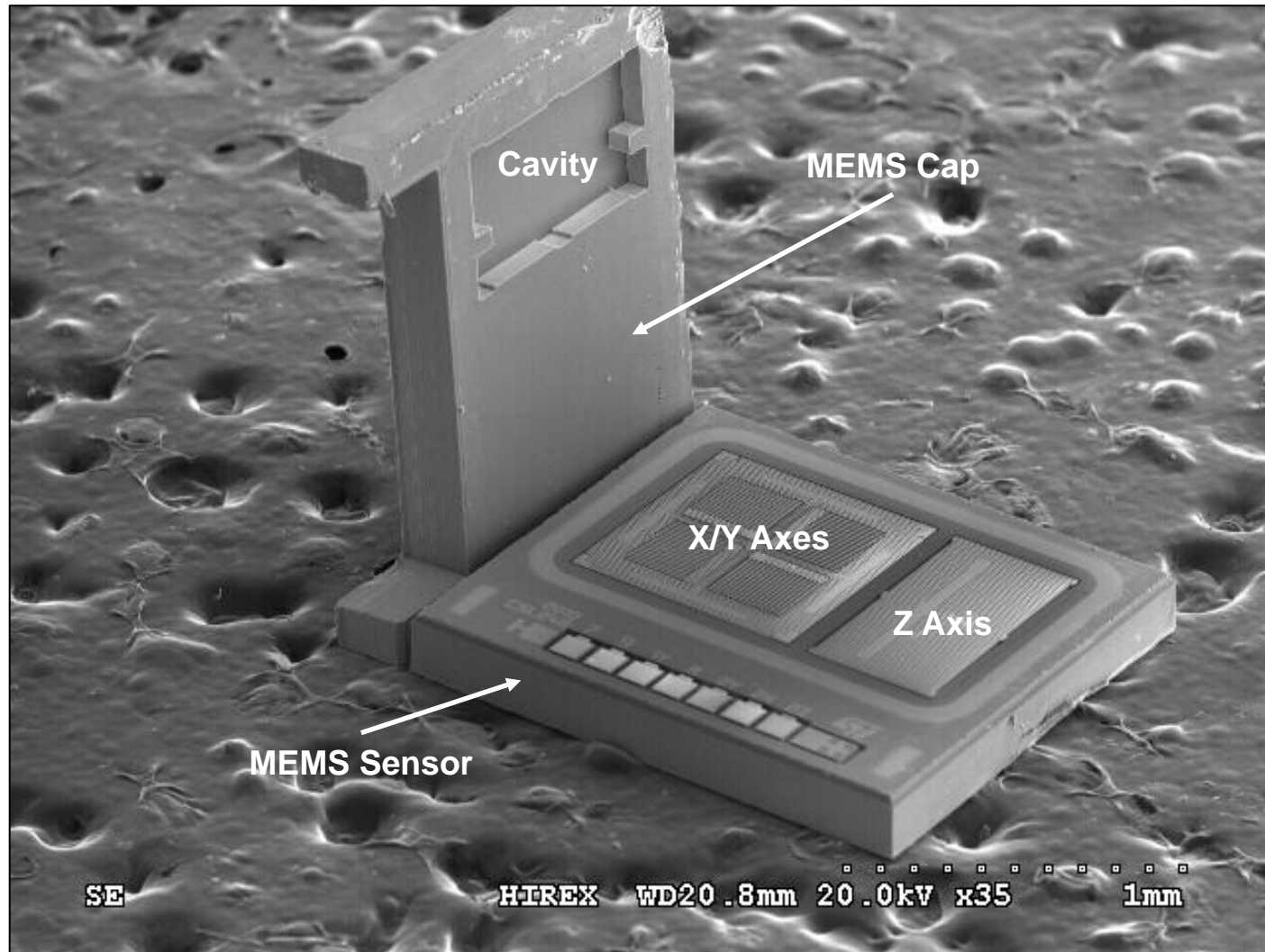


LIS3DH

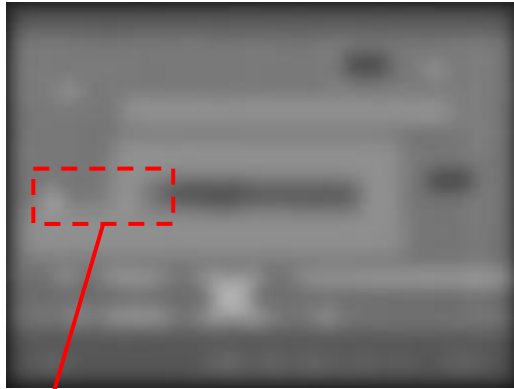
The schematic diagram below is based on the observations made during this study and detailed in the next slides.



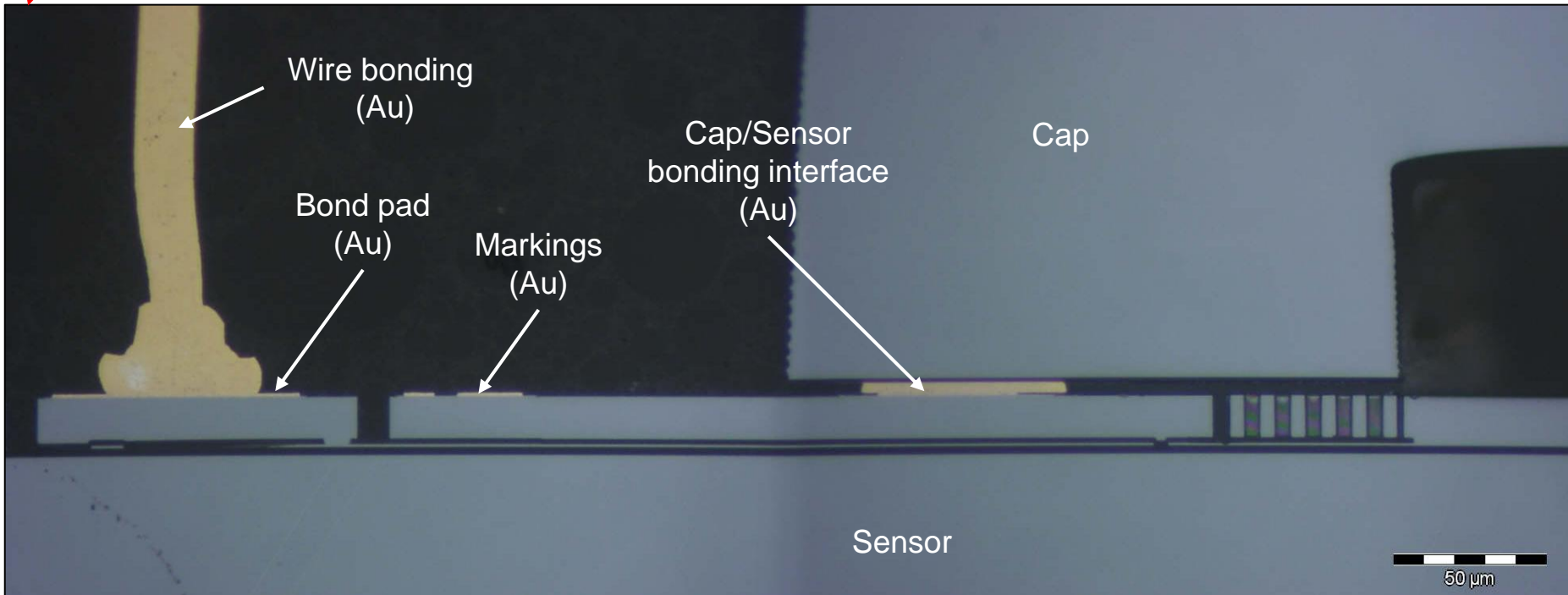
- The ASIC is implemented using a CMOS 1.8µm process with digital and analog functions.
- The sensing elements are made in the polysilicon and metal layers and are processed in a different step.
- The sensor is made in a separate step that can be packaged using standard assembly process.
- The ASIC and MEMS are connected in a 1.8µm package.



- A cavity in the Cap is etched only above the Z-axis of the sensor.



Cross-section Overview



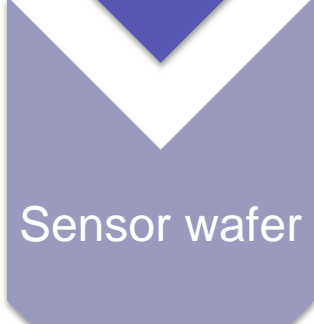
MEMS Cross-Section – Optical View



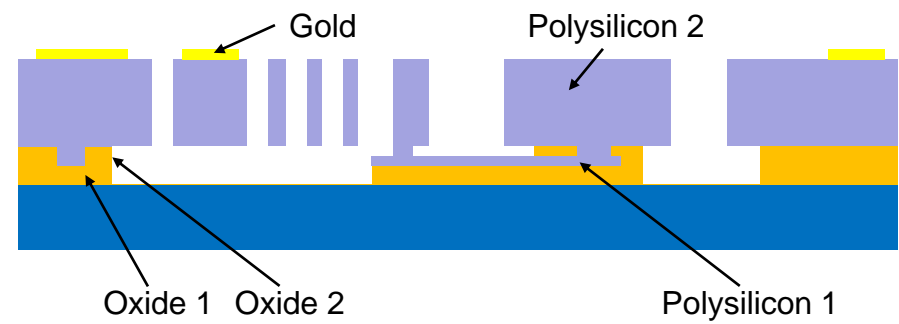
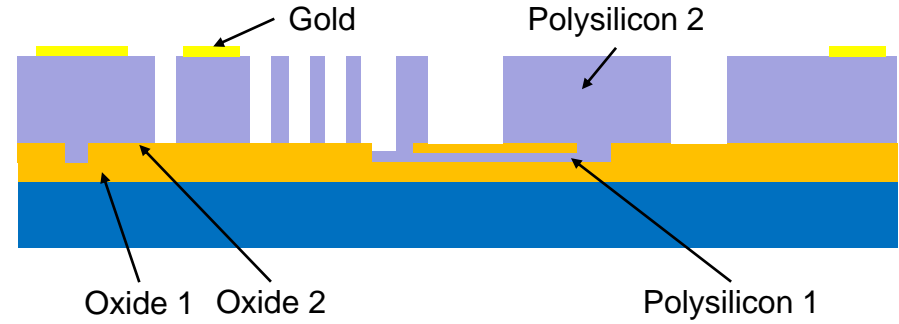
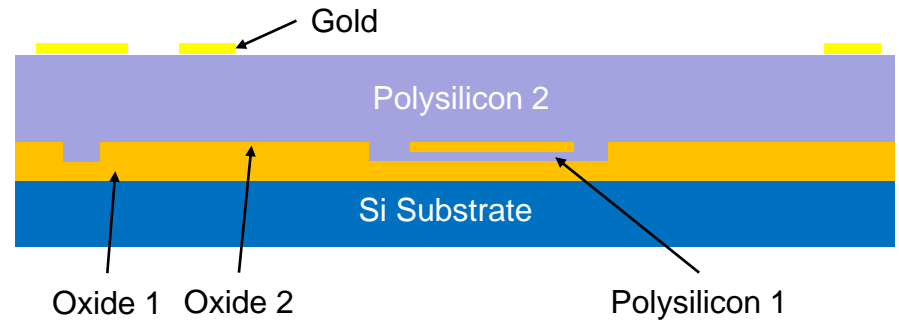
- Gold bond pads (lift-off patterning)

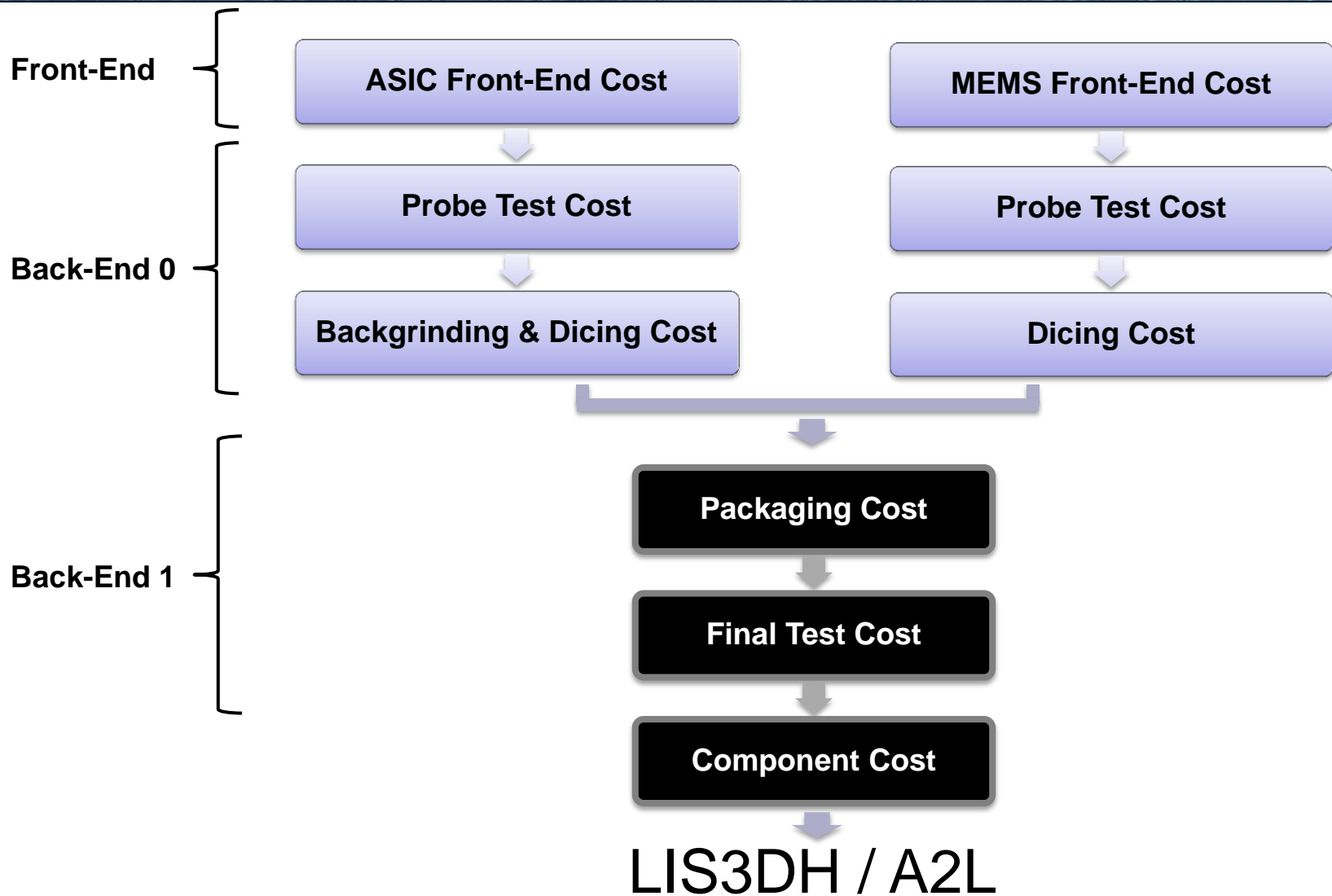


- Trench Etch (DRIE)



- Release (HF vapor etching)





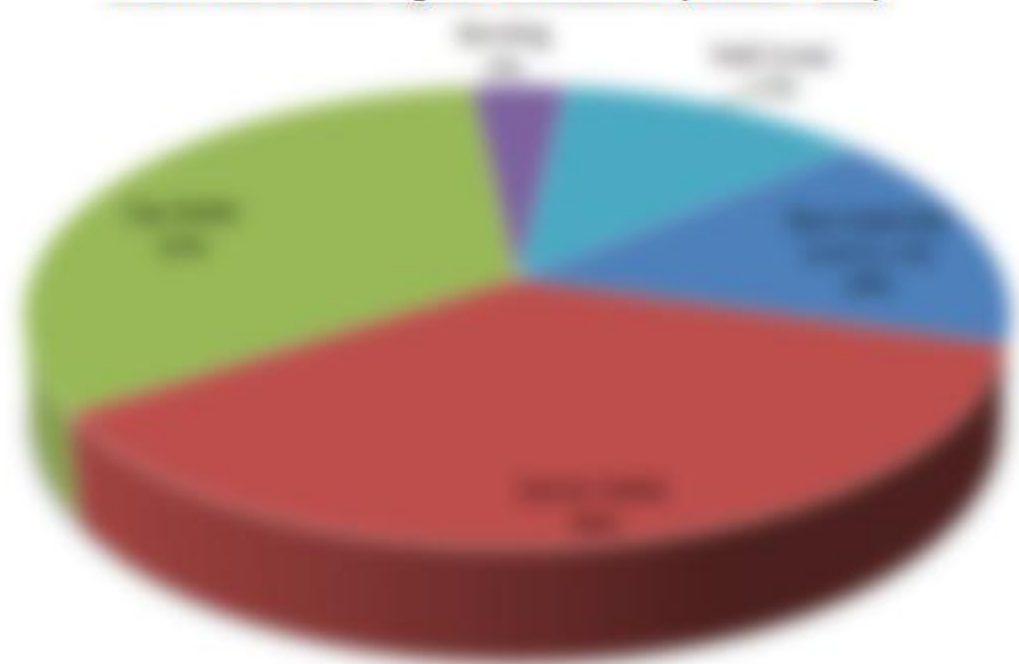
- We perform the economic analysis of the ASIC with the [IC Price+](#) software.
- We perform the economic analysis of the MEMS and the packaging with the [MEMS CoSim+](#) software.

	Low Yield		Medium Yield		High Yield	
	Cost	Breakdown	Cost	Breakdown	Cost	Breakdown
Front-End Cost						
BE 0 : Probe Test						
BE 0 : Backgrinding						
BE 0 : Backgrinding yield losses						
BE 0 : Dicing Cost						
A SIC Wafer Cost						
Nb of potential dies per wafer						
Nb of good dies per wafer						
Front-End Cost						
BE 0 : Probe Test Cost						
BE 0 : Backgrinding Cost						
BE 0 : Dicing Cost						
BE 0 : Yield losses Cost						
A SIC Die Cost						

- The ASIC die cost ranges from [] to [] according to yield variations.
- The main part of the ASIC die cost is due to [] with []
- The back-end 0 yield ranges from [] to []

MEMS Front-End	Low Yield		Medium Yield		High Yield	
	Cost	Breakdown	Cost	Breakdown	Cost	Breakdown
Raw Substrate Cost (2 x Si)	100000	100%	100000	100%	100000	100%
Sensor Wafer	100000	100%	100000	100%	100000	100%
Cap Wafer	100000	100%	100000	100%	100000	100%
Bonding	100000	100%	100000	100%	100000	100%
Yield losses	100000	100%	100000	100%	100000	100%
MEMS Front-End Cost	100000	100%	100000	100%	100000	100%

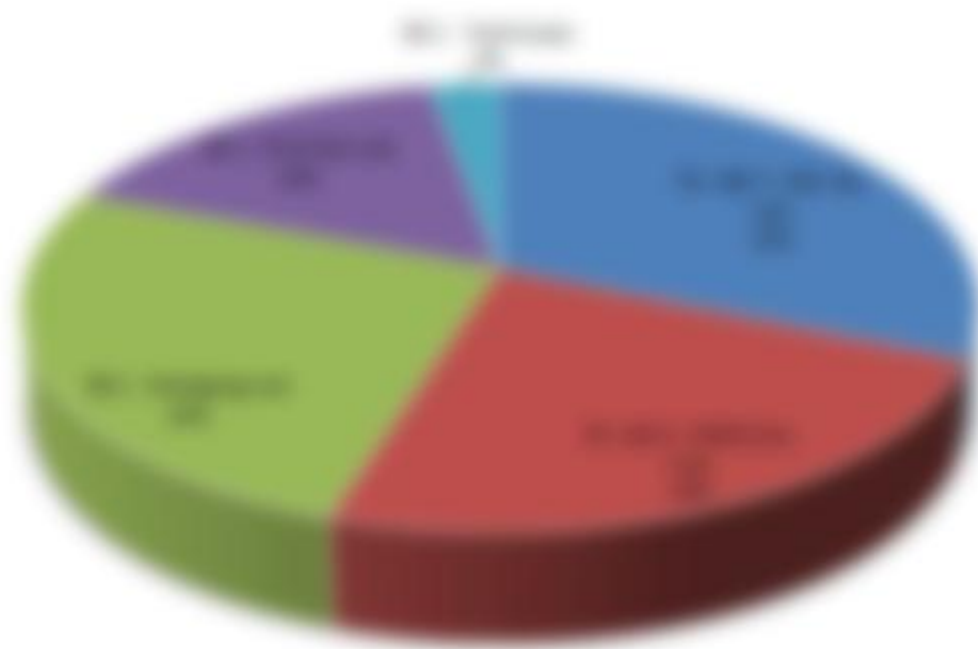
MEMS Manufacturing Cost Breakdown (Middle Yield)



- The **Raw Substrate Cost (2 x Si)** represents the main part of the manufacturing cost with **45%**.
- Due to the use of Gold for the wafer bonding, the cap wafer is more expensive than for the previous generations.

	Low Yield		Medium Yield		High Yield	
	Cost	Breakdown	Cost	Breakdown	Cost	Breakdown
FE + BE 0 : ASIC Die cost						
FE + BE 0 : MEMS Die Cost						
BE 1 : Packaging cost						
BE 1 : Final test cost						
BE 1 : Yield losses						
LIS3DH Component Cost						

LIS3DH Component Cost Breakdown (Medium Yields)



- The component cost is between [redacted] and [redacted] according to yield variations.
- The die (ASIC + MEMS) represents [redacted] of the total manufacturing cost.
- The packaging cost represents [redacted] of the total manufacturing cost.
- Final test cost and yield losses (due to packaging and final test) represent [redacted] of the total manufacturing cost.