Cost Modeling of "MEMS Systems"

Scotten W. Jones, President

IC Knowledge LLC

Introduction

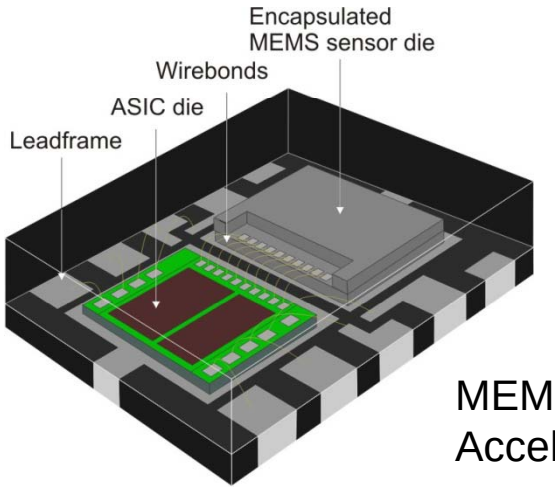
- In this talk I will describe
  - Why MEMS Cost Modeling is important
  - What is a “MEMS System”
  - What some of the challenges of MEMS Cost Modeling are
- I will then present a commercially available MEMS Cost Modeling product that meets the requirements described above

Why Cost Model

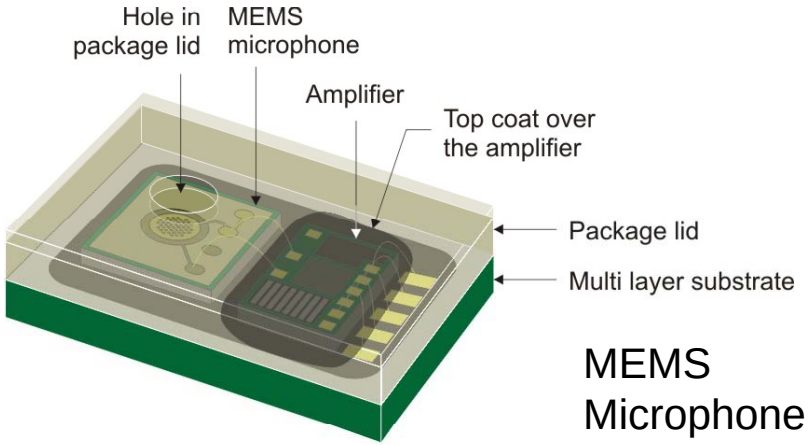
- Cost is a critical driver of the success of any product
- Cost modeling can provide insight into
  - What a product being developed will cost to produce
  - How various process options compare for cost
  - What competing products cost to produce
  - What a product being purchased costs the supplier to produce and therefore what kind of margins are the supplier charging
  - What the largest cost categories are to address for cost reduction efforts

What is a “MEMS System”

- Many of today's MEMS products are complete systems and incorporate:
- MEMS sensors
- Integrated Circuit signal conditioning
- May provide digital output
- Custom packaging



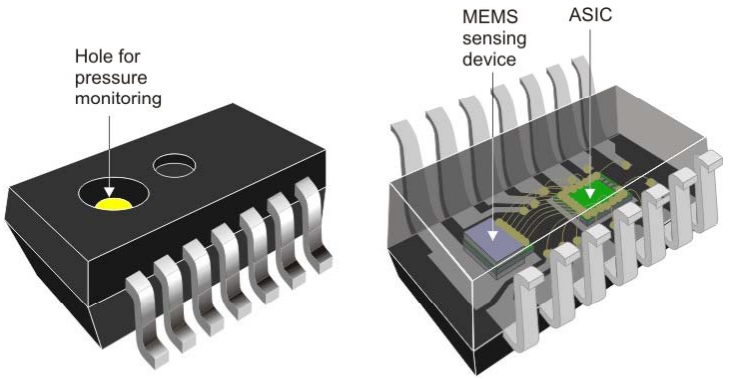
MEMS
Accelerometer



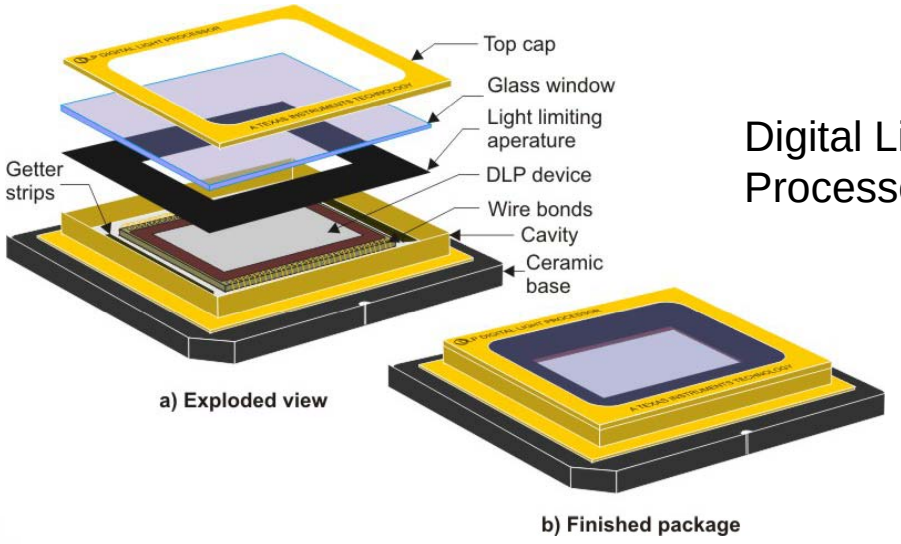
MEMS
Microphone

MEMS Cost Modeling Challenges 1

- Products may include multiple MEMS and/or IC Die
- Many/most MEMS processes are custom
- Many/most MEMS packages are custom
- Non standard test requirements



Tire pressure measurement system



Digital Light Processor

MEMS Cost Modeling Challenges 2

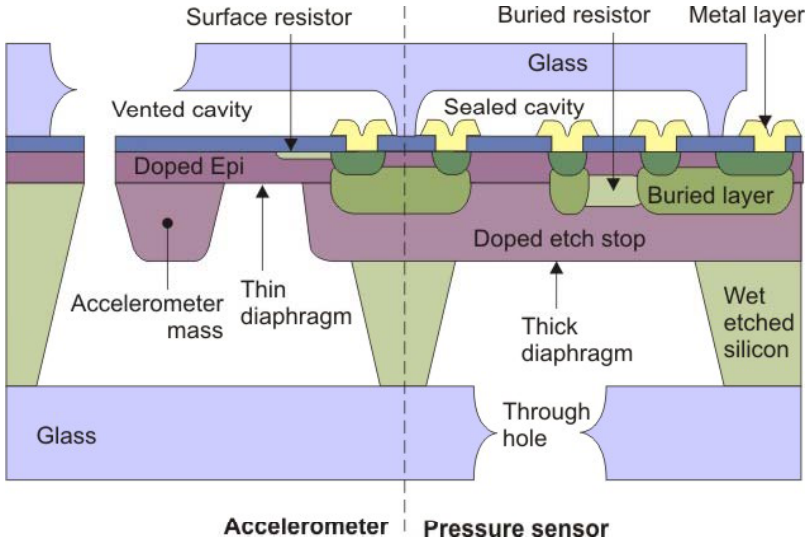
- Cost Modeling users have different needs and levels of technical knowledge:
  - Fund raising – 3rd party modeling to prove to investors that the product can meet cost targets – knowledge varies - needs customization
  - Purchasing – want to cost suppliers product – may have limited information and/or technical knowledge – wants standard selections
  - Marketing – want to cost their own or competitors product – knowledge varies – may want standard selections or customization
  - Development engineer – wants to cost products or processes during development – deep technical knowledge – wants customization
  - Managers – benchmarking, product costing, competitive analysis – want to cost products or processes – knowledge varies – customization varies
  - Others
- To meet all these needs a model must be flexible and comprehensive

IC Knowledge – MEMS Cost Model

- Includes 4 complete die costing engines – 2 IC and 2 MEMS cost engines
  - The IC cost engines analyze IC die and IC/MEMS integrated die where the IC processing is dominant
  - The MEMS cost engines analyze MEMS die and MEMS die with some electronics where MEMS processing is dominant
  - The 4 engines may be used simultaneously in any combination
- Packaging and test are supported

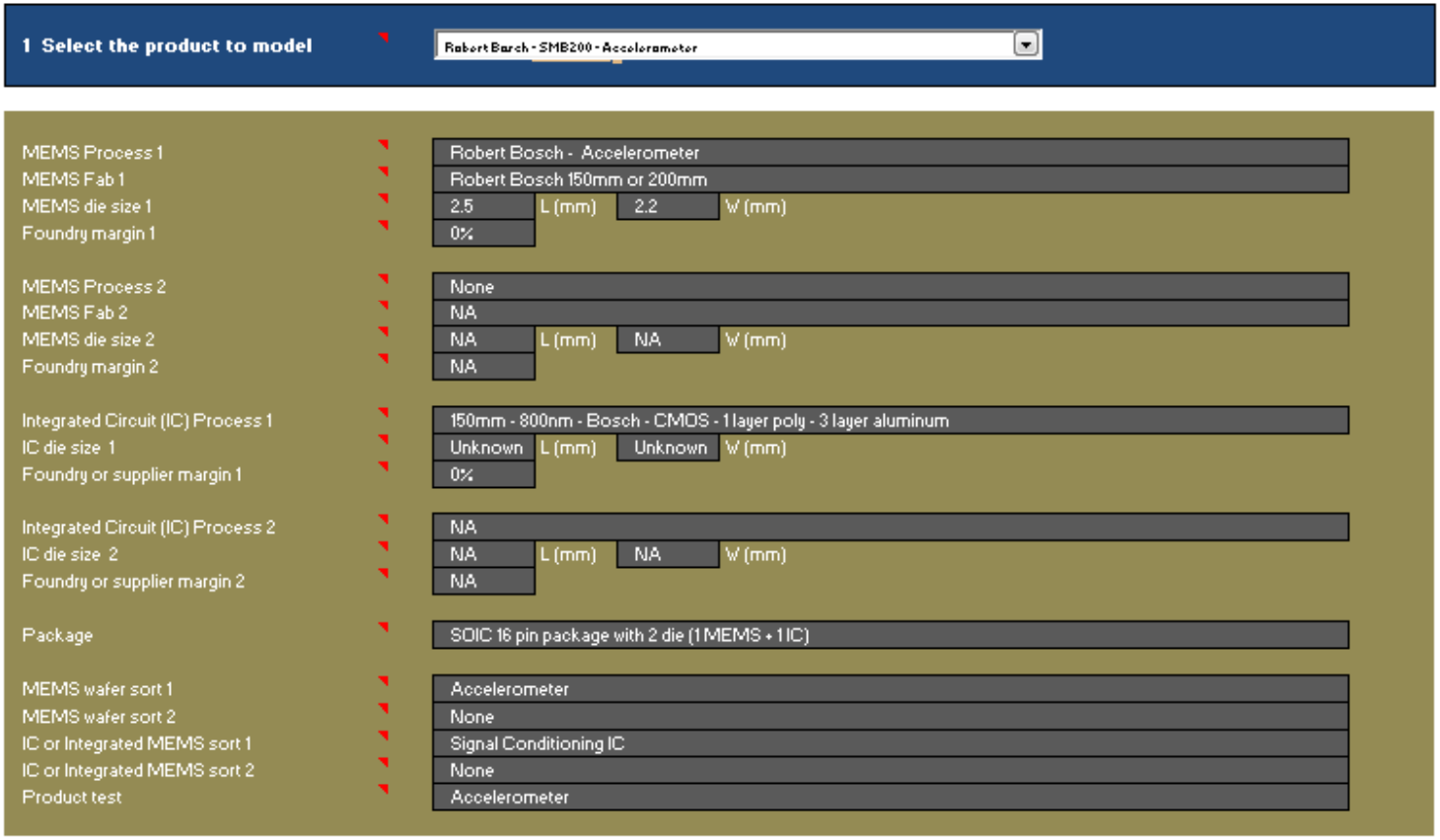
Multiple ways to build a model

- Product driven
  - Select a product and throughout the model input selection help is provided
- Custom
  - Select existing MEMS processes or define your own MEMS process
  - Select existing MEMS Fabs or define your own fab
  - Up to four substrates per process may be selected
  - Select IC processes
  - Select package and tests



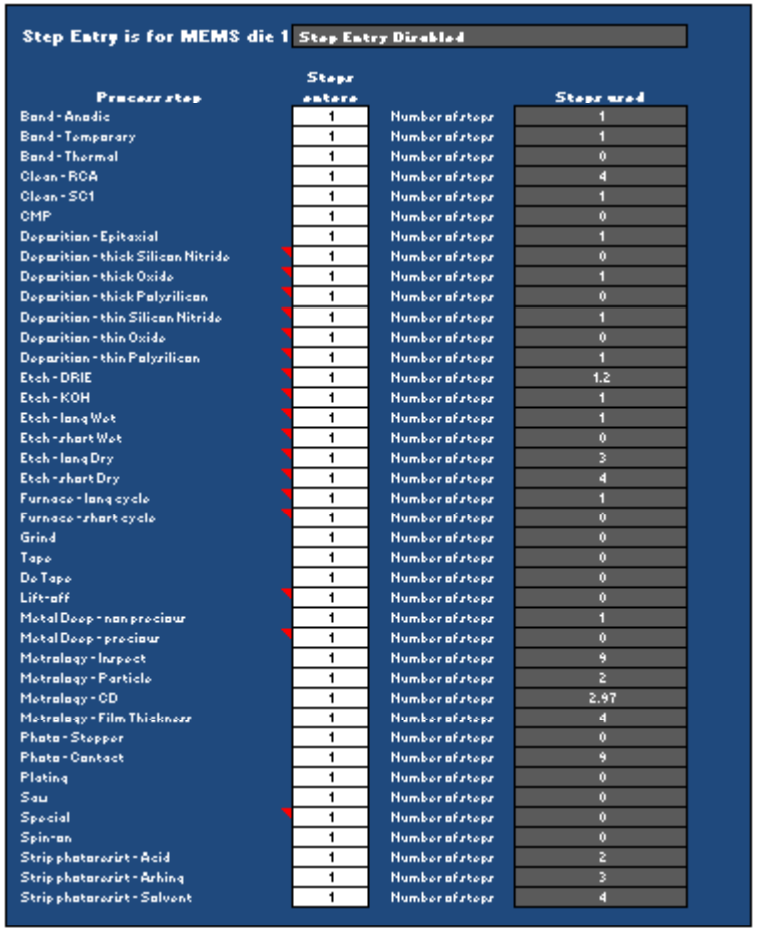
Tire pressure measurement system with three substrates

Product Selection



Custom Process Definition

- A set of process steps are presented
- For predefined processes the number of times each step is used is displayed
- For custom processes the user enters how many times each process is used
- Certain etch and deposition steps are thickness based



Wafer Cost Output 1

	Robert Bosch - SMB200 - Accelerometer			
		Die Cost Off		Die Cost Off
	MEMS Part 1	MEMS Part 2	IC Part 1	IC Part 2
Wafer fab capacity (wafs/mth)	26,000	NA	137,000	NA
Utilization (%)	90%	NA	90%	90%
Wafer size	200mm	NA	150mm	150mm
	($/waf)	($/waf)	($/waf)	($/waf)
Starting wafers	$92.75	$0.00	$17.00	$0.00
Direct labor	$56.17	$0.00	$48.29	$0.00
Depreciation	$6.96	$0.00	$11.42	$0.00
Tool maintenance	$18.93	$0.00	$13.31	$0.00
Indirect labor	$9.12	$0.00	$25.54	$0.00
Monitor wafers	$3.28	$0.00	$8.85	$0.00
Facilities	$62.98	$0.00	$39.22	$0.00
Consumables	$38.34	$0.00	$64.25	$0.00
Total	$288.52	$0.00	$227.88	$0.00
Wafer yield (%)	91.0%	0.0%	97.2%	97.2%
Yielded wafer cost	$317.21	$0.00	$234.45	$0.00
Suggested margins	0%	NA	0%	NA

Wafer cost output 2

These are consumables costs for MEMS die 1 only

	$/year	$/waf
Reticles	$5,054,400	$18.00
Photochemicals	$1,333,900	$4.75
Cleaning and etching chemicals	$1,298,458	$4.62
Spin-on	$0	$0.00
Bulk gases	$690,151	$2.46
Specialty gases	$342,576	$1.22
CMP	$0	$0.00
Quartzware	$1,284,855	$4.58
Cleanroom and safety supplies	$762,000	$2.71
Precious metals	$0	$0.00
User entered consumables	$0	$0.00
Total cost	$10,766,340	$38.34

Product cost

	($/die)	($/die)	($/die)	($/die)
Gross die (n/waf)	2,109	0	1,043	0
Die yield (%)	85.0%	NA	94.2%	NA
Net die (n/waf)	1,792	0	983	0
Yielded die cost ($/die)	$0.189	$0.000	$0.25	$0.00

	($/part)
Packaging yield	97%
Package cost	$0.064
Packaged unit cost	$0.519
Class test yield	98%
Class test cost	$0.044
Product cost	**$0.574**

Conclusion

- Cost modeling is a critical capability for product design and analysis
- MEMS cost modeling has diverse requirements
- The IC Knowledge – MEMS Cost Model is:
  - Commercially available since 2004
  - Well vetted with a wide user base
  - Flexible enough to meet the needs of a diverse user base
  - Flexible enough to provide pre defined and custom cost capabilities

Thank you!