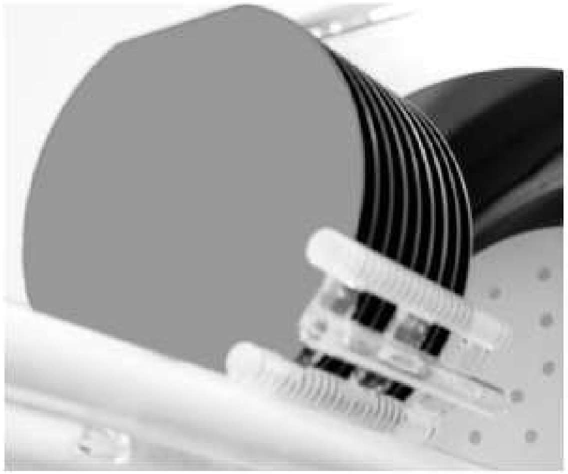
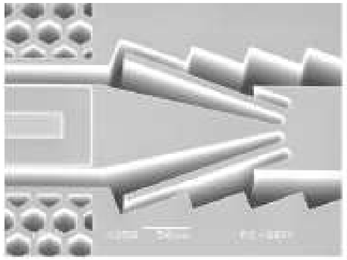
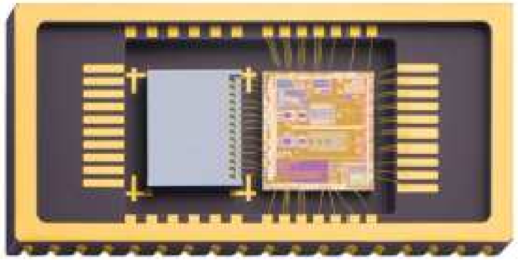
ENVISION MEMS | DELIVER MEMS







Tronics Submicron Technologies for MEMS

Philippe Azoley
Director of industrial operations
philippe.azoley@tronicsgroup.com

PLASMA ETCH AND STRIP IN MICROTECHNOLOGY
PESM2014
MAY 12-13, 2014 • MINATEC, GRENOBLE, FRANCE

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Tronics Overview

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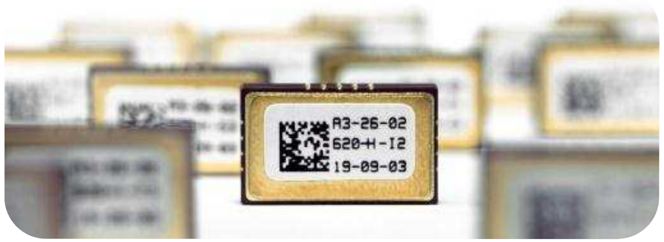
Key facts about Tronics

in the MEMS business

high-end sensors delivered



[2012] : **22 M$, 90 employees**

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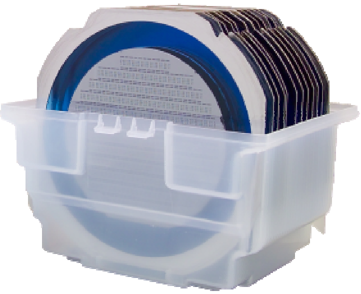
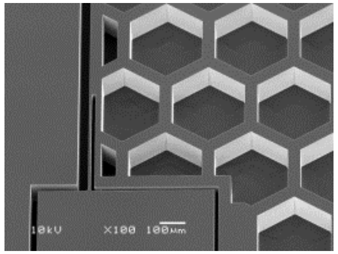
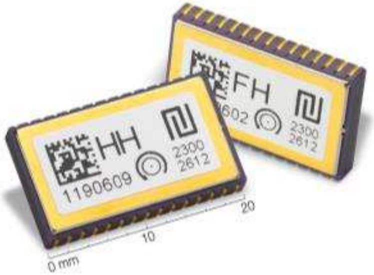
We offer solutions for…



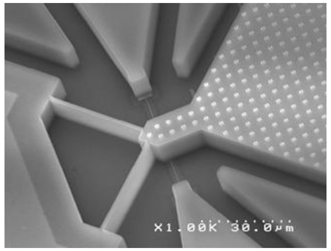
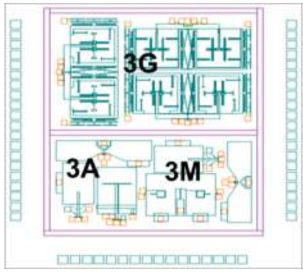

Full Service MEMS Foundry




Advanced MEMS Development




High Performance Inertial Sensors

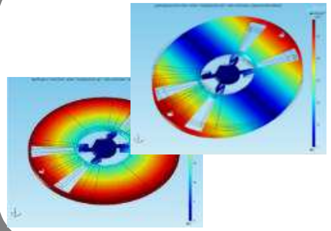



Consumer Inertial Technologies

Flexible IP model for custom products manufacturing

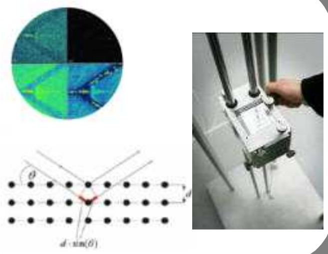
Full Service MEMS Development & Manufacturing

MEMS= Micro Electro Mechanical Systems; *Mechanically active components*



Design/simulation
Modellisation

Wafer processing
& singulation



Quality control
& Reliability testing

Assembly, packaging
& calibration

… from design/simulation to integrated packaged components

Volume Manufacturing – Exotic Processes – Custom Components

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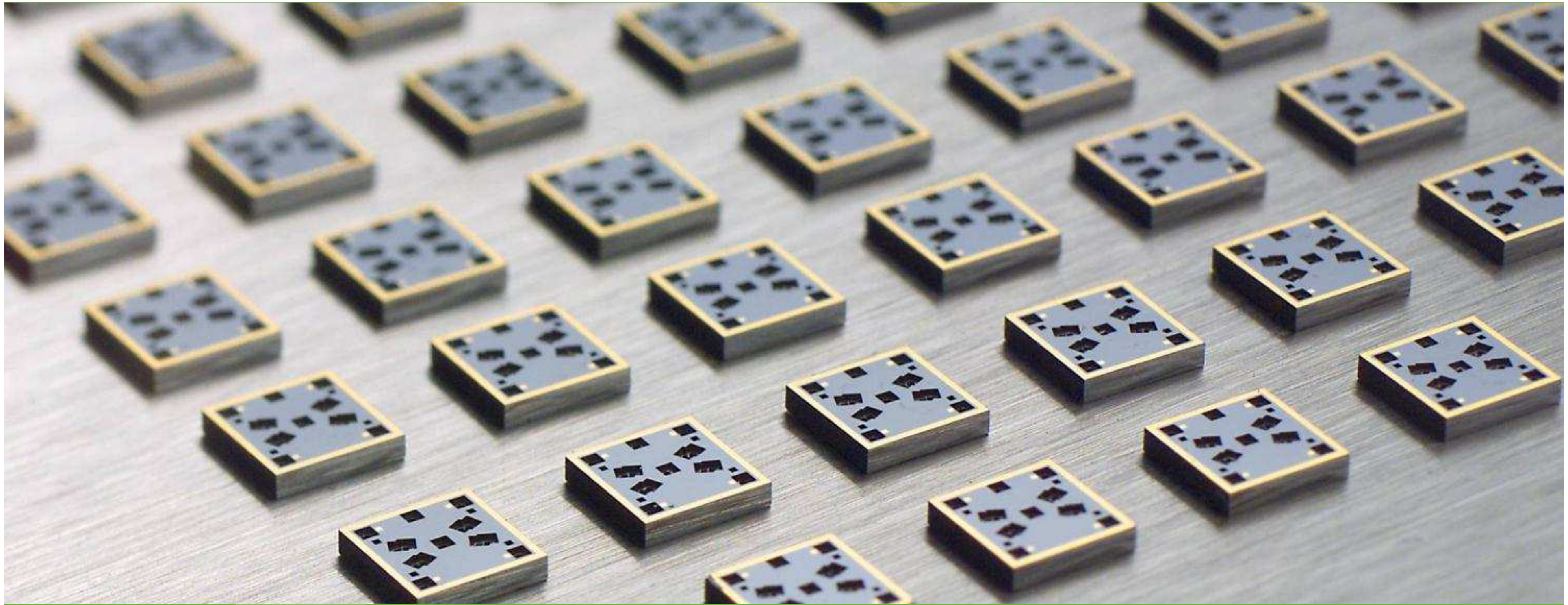
Global Company | Local Support



Tronics technical evolution

Tronics technology & product history 1/2

1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

"Initial" technos
- **bulk**
- **Released SOI**

New Techno
- **SOI/cavity**
- **DRIE**

Vaccuum at package level

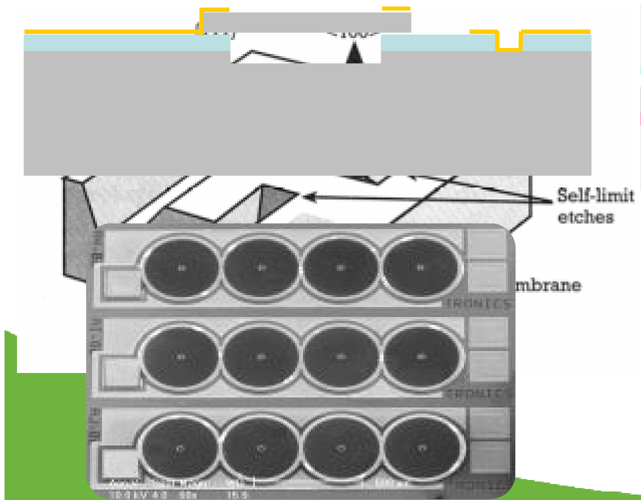
Own fab Crolles

Technical status
Critical dimension = 3µm

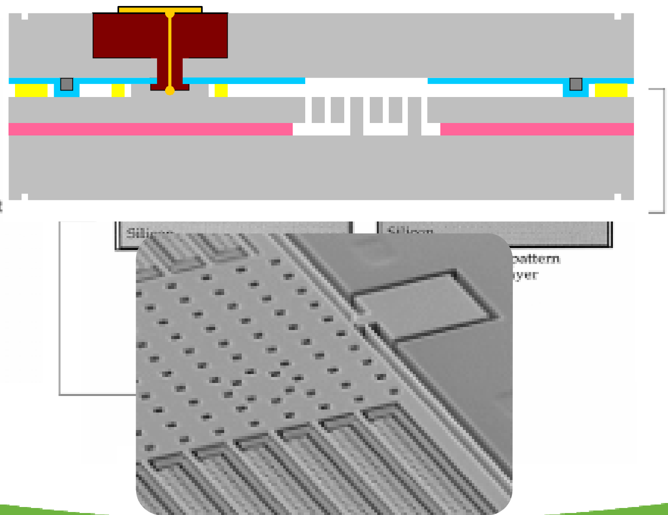
Limited by process/eqt/integration

Development & industrialization

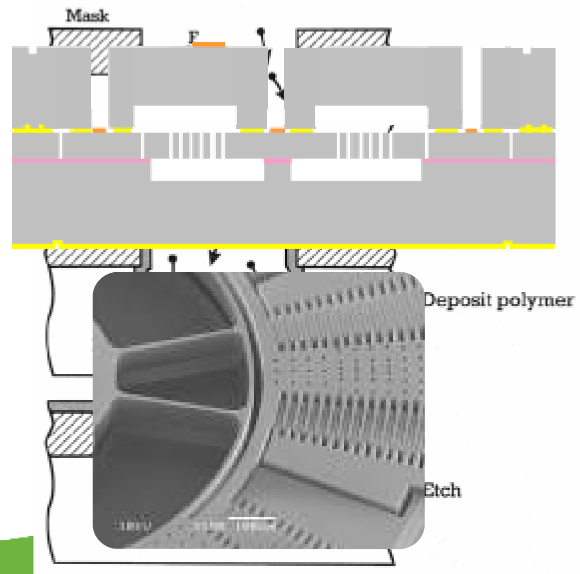
Bulk techno
KOH/TMAH



Surface techno
Wet release/poly Si



High aspect ratio
DRIE



Which type of evolution ?

Clear target

Decrease cost/price
Increase performance/reliability

Tronics choice = Miniaturization

Continuous Improvement
Design / Process / Supply

Shrink
active part

- ↘ Critical Dim.
- ↗ SOI/PolySi Thickness

Develop
shrink inactive part

- Bonding seal → Metal
- Interconnect → TSV

Optimize
supply chain

- Wafer size 4" → 6"
- Supress package → VWLP

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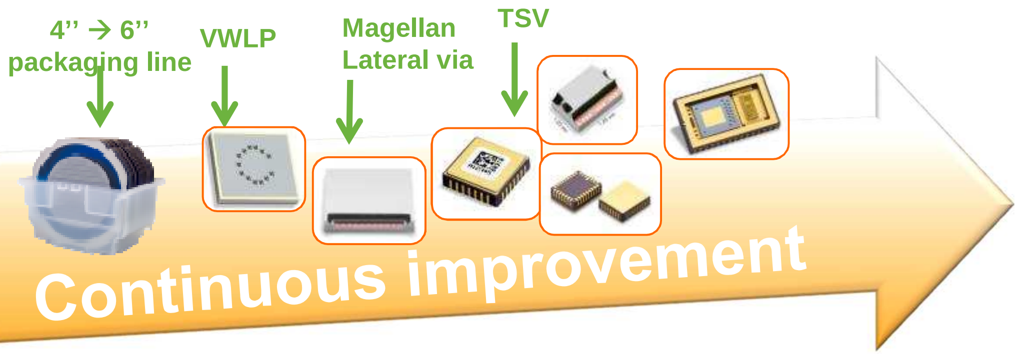
Tronics technology & product history 2/2

1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013

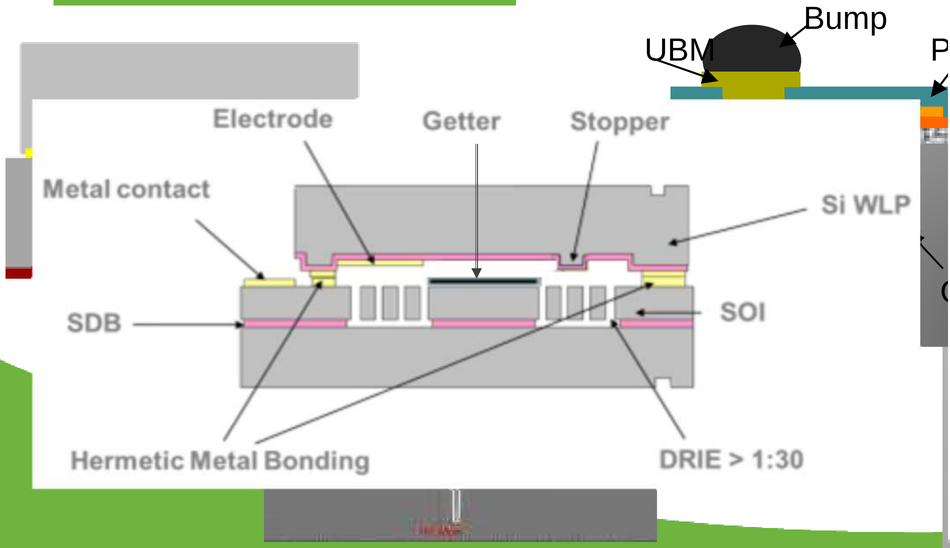
Technical status
Critical dimension = 1,5 µm
Divided by 2 compared to first technologic roadmap

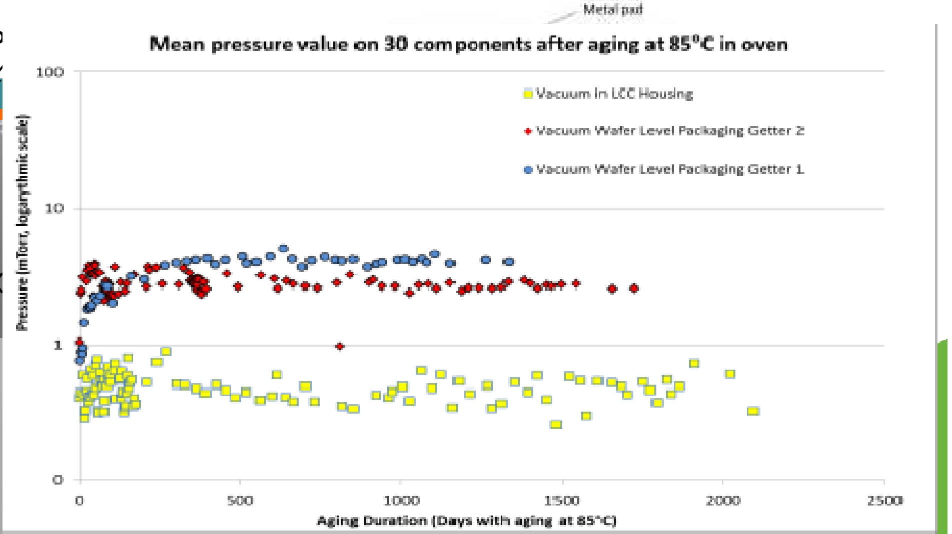


Increase Proof mass thickness → able to decrease the gap CD to 1,5µm

TSV last
Cu TSV

VWLP
Aging & characterization





Then, Same target, Same evolution ?

Re-Shrink
active part

- CD limited by capacitive principle
- Need minimum mass for performances

Develop
shrink inactive part

- Sealing - Need min width for hermeticity
- TSV optimization → limited gain

Optimize
Supply chain

- Wafer size 6" → 8" →Need high volume →Expensive
- VWLP done → Limited gain

Tronics fact
We can't continue in the same way !

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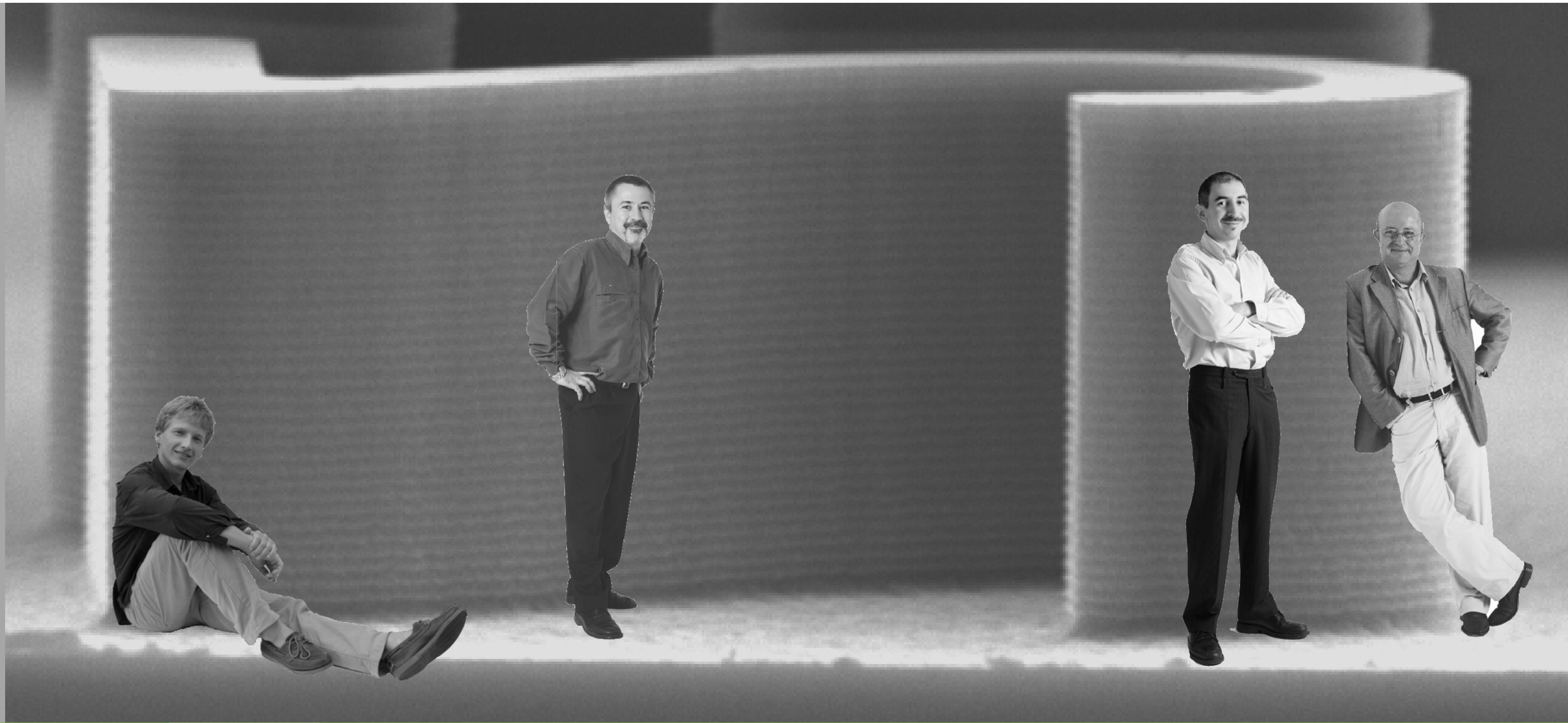

Tronics technologic roadmap

Standard microtechnology

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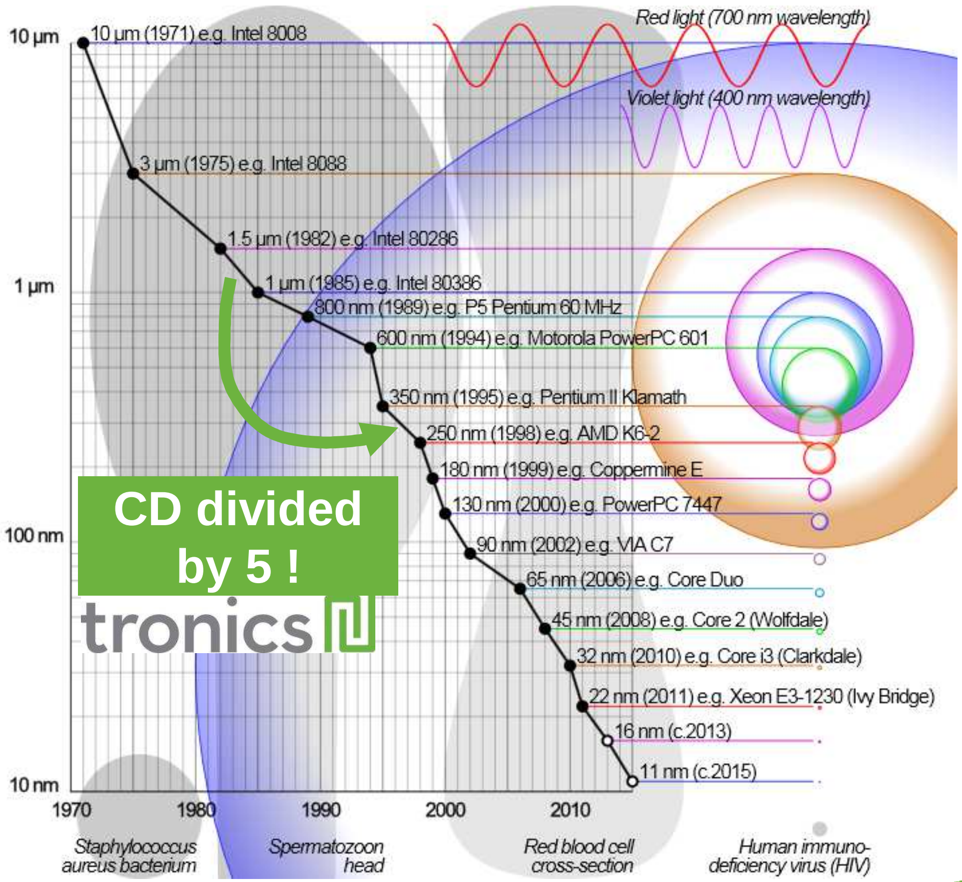
Submicron for MEMS & Tronics

Submicron exist since long time in Microelectronic
Continue evolution of tools & know how (Moore law)
→ Technical solution are here !

Critical dimension targeted = 0,3µm



For Tronics : 'REVOLUTION' rather than EVOLUTION !

Submicron in MEMS – What do we need ?

1st decision for this CD evolution → Equipment invest

Lithography equipment

Stepper CD=0,3µm

Nano-imprint CD=0,1µm

Dry etch equipment

DRIE etcher

Control equipment

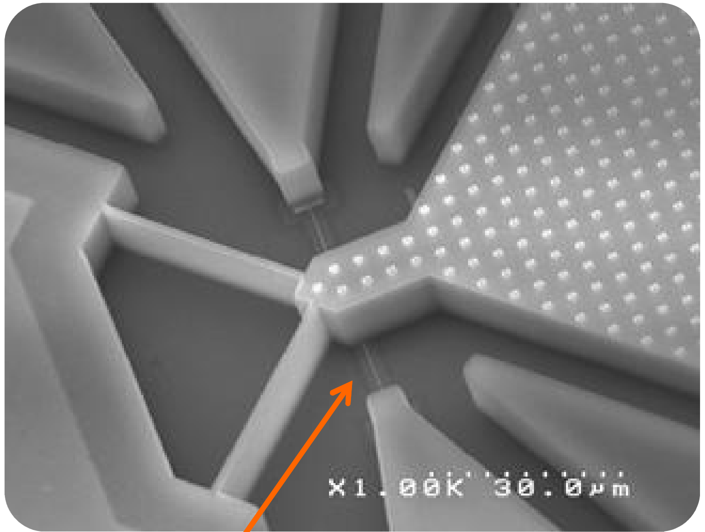
High perf. SEM

Submicron Technologies

2nd decision for this CD evolution → Technology invest

M&NEMS
Breakthrough submicron technology

leti → tronics



Si Nanowire

Critical Dimension = 0,5µm

NIL
Industrialized submicron technology

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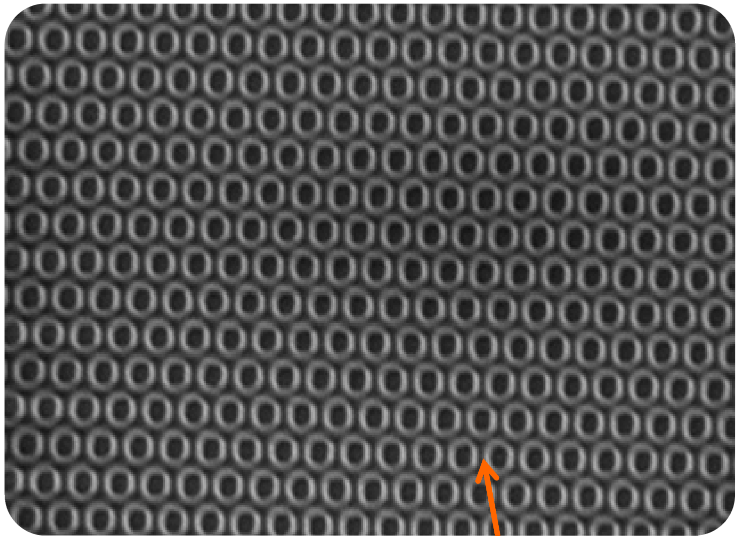


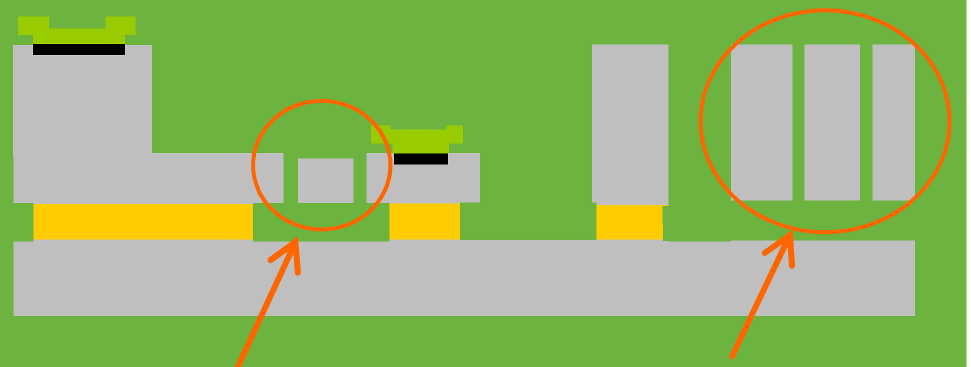
Submicron holes over large surface

Critical Dimension = 0,3µm

Submicron technology : M&NEMS

New disruptive technology

- 2 hugely different thicknesses
- Nanogauge permits to recover a large part of the force
(no dilution in the thickness)



Thin layer for detection - NEMS

Nano-wire (0,5 µm)

Thick layer for Proof mass - MEMS

Seismic mass (20 µm)

Tronics objective : Development

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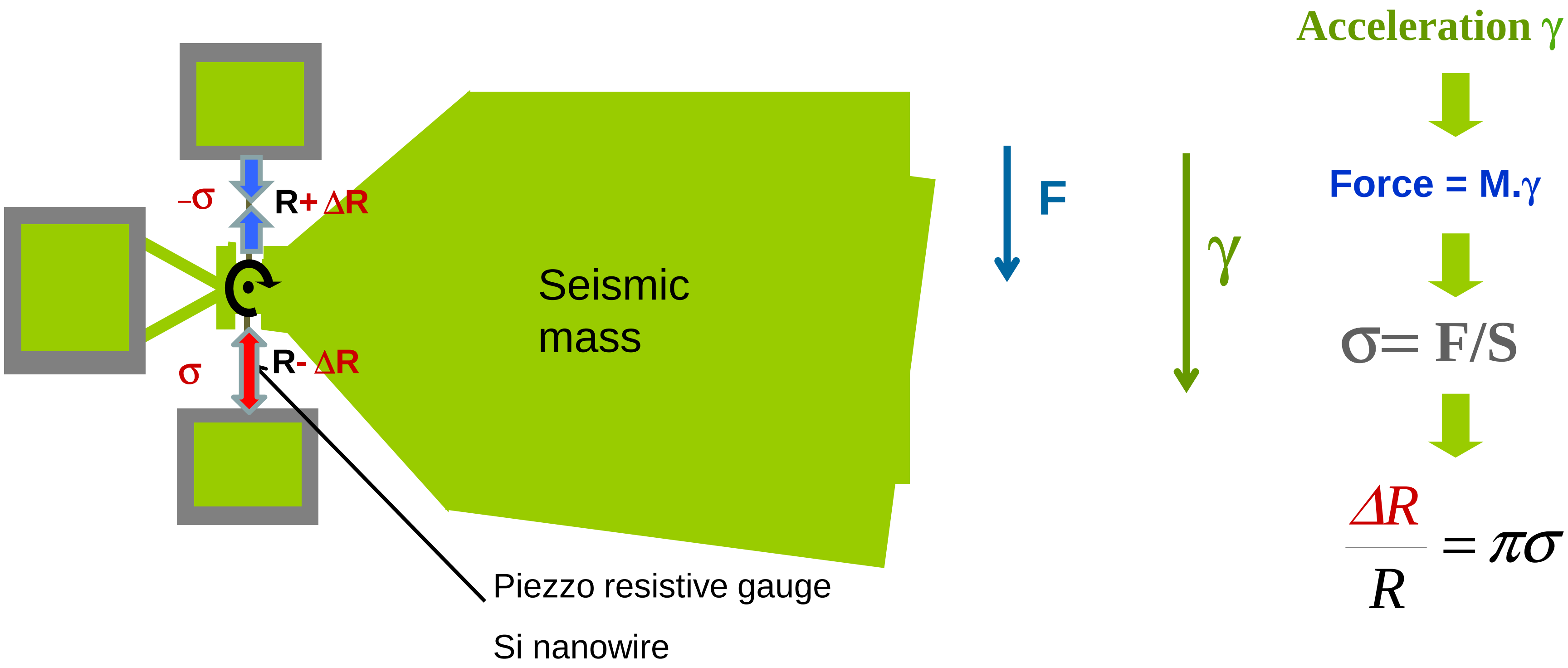
Piezzo Resistive Effect: Working Principle



Gauges made by monocrystalline Silicon Nano-wire
No gauge bending, only compression or strain

Standard piezzo-resistive detection →Standard ASIC

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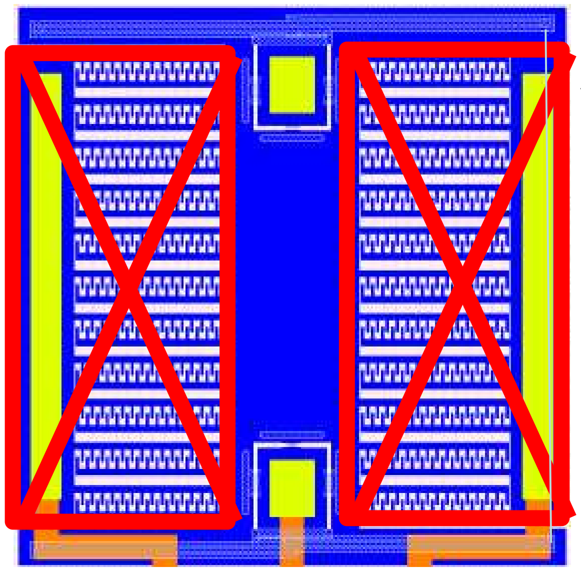
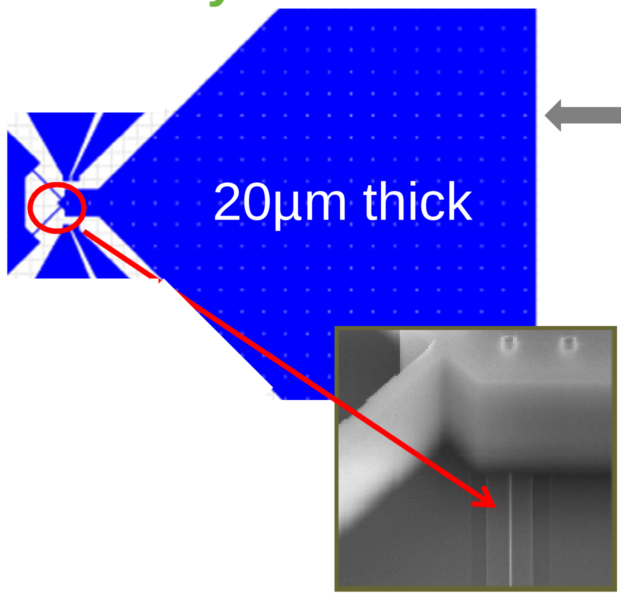
Roadmap to extreme miniaturization

Capacitive MEMS
Fully optimized



Same scale

Nanogauge
today



Nanogauge
tomorrow

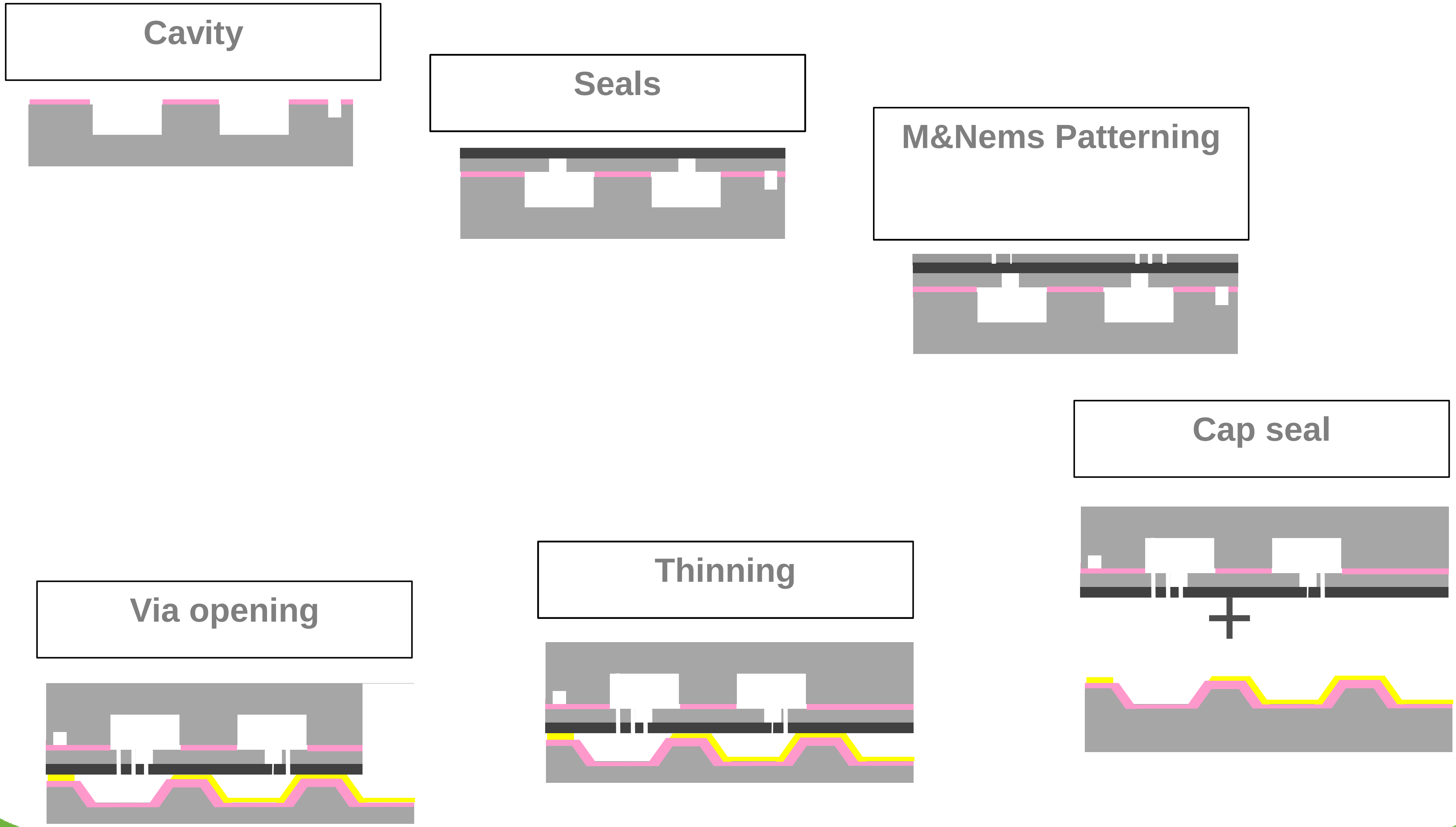
1-axis accelemeter
0,2 mm²

Same accelerometer
0,1 mm²

Same accelerometer
0,07 mm²

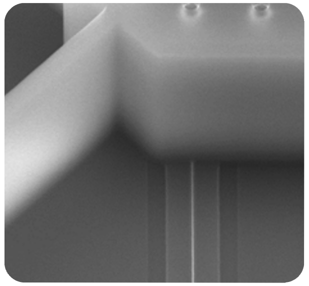
M&NEMS technology decrease critical dimension but also die size and finally cost

M&NEMS Process



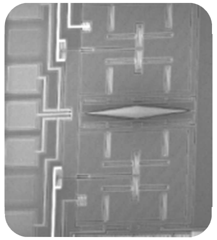
M&NEMS Application

Nanogauge

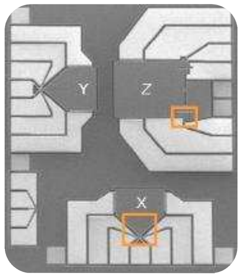


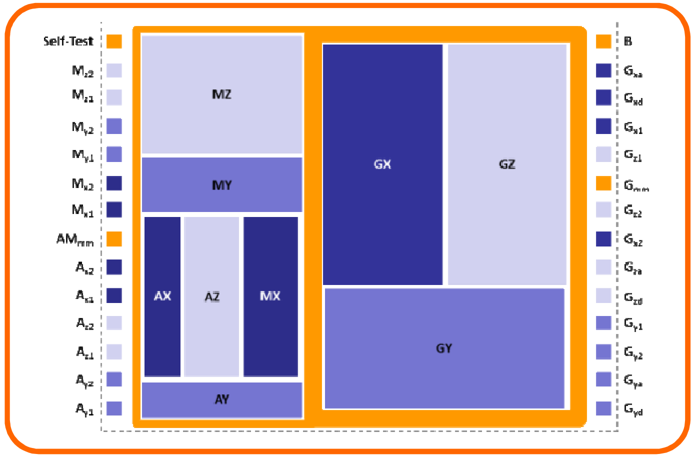
3D Compass

3D Gyro



3D Accel





1 single technology
9 DOF in a single chip

Compared to standard MEMS technology, Area gain x4

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Motion sensing for mobile applications

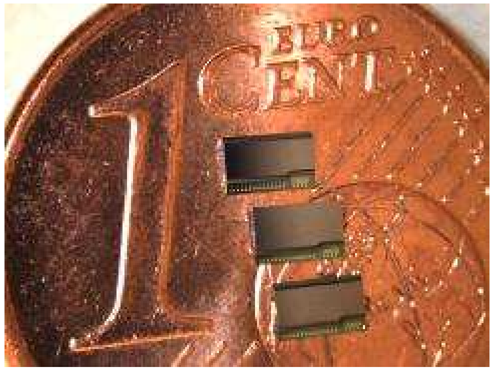
Application targeted : consumer market

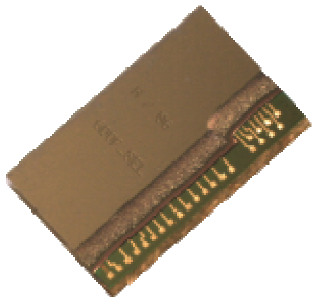
6 DOF for Gaming
(3D Acc. + 3D Gyros)

6 DOF for Augmented reality
(3D Acc + 3D Compass)

9 DOF for
Indoor location &
Pedestrian
Navigation
(3D Acc.
+ 3D Gyros
+ 3D Compass)

February 2014 : 1st M&NEMS prototype - 6 DOF (3A3G)





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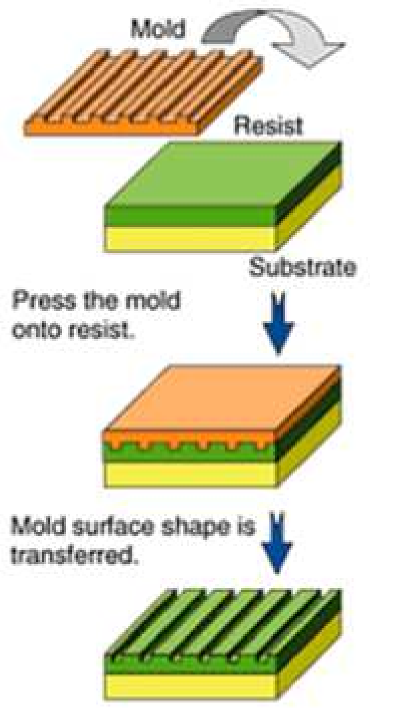
Submicron technology : NIL

« Old » technology mainly used in university

Well adapted for glass processing

Critical dimension ~ 10 nm



Tronics objective : Industrialization

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NIL vs stepper lithography

Tronics criteria	NIL	Litho i-line	Litho DUV
Capability dimensions - Squareness - 0.2 µm spacing	++ Can handle dimensions down to 10nm	-- 0.28 µm bottom limit. 'squareness' not possible	+ Spacing is feasible, but 'squareness' difficult to obtain
Timing required to setup technology	+ Tool can be easily implemented	-- Not an option	-- Requires >1yr development
Maturity technology	-- NIL not used in production	++ HVM technology	++ HVM technology
Process complexity	+ Requires separate stamp manufacturing	- Coating-litho Few restrictions on environment/timing	-- Coating-litho Resist sensitive to environment/timing
Pricing tool	++ ~ 300 k€	- ~ 1 M€	-- 3 M€
Pricing master/reticle	- ~ 150 k€ for 6" master need to find alternatives	- ~25 k€ phase shift mask with advanced OPC's	- ~25 k€ phase shift mask with advanced OPC's

DUV : too expensive/complicated to put in place

i-line : impossible to pattern square structures

NIL – Best solution for required application

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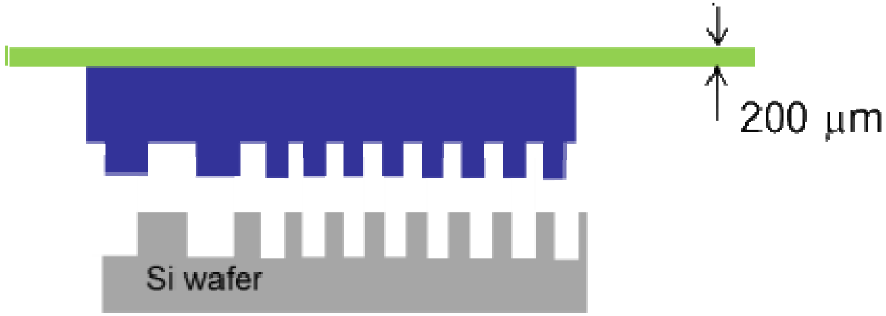
NIL (SCIL) process

Master fabrication

Si wafer with desired pattern by e-beam

Stamp fabrication (mold)

Master replicated with polymer material on a glass frame



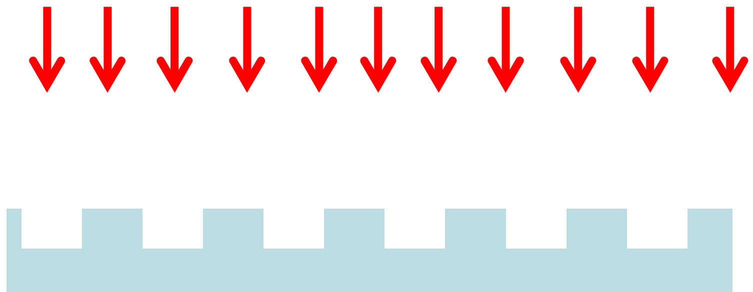
Imprint & etch process

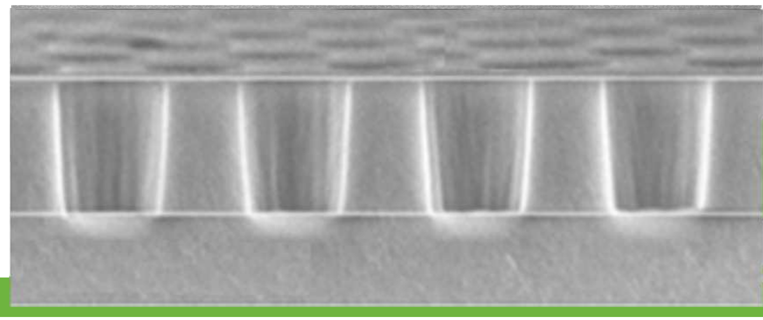
- Apply hard mask & nano-imprint resist on 'stamp' in NIL resist (currently still liquid)

- UV cure → fix structures in the resist
- Stamp release

- Breakthrough etch (NIL resist residue)
- Hard mask etch

- Substrate etch
- Strip/clean

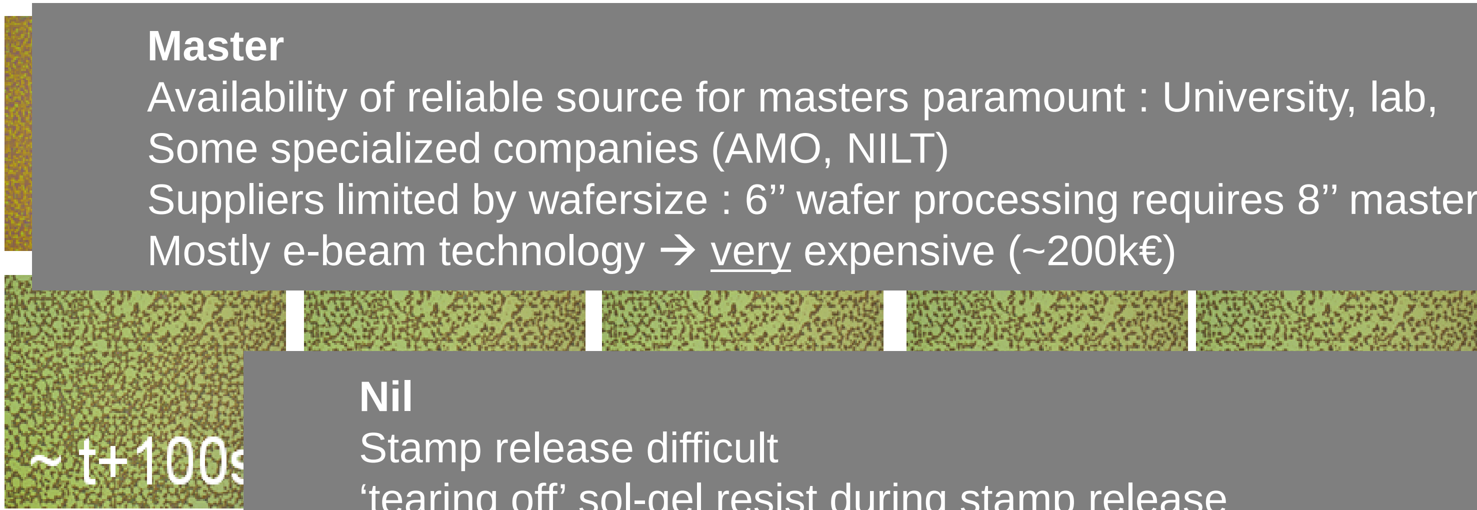




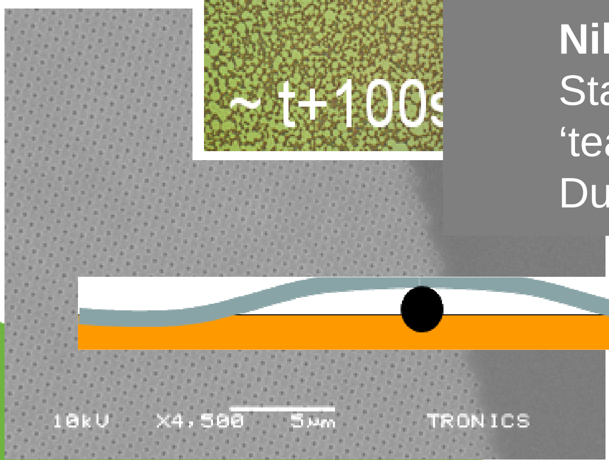
NIL technical challenges

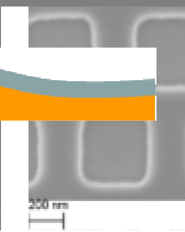
Resist
Sol-gel resist characteristic :
- Very low viscosity (almost like water), fills easily the stamp
- SiO2-like material, very thin layer of resist
- Stability of sol-gel resist after coating

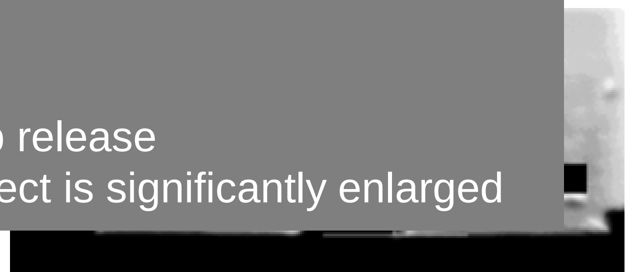
Master
Availability of reliable source for masters paramount : University, lab,
Some specialized companies (AMO, NILT)
Suppliers limited by wafersize : 6'' wafer processing requires 8'' master
Mostly e-beam technology → very expensive (~200k€)

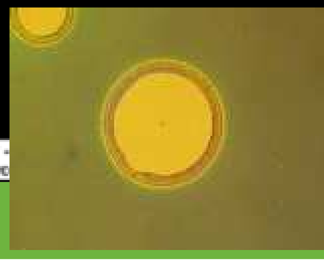


Nil
Stamp release difficult
'tearing off' sol-gel resist during stamp release
Due to insufficient coverage, area defect is significantly enlarged



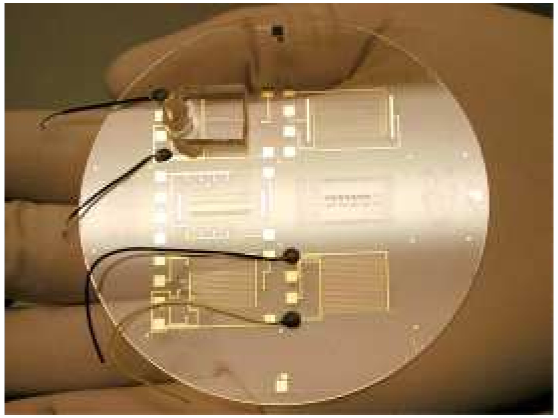






NIL application targeted

NIL for Microfluidic



NIL for Photonic

NIL for Solar

Currently in production at Tronics since end of 2012 for a confidential application

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Next steps (ongoing)

Photolithography

→ Resolution
(Stepper Sub-µ, Nano-Imprint)

→ 3D (dry film, Spray,…)

→ Lift Off

Etch

→ High factor form, homogeneity

→ Thickness, roughness, angle

→ Material : Glass, other

Deposit

→ Cu, Au Electroplating..

→ Thin film magnet, W strain alloy

→ BCB, SOL GEL, Piezzo…

Substrate

→ Thin/Thick SOI

→ Thickness: very thin to very thick

→ Temporary bonding

→ Glass

Back-End

→ TSV, BUMPS

→ Getter

→ Interposer

Packaging

→ Low stress

→ Low price

Many development are linked to submicron

Summary

Summary

- After following the **general trend in MEMS** global evolution since 10 years
- Tronics has decided to continue to **innovate** by using emergent processes and technology directly from research.
- Since 2 years, Tronics has invested in 2 main disruptive technology : **M&NEMS & NIL**.
- Tronics has entered into submicron world by jumping directly from **1,5µm to 0,3 µm.**
- This **internal revolution** is now a standard at Tronics and industrial product are currently delivered to customer !

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Thank you for your attention !

Any « submicron » question ?

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