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Alcatel Micro Machining Systems

Enabling DRIE processes for high potential MEMS products

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October 12th 2006

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Outline

- Introduction
  - who we are ?
  - market and applications
- DRIE for MEMS
  - Bosch Process
  - High etch rate
  - Super High Aspect Ratio
  - Aspect Ratio Dependent Etching
- Conclusion
  - from MEMS to smart Systems integration

Part of a worldwide leader, high technology, Multinational corporation

ALCATEL Lucent Technologies

Alcatel Lucent

- World's leading Communication Group
- >21 B$ (2005 sales)
- >81 000 employees world-wide

P. Russo

S. Tchuruk

FCG
Fixed Communications Group

MCG
Mobile Communications Group

PCG
Private Communications Group

Enterprise Solutions
Space Solutions
Transport Solutions
Integration & Services

100%

Alcatel Vacuum Technology

100%

Alcatel Micro Machining System (AMMS)

196 M€
(2005 sales)

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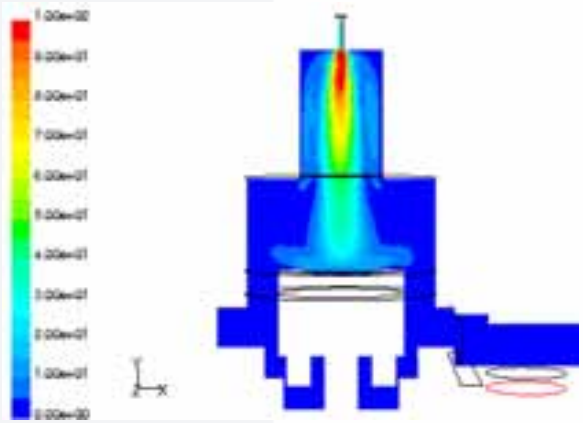
AMMS Global network

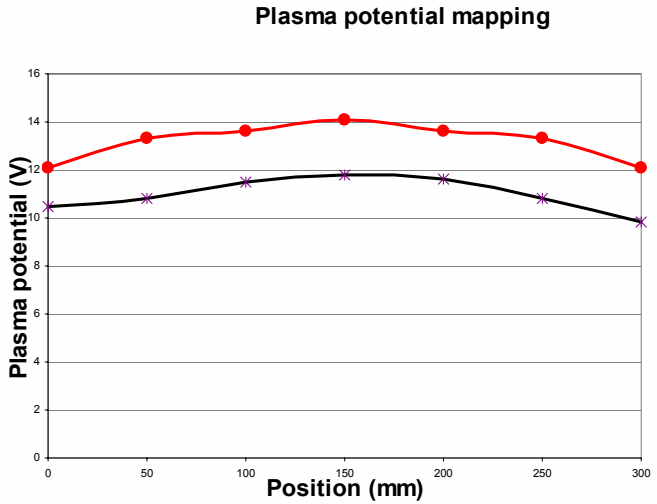
...Market proximity, competence & optimized cost

AMMS HDP Technologies

AMMS Patented Plasma source

- De-coupled plasma process chamber
- Low temperature plasma
- High uniformity on large diameter
- Design for uniform and high gas flow rate





Markets and Technologies

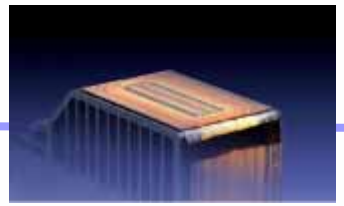
… MEMS Market

› **Deep Etching Technique is Key to address the 3rd Dimension**

MEMS

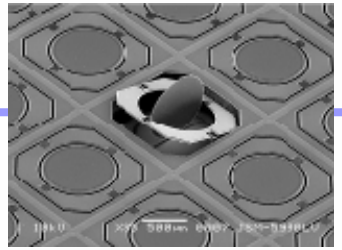
←Inertial Sensors

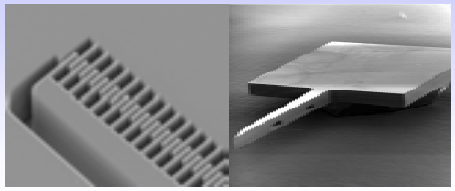
←Ink Jet Printer Heads



←Silicon microphones

←RF Mems

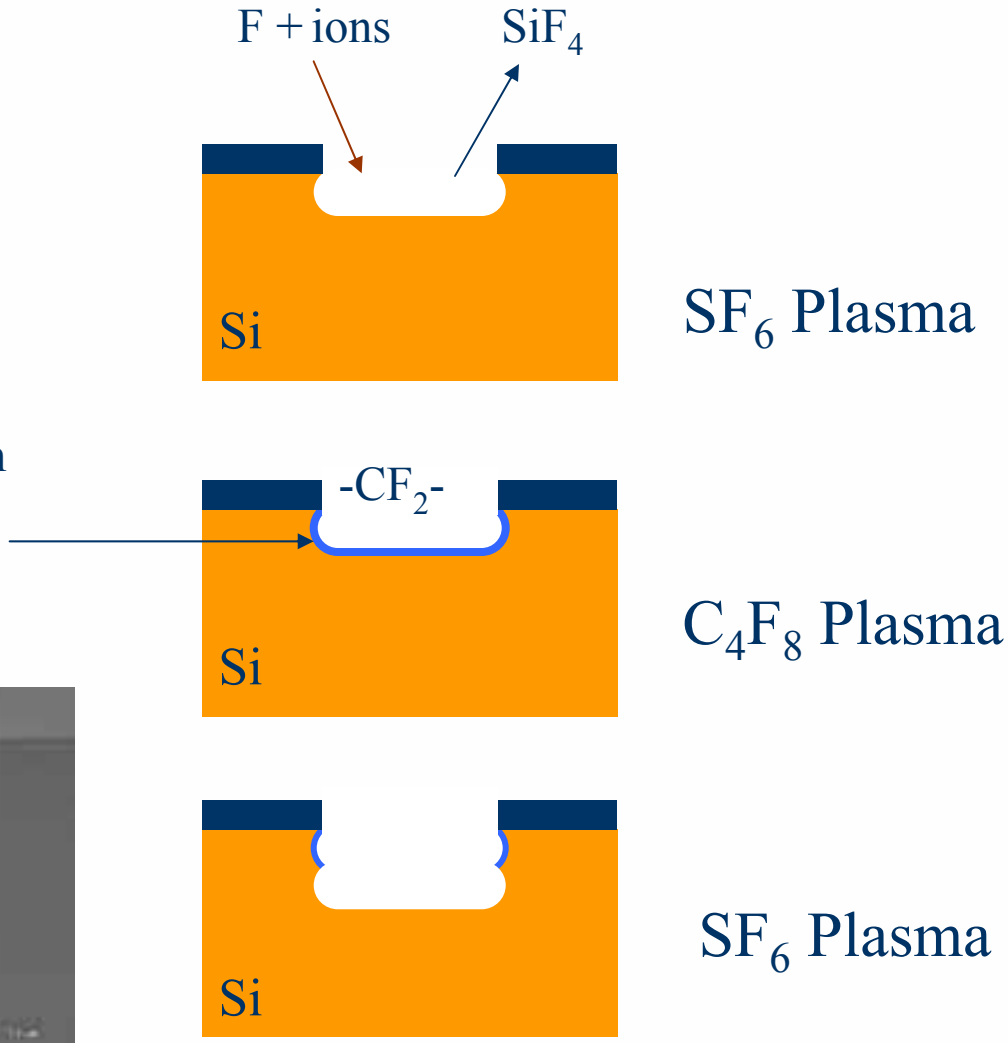


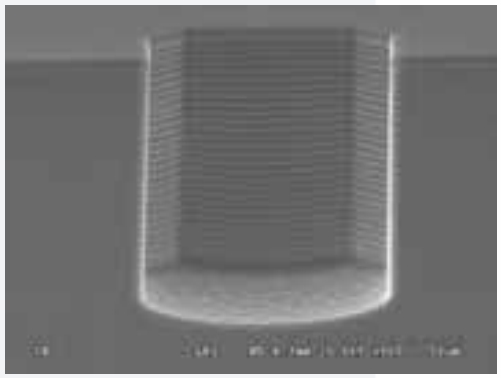


A common use of …

Deep Etching

Bosch Process





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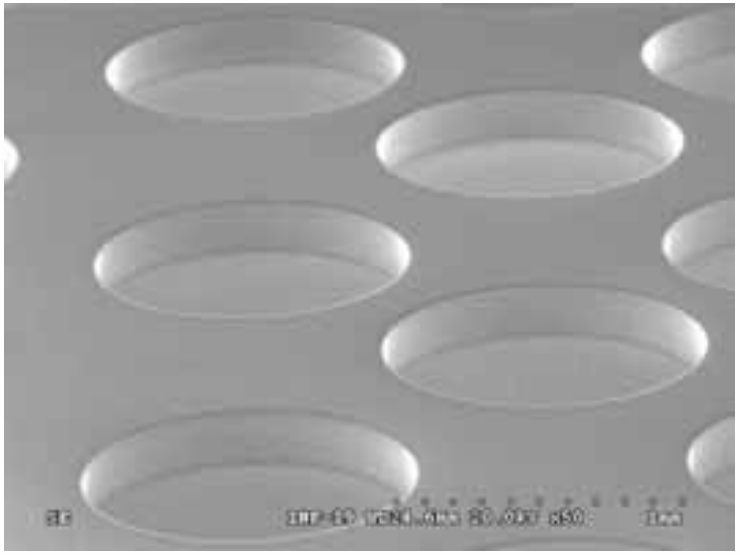
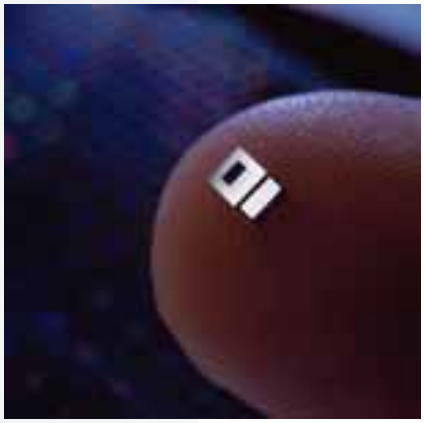
MEMS: Silicon microphones

Big performance from a small, low-cost chip is the claim to fame of this multimicrophone MEMS IC with an onboard amplifier. Produced by Akustica, it heralds the next technological revolution in acoustics for the hearing impaired and for cell phones.





- Accurate depth control
- Etching of large silicon surfaces
- High uniformity at **high etch rate** (>8µm/mn)

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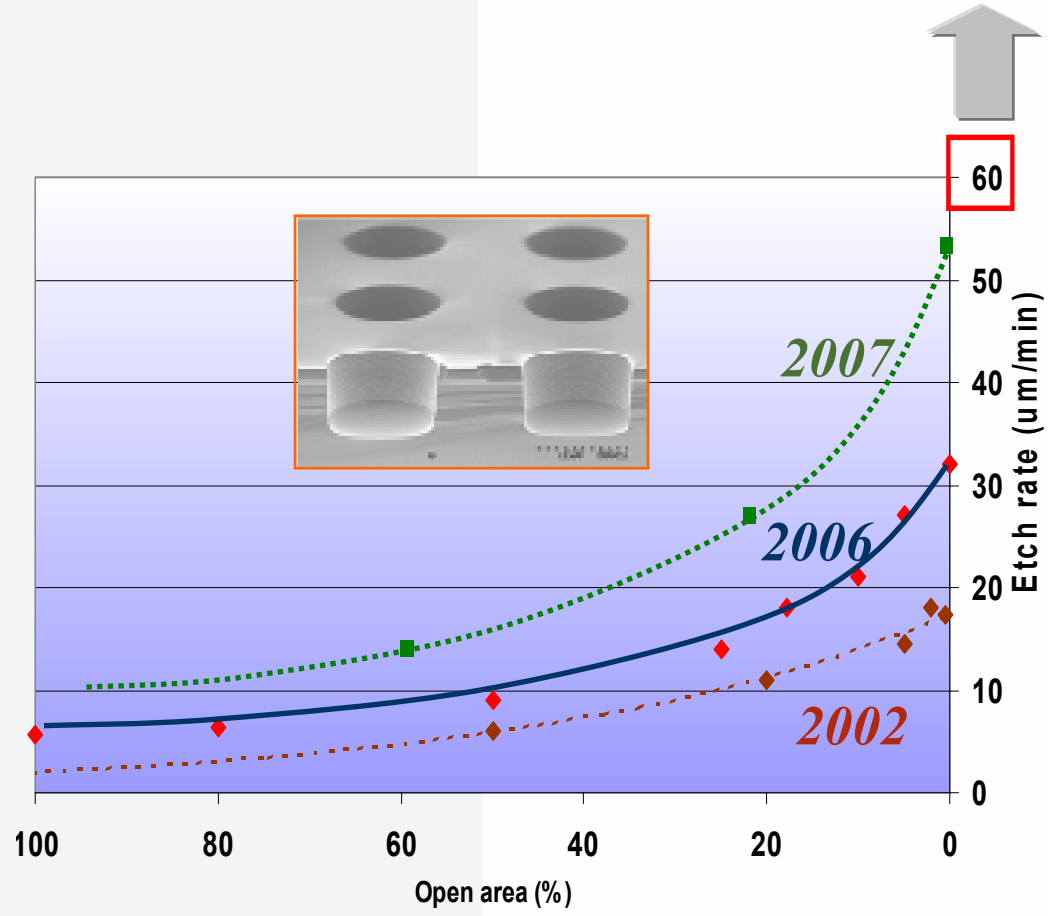
Technology leadership

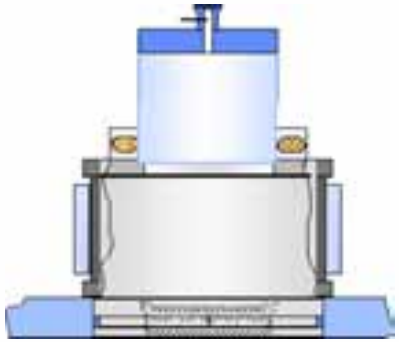


- Being first to push Bosch process limits and bring into market cost effective high etch rate capabilities

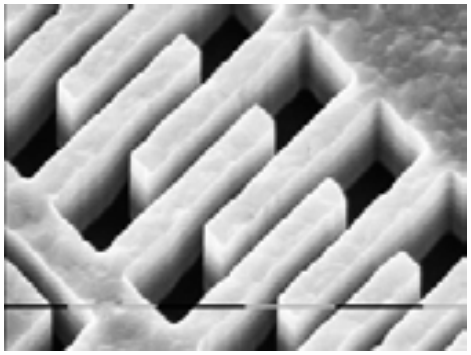
  (I-Speeder project 2001- cooperation with Robert Bosch)

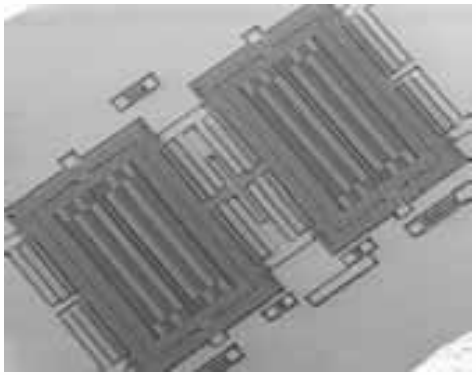
- Introducing MEMS **specific handling** and clamping solutions

- The only OEM providing both **Cryogenic and room temperature** etching capabilities

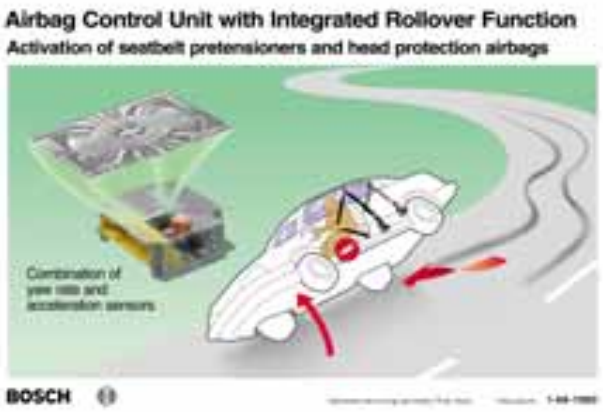


MEMS: Inertial sensors





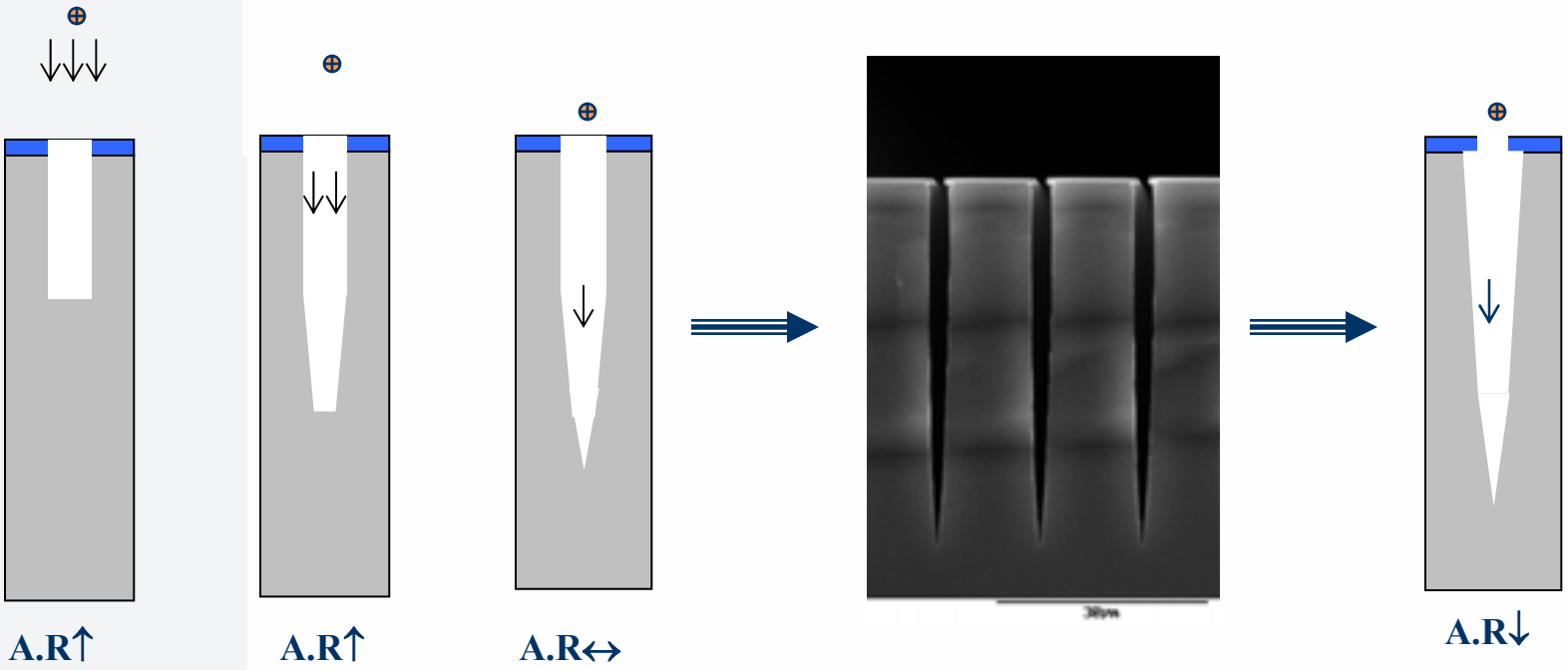
Coutersy of Robert Bosch



- Vertical profile control
- High uniformity at high etch rate
- Higher **Aspect Ratio**
- Etching of large and narrow features with controlled **ARDE**

Limitations

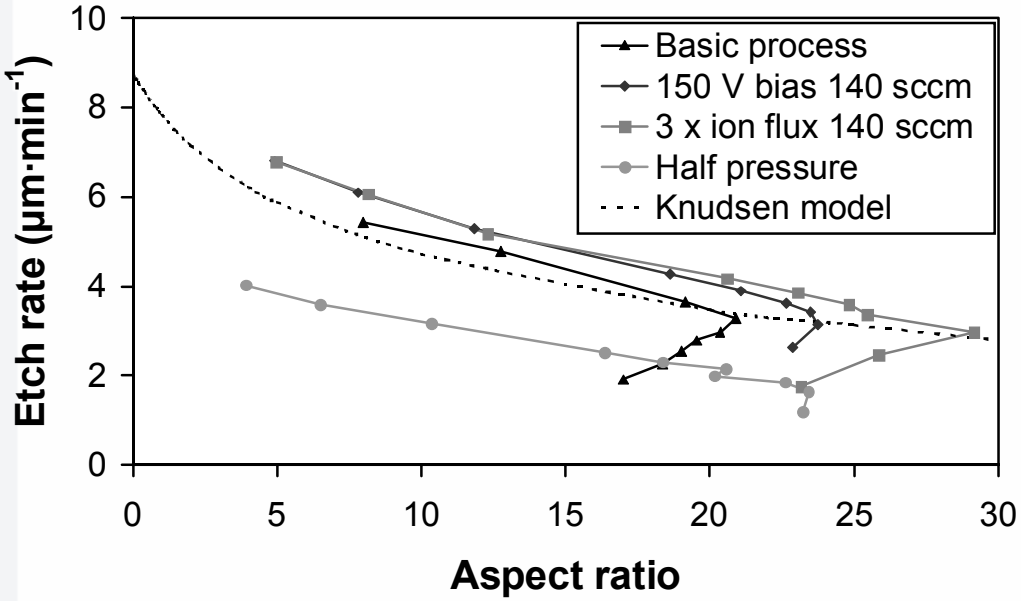
- Improper removal of bottom polymer layer



With standard “Bosch” process Aspect Ratio limited at 20

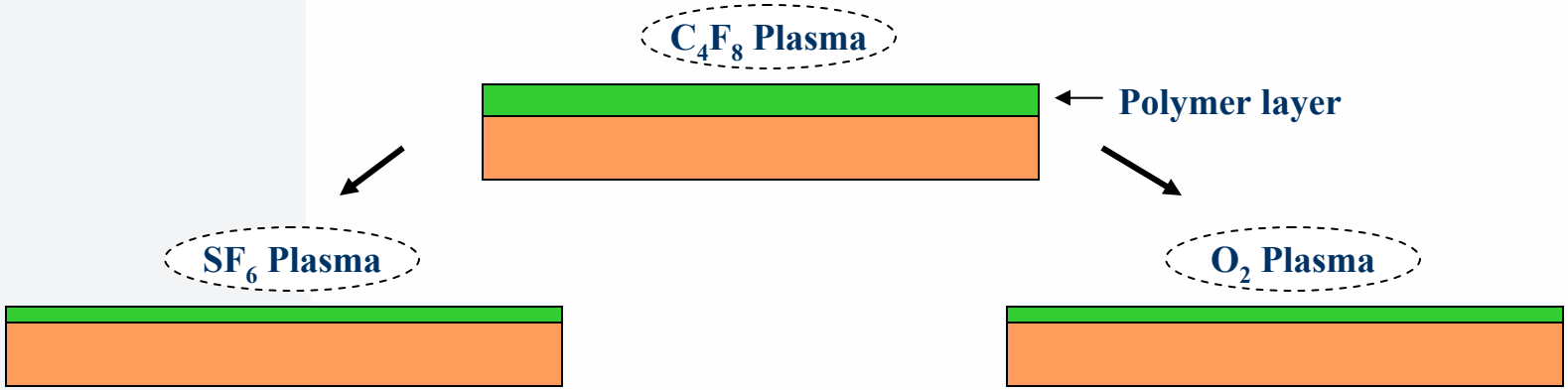
Standard ways of improvement

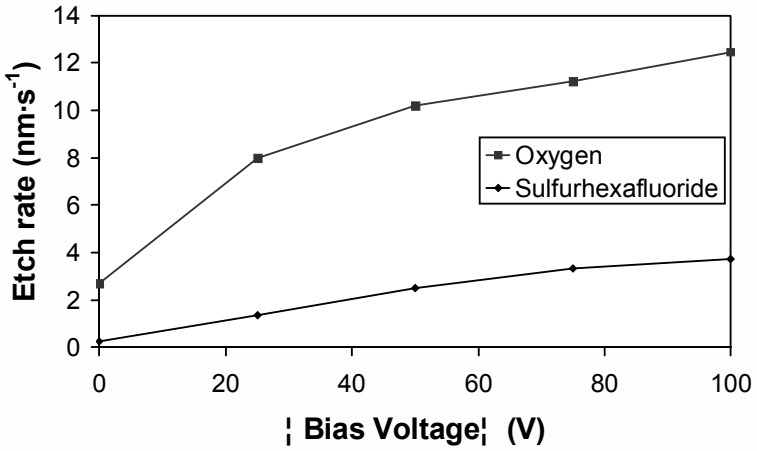
- Decrease process pressure, increase ion energy, ion flux



- Improved Aspect Ratio up to 30 but!
- Decrease of etch rate and/or selectivity

New way of improvement

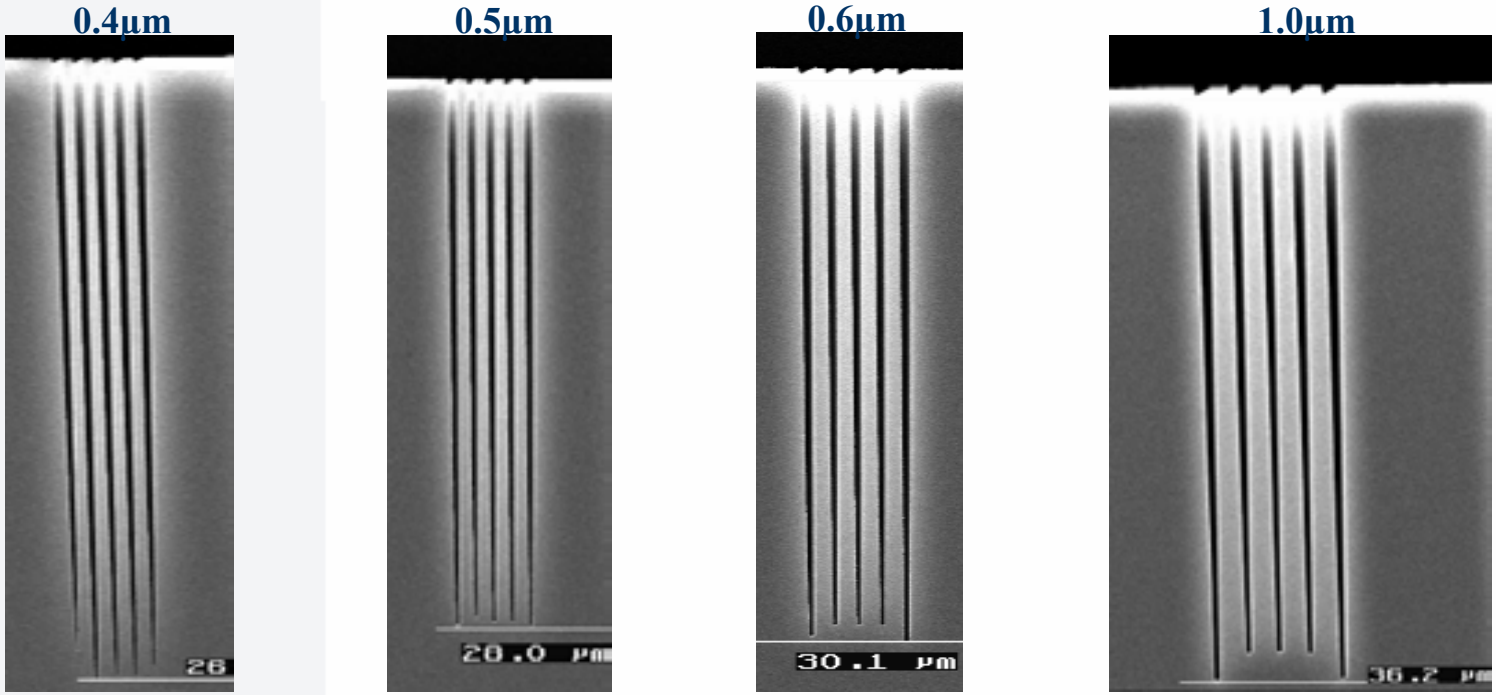




- O_2 Plasma removes polymer 5 time faster than SF_6!!
- [Polymer/Si]SF6 << 1 while [Polymer/ Si]O2 >>1

Process results

New Alcatel process with optimal polymer removal



Aspect Ratio > 60

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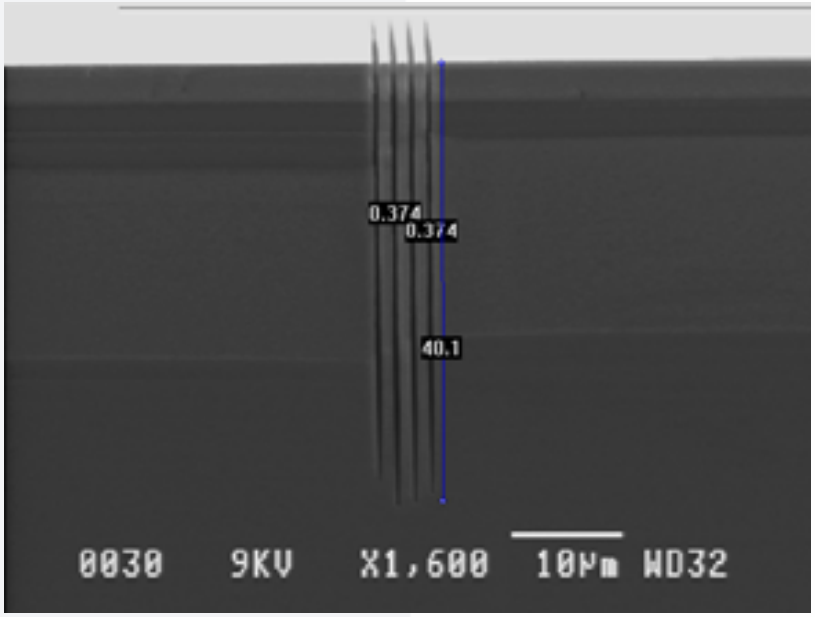
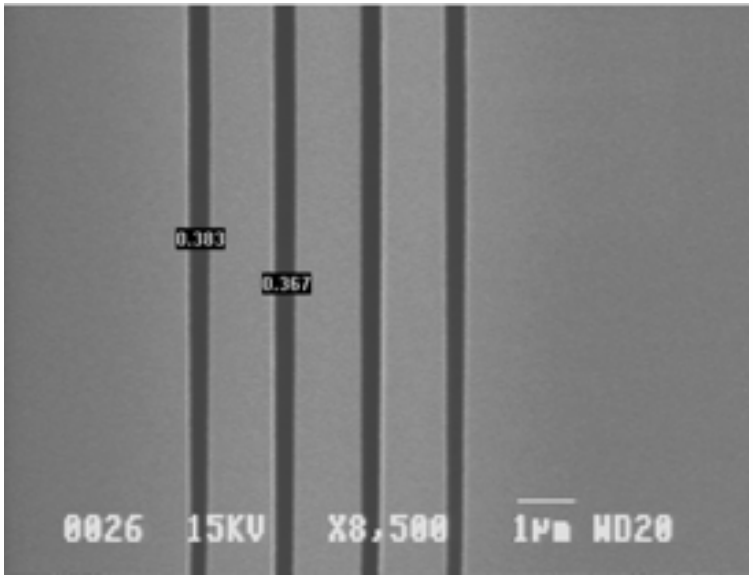
Patented
Super High Aspect Ratio Process



Trench Width: 0.374 µm
Depth: 40.1 µm

Aspect Ratio >100

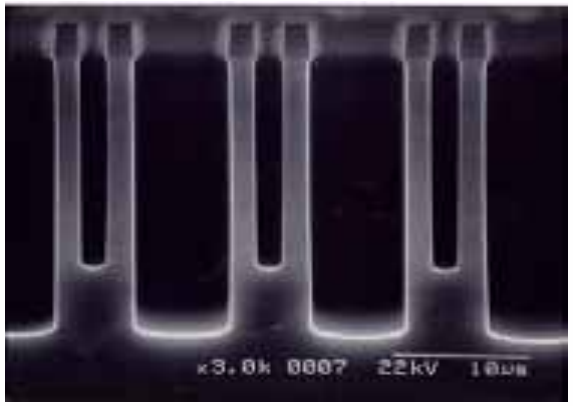


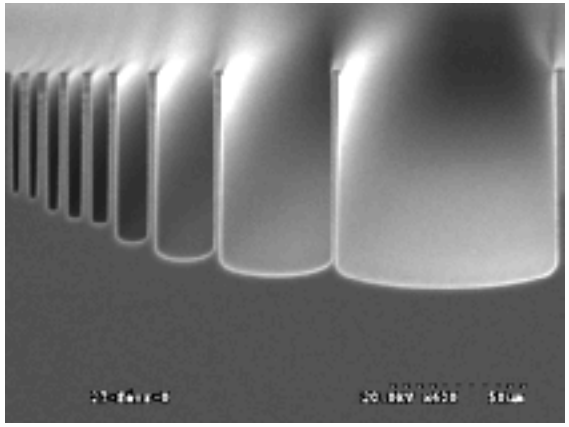
By courtesy of ESIEE - Paris

ARDE in DRIE Silicon Etching

ARDE is the physical effect where the etch rate decreases when increasing the aspect ratio.

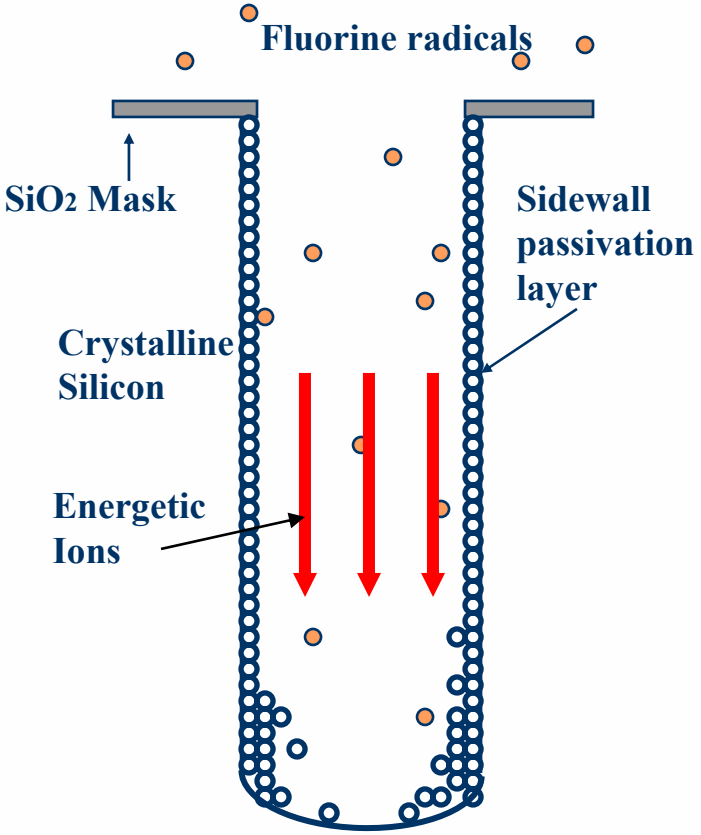
- Structures with different dimensions have non uniform etch rate.
- Complex devices cannot be made
  - Substrate with etch stop layer ⇒SOI wafers.
  - High over etch time to complete the etching of the narrow structures.





WHY ARDE ?

- **Radical's Depletion**
  - Knudsen transport
- **Ion Depletion**
  - Side wall scattering
  - Electronic deflection
  - Angular distribution



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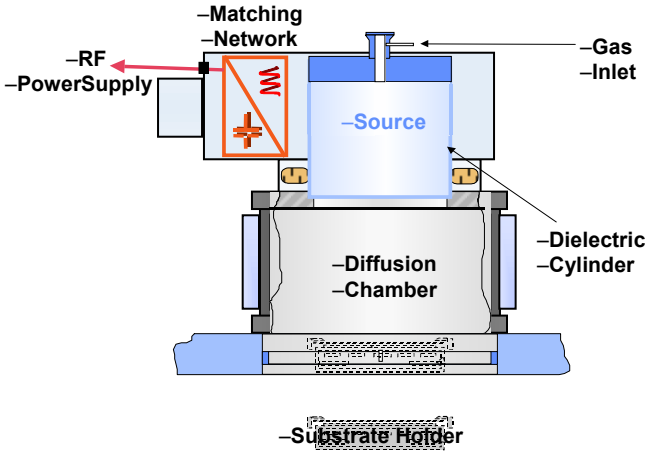
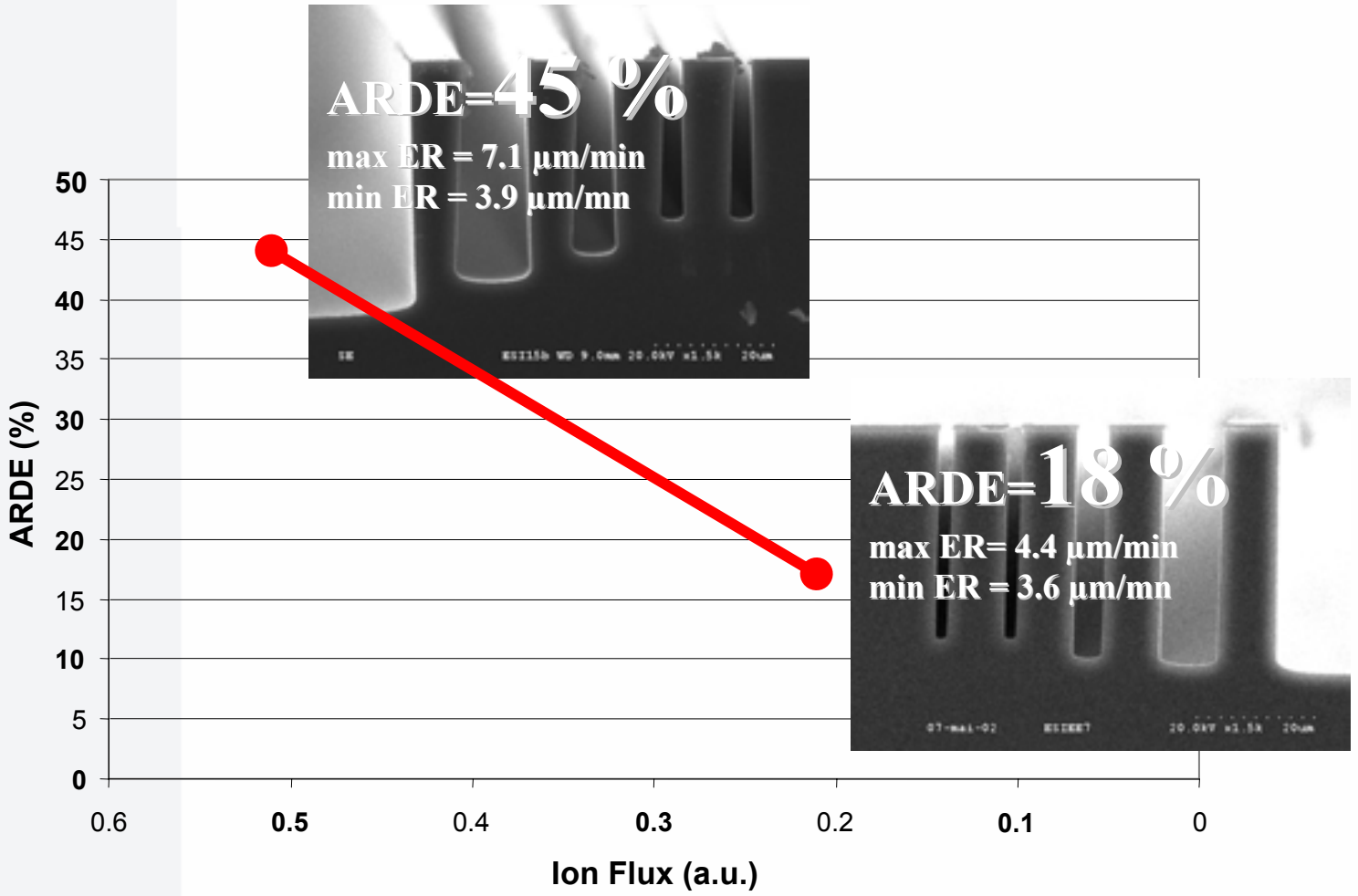
Experimental Setup

- AMS 200 “I-Speeder”
- Alcatel test wafers : trench widths 200/10 µm, 20% Si exposed area
- “Bosch” Process:Time multiplexed etch/passivation
- “ARDE” = (ER max - ER min)/ER max



Ion Flux Effect



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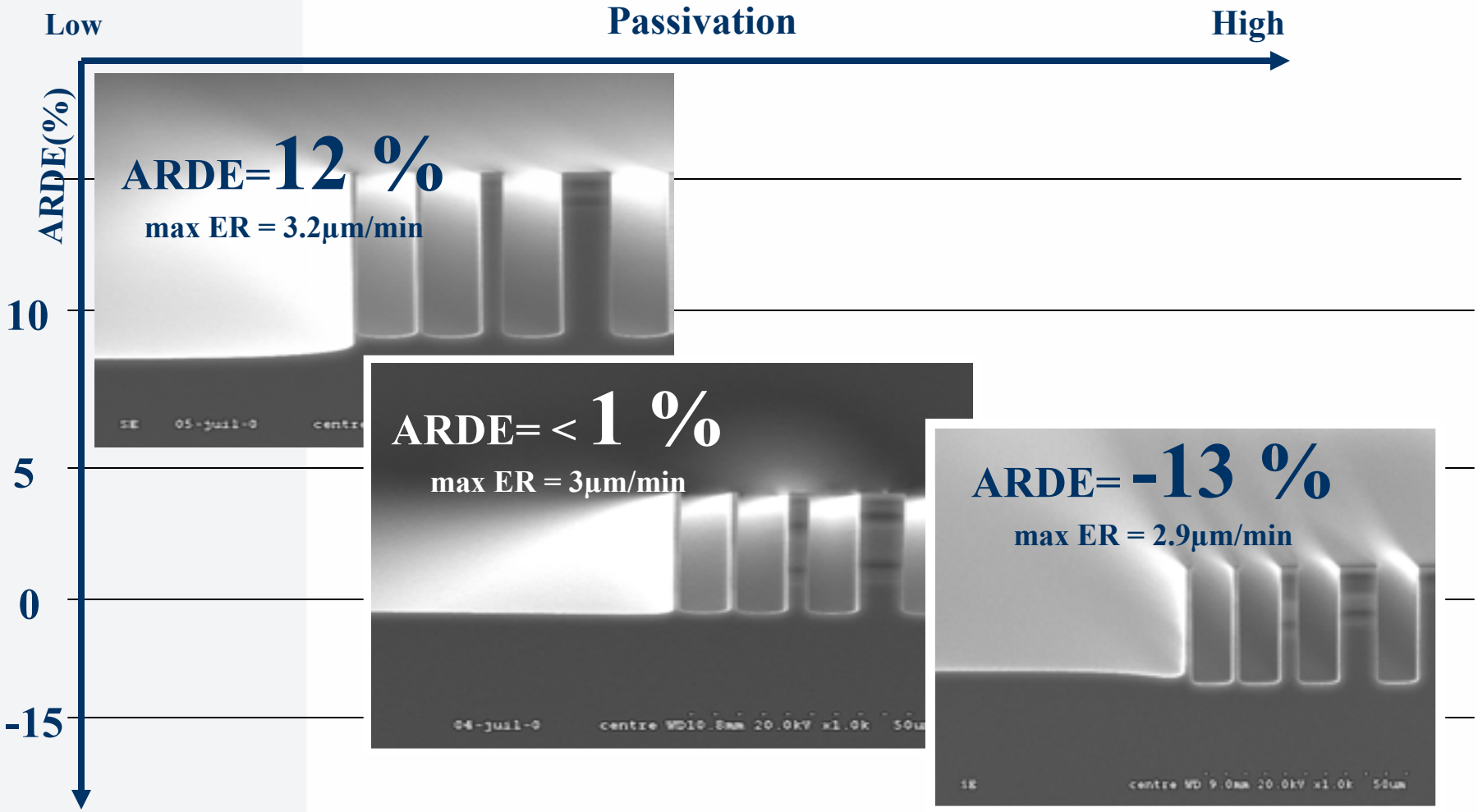
Passivation Control



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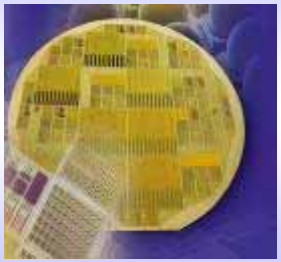
Conclusion

… from MEMS to Smart System Integration

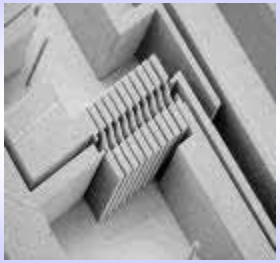
Semiconductor

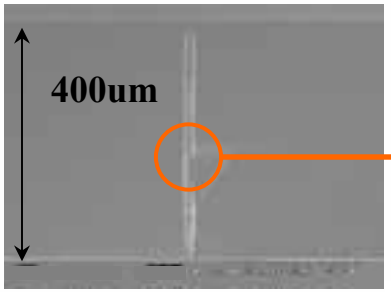


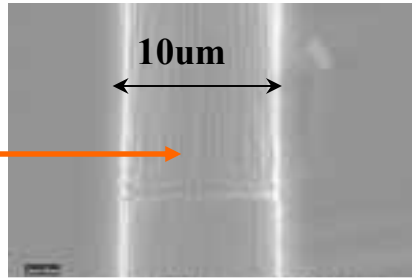
Manufacturing Tools 3D
- Deep Etching
- Lithography
- Bonding , …

3D SC
- 3D Chips
- Wafer Level Packaging

MEMS

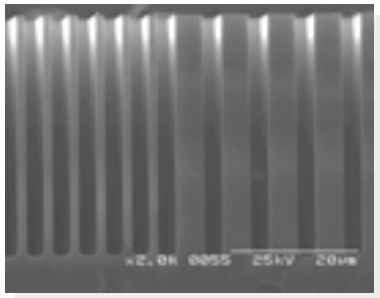






Courtesy of
ST Microelectronics

Courtesy of
Philips



Courtesy of
Toshiba

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