



MicroNanoFabrication Annual Review Meeting

Welcome !

- 7th MicroNanoFabrication Annual Review Meeting organized by the EPFL Center of MicroNanoTechnology (CMI)
- 8th will be organized by the CMI on May 8, 2007



May 16th, 2006



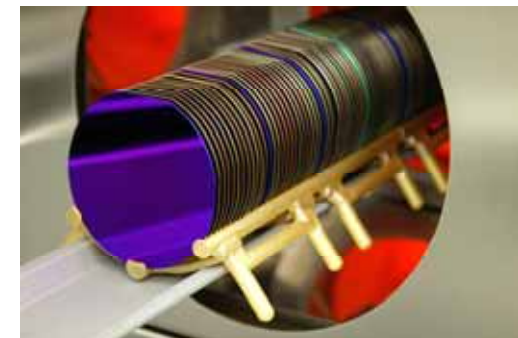
Ph. Flückiger



Thank You !

Many thanks to :

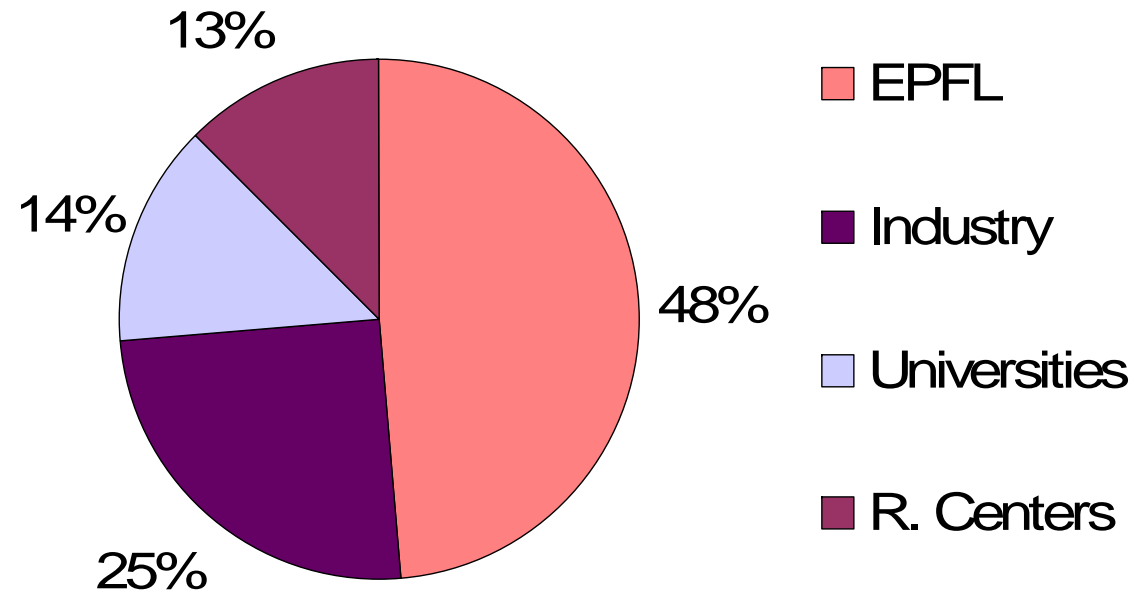
- the users of the CMI and the users of the COMLAB for submitting 140 abstracts
- the speakers
- the administration of EPFL who is strongly supporting the CMI
- Claudia for her administrative job
- all of you for taking the time to participate to this meeting





Participants (as of May 12th, 2006)

Total : 203 people (+10.1%)





Abstracts



STI-IMM-LEG-Ionescu	15
STI-IMM-LEG-Fazan	1
STI-IMM-LMIS-Brugger	18
STI-IMM-LMIS-Gijs	9
STI-IMM-LMIS-Popovic	3
STI-IMM-LMIS-Renaud	12
STI-CMI	6
STI-IMX-LC-Murali	6
STI-IMX-LC-Setter	1
STI-IMX-LTC-Manson	1
STI-IPR-LSRO2-Clavel	3
STI-IPR-LSRO1-Bleuler	1
STI-IOA-LOA-Salathé	1
STI-IOA-LOA-Hoffmann	3
STI-ITOP-NAM-Martin	4
SB-CIME-Buffat	3
SB-ISIC-LEPA-Girault	2
SB-ISIC-LGCB-Stockar	1
SB-IPMC-LCB-Meister	1
External laboratories	8
CSEM	4
Private companies	17
Training of students	4
Total	124

IMT-de Rooij	5
IMT-Koudelka-Hep	2
IMT-Staufe	2
IMT-Shea	2
IMT-Vettiger	1
CSEM	4
Total	16

The projects at CMI are driven by :

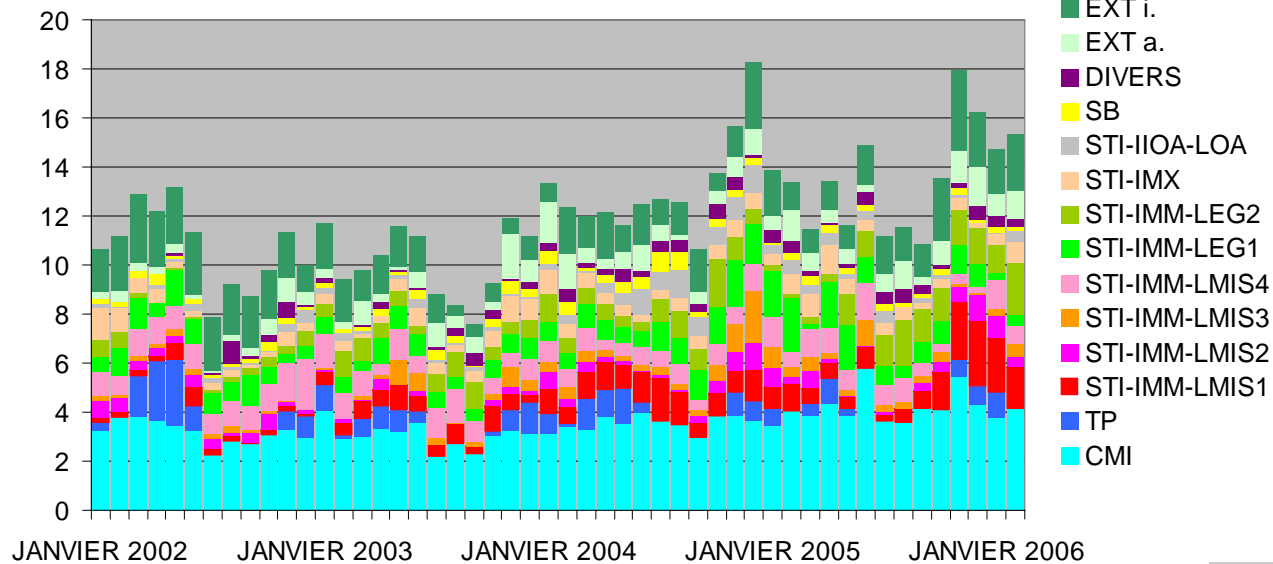
- 19 laboratories of EPFL (STI, SB)
- 7 external laboratories
- 12 private companies

+ 10% in 2006 compared to 2005



CMI Cleanroom Occupancy

Average number of people in cleanroom
Monday - Friday, 8h/day



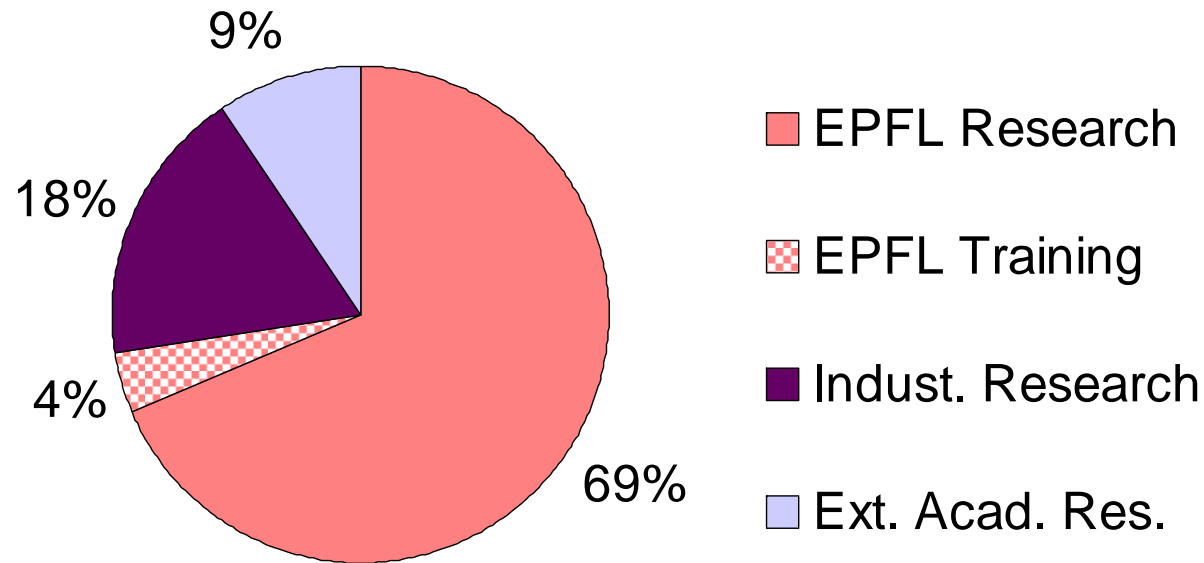
2004 : 13.1 people 8h/day
2005 : 13.3 people 8h/day

+ 1.5% in 2005 compared to 2004



CMI Cleanroom Activity (Staff Excepted)

Year 2005





CMI Finances

- CMI running costs in year 2005 (kCHF)**

Infrastructure : energy, N2, water, maintenance (covered by EPFL budget)	791
Processing : consumables, maintenance of processing equipments	1'156
TOTAL	1'947

+ 11% in 2005 compared to 2004

- CMI resources in year 2005 (kCHF)**

CMI User's Fees (consumables) and CMI Services Revenues	1'394
TOTAL	1'394

+ 35% in 2005 compared to 2004

Not included in this table are :
- the salaries of the staff
- the costs of the new investments



CMI Staff and Inventory

- Staff**

Number of people	15
TOTAL	15



- Inventory 2006 in kCHF**

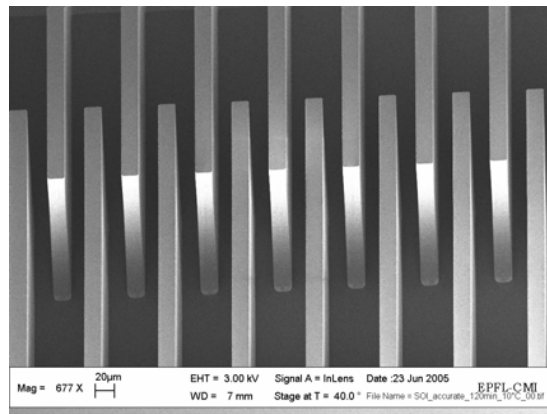
Infrastructure	13'000
Scientific Equipment (including ordered equipment)	21'000
TOTAL	34'000



Dry Etching

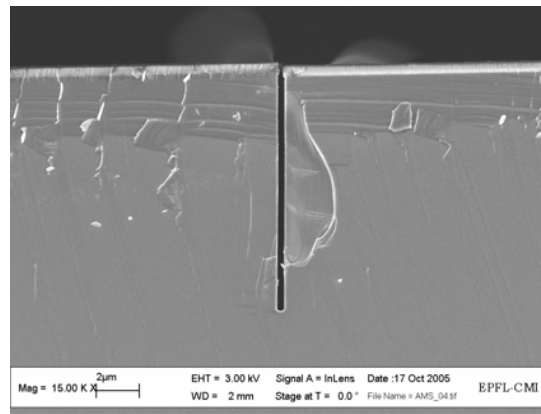
Process development with the AMS200 etcher from Alcatel

For more information: cyrille.hibert@epfl.ch



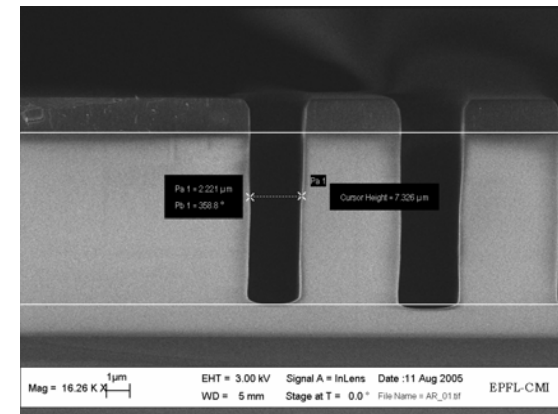
Silicon on Insulator (SOI)

- SOI 200µm
- no visible notching
- with 50% overetch



Nano gap in silicon

- aspect ration of 40
- 300nm wide
- 12µm deep



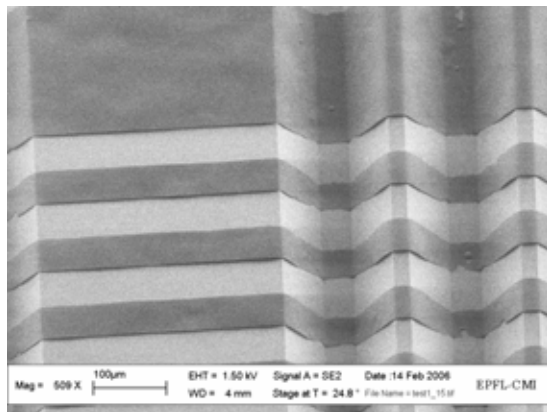
SiO₂ trenches

- 9µm SiO₂ (LTO)
- Poly Si mask
- AR 3.3
- ER 0.5µm/min

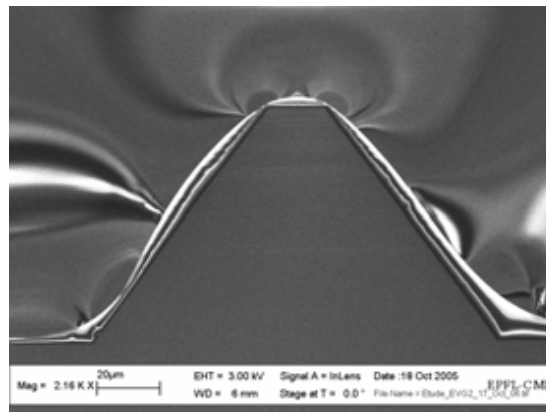
Spray Coating

Process development with the EVG150

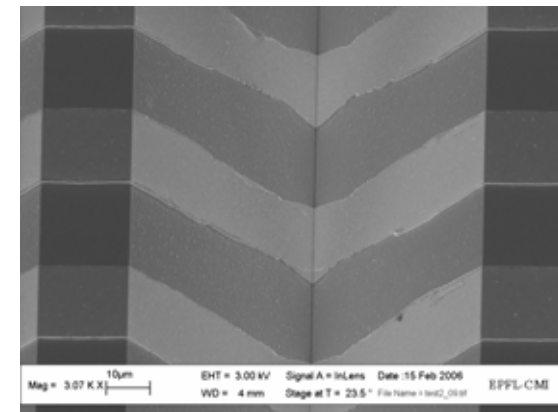
For more information: faouzi.khechana@epfl.ch and georges-andre.racine@epfl.ch



Patterned photoresist
- diluted AZ9260
- 150µm aluminium topography



Cross-section
- 150µm topography

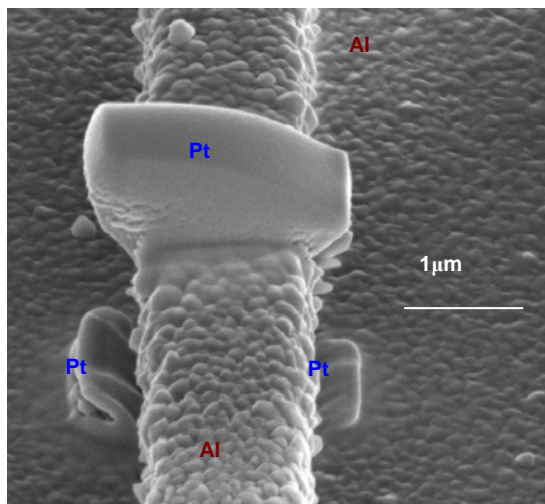


Dry etched aluminium
-70µm V-grooves

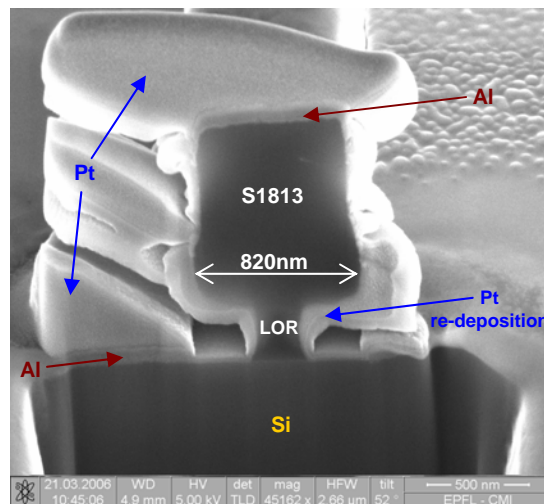
Lift-off

Process development with the EVG150, the RT and the LAB600H

For more information: jan.schildknecht@epfl.ch, philipe.langlet@epfl.ch and georges-andre.racine@epfl.ch



Protective Pt layer
- required for FIB analysis



Bi-layer LOR+S1813
- robust process
- for film thickness < 800nm
- for CD > 2.5µm

- example: 100nm Aluminium

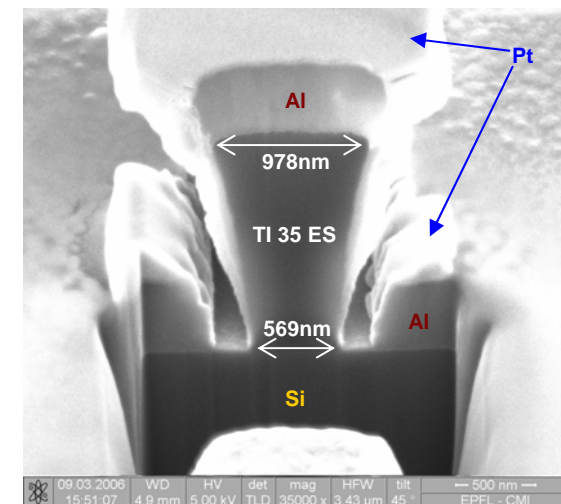


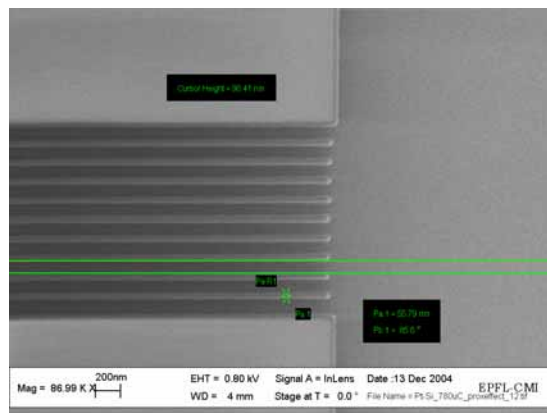
Image reversal TI35ES
- requires more accurate T control
- for film thickness < 1.2µm
- for CD > 1.5µm

- example: 300nm aluminium

EBeam Lithography (EBL)

Process demonstration done with the VISTEC EBPG 5000 plus ES

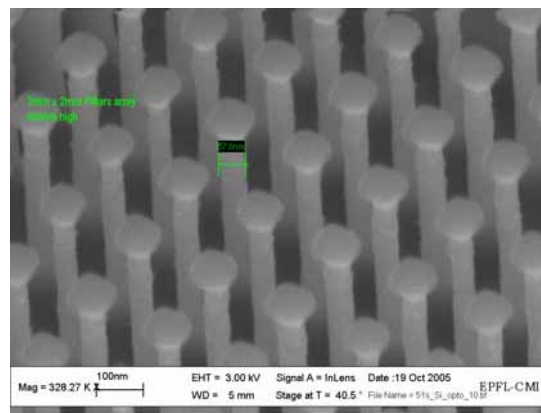
For more information: benjamin.dwir@epfl.ch and cyrille.hibert@epfl.ch



PMMA resist (positive)

- positive
- adapted for lift-off processing
- bi-layer possible for negative profile

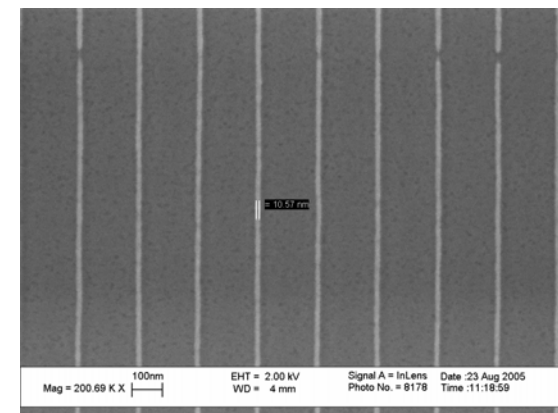
- 150nm thick PMMA
- $780\mu\text{C}/\text{cm}^2$
- 60nm lines



ZEP520 (positive)

- positive
- better plasma resistance
- higher sensitivity than PMMA

- 150nm thick
- $130\mu\text{C}/\text{cm}^2$
- 60nm x 600nm Si pillars
- 2mm x 2mm array (5nA)



HSQ (negative)

- negative
- very high resolution
- similar to SiO₂ after crosslinking
- good selectivity against Si

- 30nm thick
- $600\mu\text{C}/\text{cm}^2$
- 10nm lines



Arriving soon ...

- *<10nm lithography performance on axis*
- *<30nm lithography performance in 100mm field size*
- *100kV Field Emission Gun*
- *Beam current 100pA to 100nA*
- *20MHz pattern generator*
- *30nm (3σ) stitching accuracy*
- *30nm (3σ) overlay accuracy*
- *256 μ m field size*
- *<5nm spot size*

*Vistec (Leica) EBPG 5000 plus ES
To be delivered in autumn 2006*

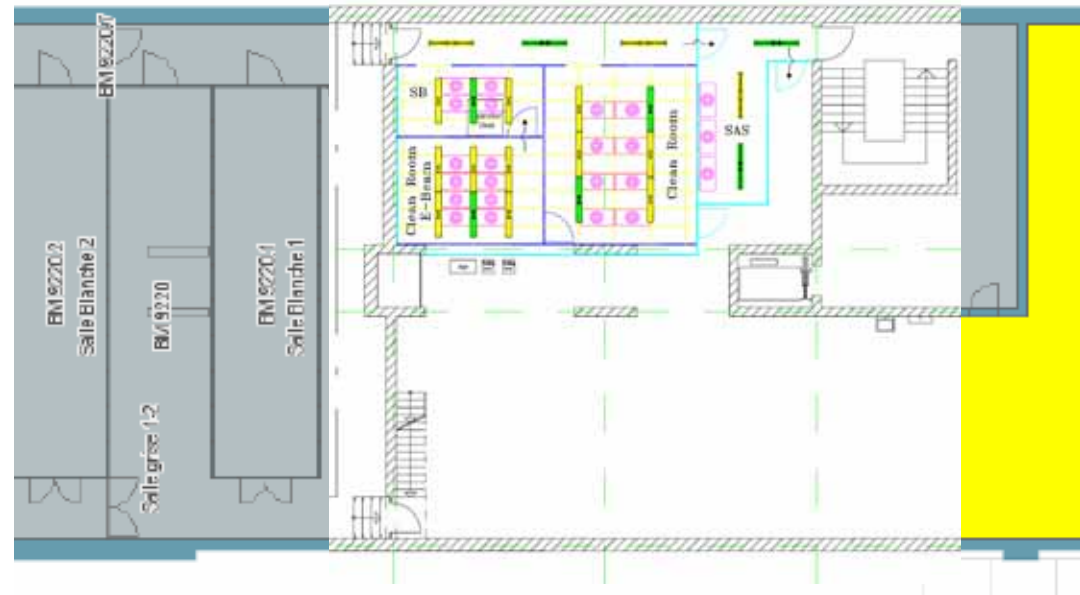




New Cleanroom for the EBL

New cleanroom:

- 80m²
- access from main cleanroom Z1
- access from outside



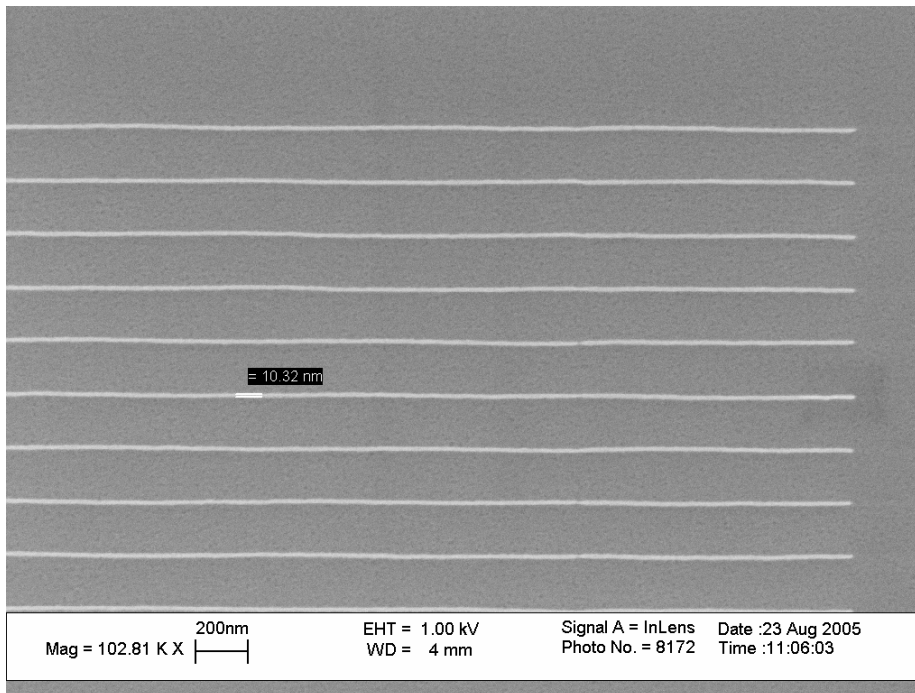
Specifications:

- temp. stability : within +/-0.25°C
- rate of change: within 0.1°C/hour



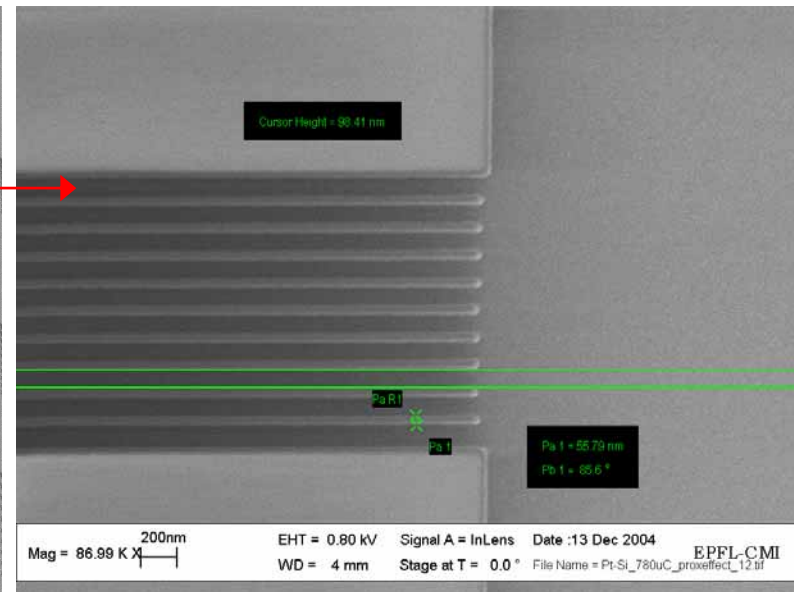
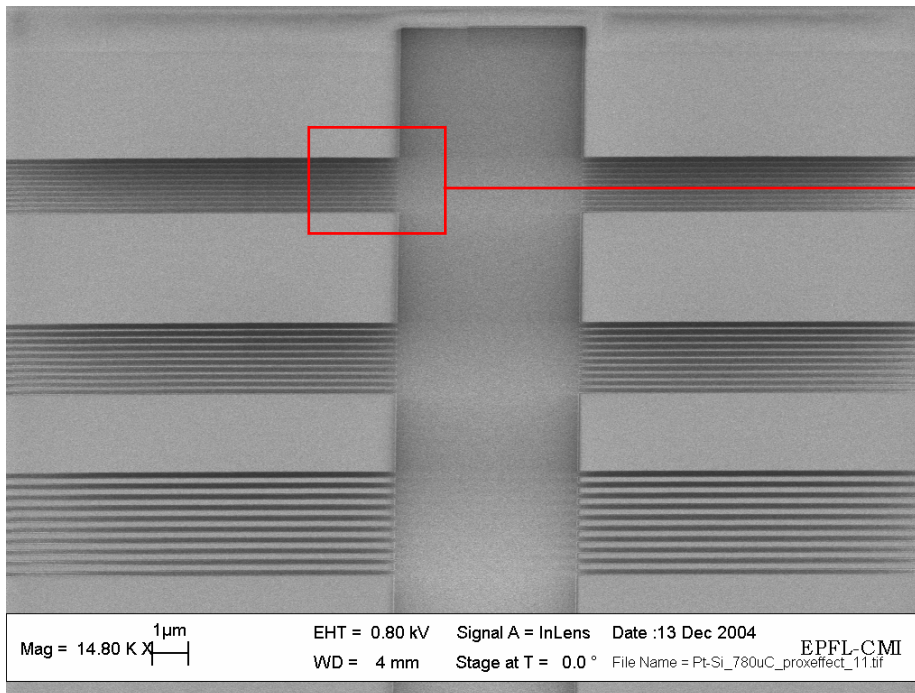
EBL Performances

- High resolution: 10nm lines in HSQ resist (obtained during live demo)



EBL Performances

- Reduced proximity effect (100kV)

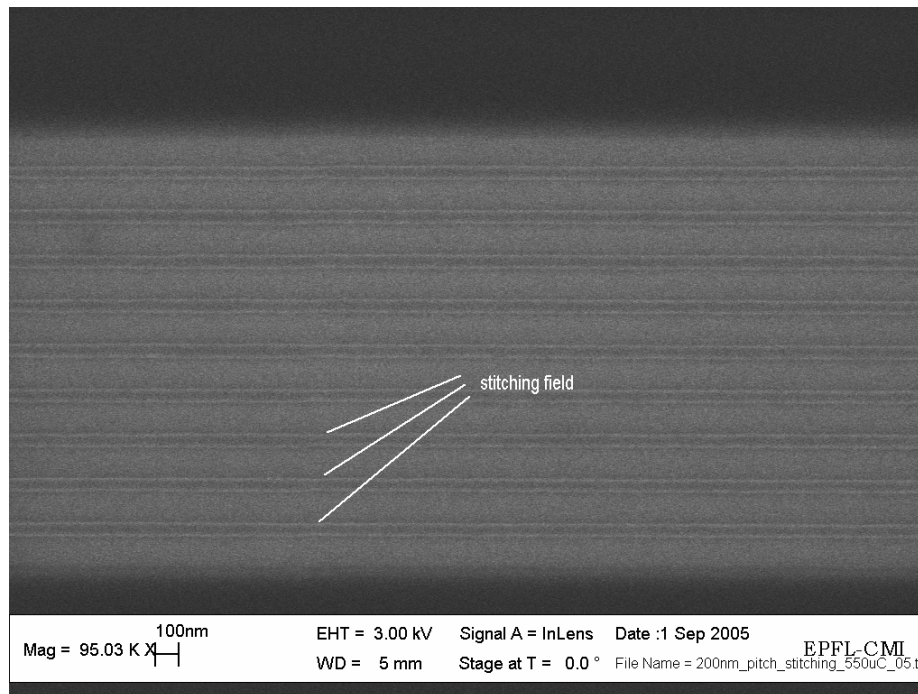


Leica EBP5000



EBL Performances

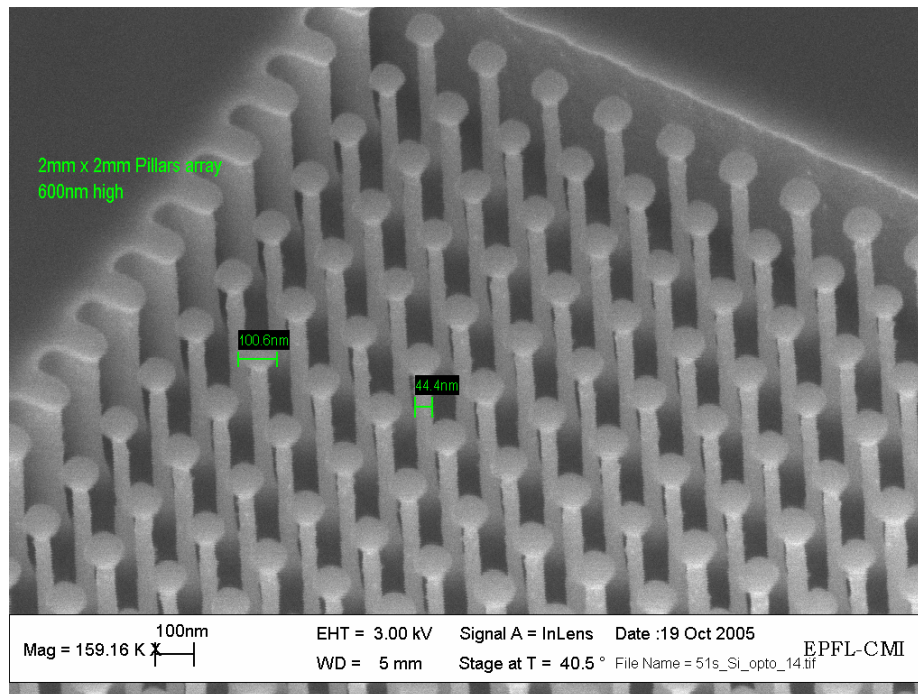
- Stitching accuracy better than 30nm (3σ)





EBL Performances

- Pattern transfer by plasma etching (ZEP520 resist)





Similar EBL tools installed in Europe

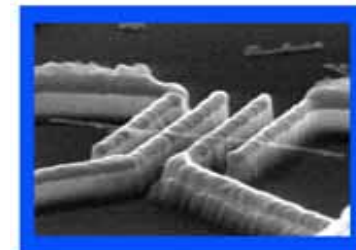
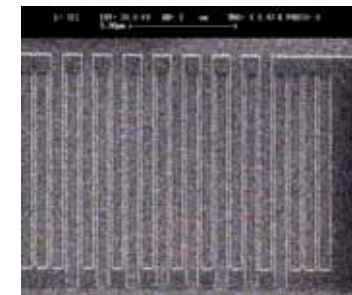
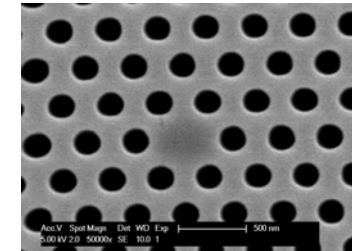
1. LPN/Marcoussis (2x),
2. IEMN/Lille
3. LETI/Grenoble (x4)
4. Chalmers/Göteborg
5. Dimes/Delft,
6. Tyndall/Cork
7. PTB/Braunschweig
8. HHI/Berlin
9. Univ./Hulm
10. Univ./Aachen
11. Res.Center/Juelich
12. Fraunhofer/Freiburg
13. KFK/Karlsruhe
14. Univ./Southampton
15. Univ./Cambridge
16. Univ./Glasgow
17. DTU/Denmark
18. CNR/Roma
19. Some others ?



Ongoing EBL Projects @ EPFL

1. Physics

- Photonic crystal microcavities, **SNSF**, Prof. A. Fiore
- Nanostripes of NbN, **NCCR+EU**, Prof. A. Fiore
- Contacted CNT, **NCCR & EU**, Prof. L. Forro
- Transport in inorganic wires, **NCCR**, Prof. L. Forro
- Spintronics, Prof. J.-Ph. Ansermet
- Magnetic information storage, **SNSF**, Prof. H. Brune

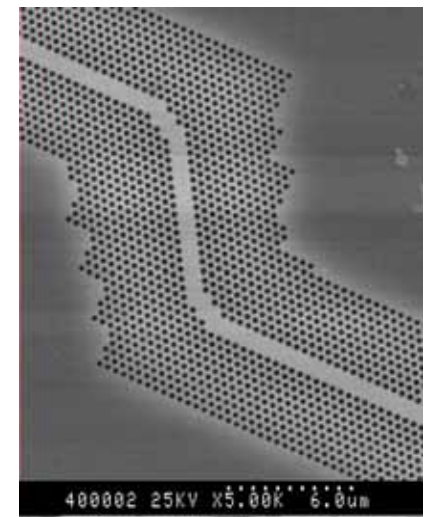
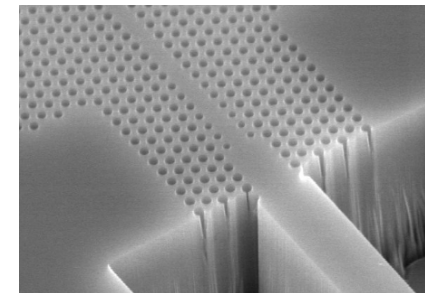




Ongoing EBL Projects @ EPFL

2. Optoelectronics

- Photonic Crystals, **NCCR+EU+SNSF**, Prof. M. Ilegems
- III-nitride photonics, **NCCR+SNSF**, Prof. M. Ilegems
- Pyramidal QD structures, **NCCR+SNF**, Prof. E. Kapon
- Photonic Crystals, **OFES**, Prof. E. Kapon
- VCSEL arrays, **SNSF**, Prof. E. Kapon
- Quantum Wires, **SNSF**, Prof. E. Kapon
- Substrates for Epi Growth, **SNSF**, Prof. E. Kapon
- DNA-based wires, **EU**, Prof. E. Kapon
- Nitride based light emitters, **NCCR**, Prof. N. Grandjean
- Quantum dot spectroscopy, Prof. N. Grandjean

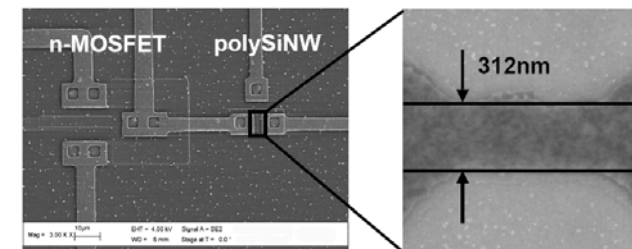
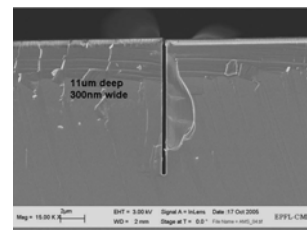
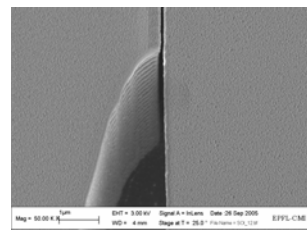
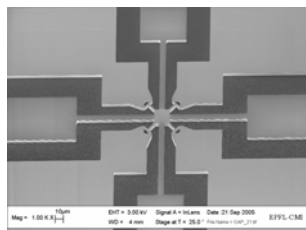
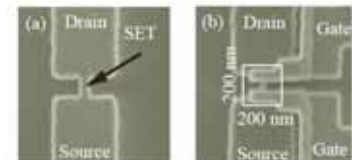
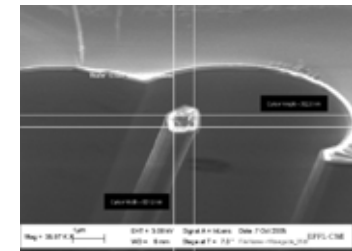
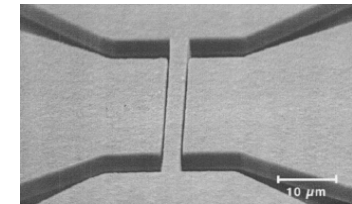




Ongoing EBL Projects @ EPFL

3. Microelectronics

- Resonators, **2xEU (NanoTimer, MIMOSA)**, Prof. A. Ionescu
- Gate all-around optical modulators, **ST**, Prof. A. Ionescu
- Single electron transistors, **EU+SNSF**, Prof. A. Ionescu
- CMOS Integrated circuits, **EU+SNSF**, Prof. A. Ionescu
- Chip post processing, Prof. E. Charbon



May 16th, 2006

Ph. Flückiger

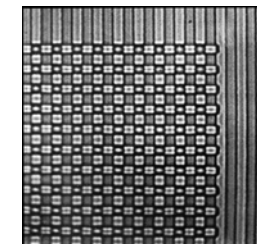
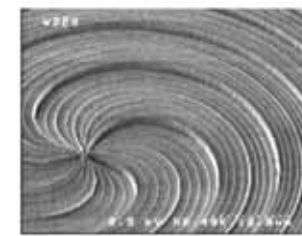
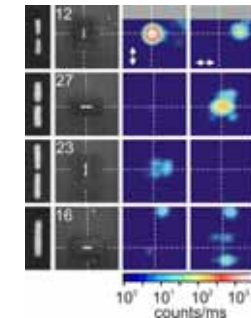
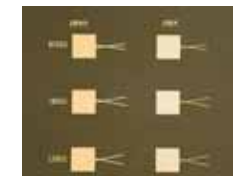
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Ongoing EBL Projects @ EPFL

4. Photonics

- Plasmo-nano-devices, **NCCR+SNSF**, Prof. O. Martin
- Light manipulation using plasmons, **NCCR+SNSF**, Prof. O. Martin
- Molecules confinement, **SNSF**, Prof. O. Martin
- Metamaterials for Antennas, Prof. O. Martin
- Sub-lambda diffractive structures, Prof. Th. Lasser
- Nanoholes for molecules manipulations, **SNSF**, Prof. Th. Lasser
- Diffractive optics, Prof. P. Jacquot
- Nanogrippers, P. Hoffmann





Ongoing EBL Projects @ EPFL

5. Chemistry

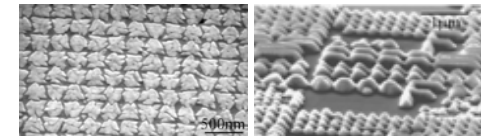
- Electrochemical cells, **SNSF**, Prof. Ch .Comninellis
- Diamond electrodes, **SNSF**, Prof. Ch .Comninellis
- Patch clamp devices, Prof. H. Vogel



Ongoing EBL Projects @ EPFL

6. Material Sciences

- Site controlled growth of PZT, **COST**, Prof. P. Muralt
- Piezoelectricity vs feature size, **COST**, Prof. P. Muralt
- Piezo devices, **EU**, Prof. P. Muralt
- Ferroelectrics arrays, **EU Nanostar**, Prof. N. Setter
- Ferroelectric on GaN 2DG substrates, **SNSF**, Prof. N. Setter
- 2D photonic crystals with organic molecules, Prof. L. Zuppiroli

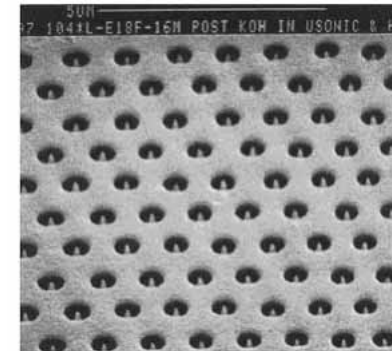
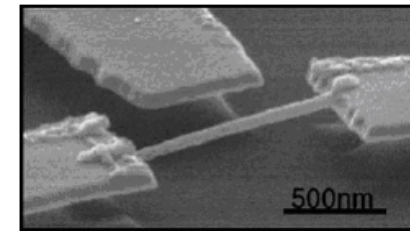




Ongoing EBL Projects @ EPFL

7. Microsystems

- Fluidic devices, Prof. Ph. Renaud
- MEMS-based ion propulsion, **ESA**, Prof. H. Shea
- Mechanical reliability, **CIMENT**, Prof. H. Shea
- Nanostencils, **EU**, Prof. J. Brugger
- Nanopores for biochips, **KTI+EU**, Prof. J. Brugger
- Templates for cell culturing, Prof. J. Brugger
- NIL masters, **CTI**, Prof. J. Brugger
- Pd H₂ sensors, **EU**, Prof. J. Brugger





Ongoing EBL Projects @ EPFL

8. Life Sciences

- Biological surfaces, Prof. J. Hubbell
- Resists chemistries for biology, Prof. J. Hubbell



EBL Users Classification @ EPFL

1. EBL is Mandatory for 11 labs

Ansermet
Brugger
Fiore
Forro
Grandjean
Ilegems
Ionescu
Kapon
Martin
Muralt
Setter

2. EBL is essential for 11 labs

Brune
Charbon
Comninellis
Hoffmann
Hubbell
Jacquot
Lasser
Renaud
Shea
Vogel
Zuppiroli

TOTAL: 22 laboratories (+ many others ...)



Conclusions

- The research activity at CMI is increasing years after years
- 26 laboratories and 12 private companies are currently using the CMI cleanroom
- Good balance between teaching activities, academic research and industrial research
- Finances are OK
- The process library at CMI is getting reinforced
- A powerful Electron Beam Lithography system will be installed in 2006





Enjoy your conference !

- Thank you for your attention and enjoy your conference