ICTS "Sala Blanca Integrada de Micro y Nanofabricación"

IMB-CNM (CSIC) managed

and

GICSERV PROGRAM

(Gran Instalación Cientifica SERvicio)

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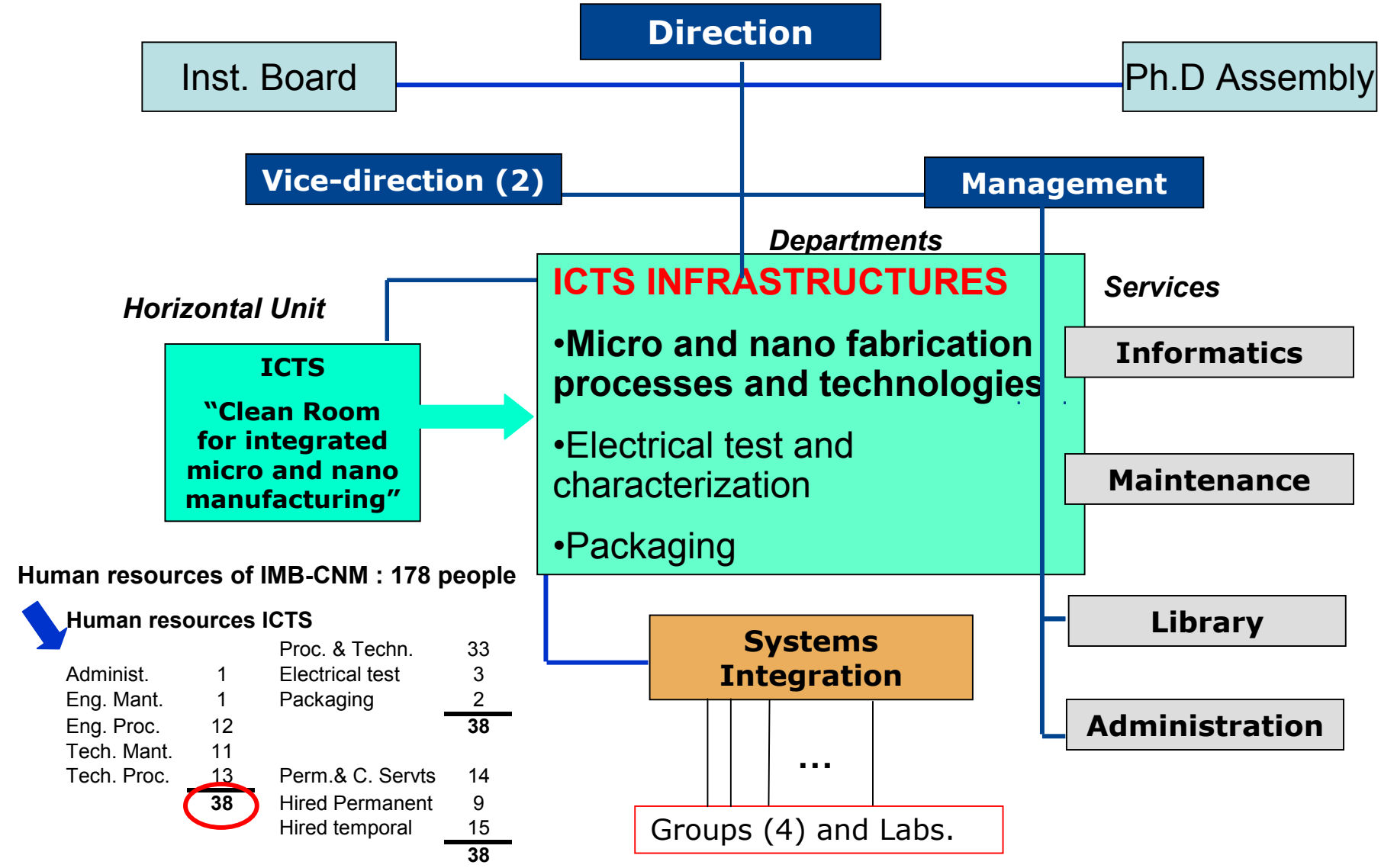
Director CNM

Presentation outline

- IMB-CNM (CSIC)
- The IMB-CNM “Sala Blanca integrada de nano y microfabricación” ICTS. Capabilities
- Access to the ICTS. The Program GICSERV
- Nanolithography Area of the ICTS

Answers to specific questions (260509 Zaragoza Nanolithography Network Meeting)



Human resources of IMB-CNM : 178 people

Human resources ICTS

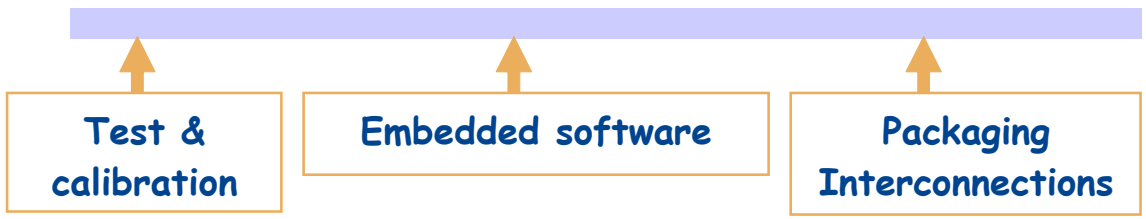
		Proc. & Techn.	33
Administ.	1	Electrical test	3
Eng. Mant.	1	Packaging	2
Eng. Proc.	12		**38**
Tech. Mant.	11		
Tech. Proc.	13	Perm.& C. Servts	14
	38	Hired Permanent	9
		Hired temporal	15
			38

2 M€ /year (2008) ordinary budget (Chapters I and II)

128 different users during 2003-2007 (IMB-CNM is one of them)

IMB-CNM Research focus

IMB scientist and research activities boost, support, reinforces and back up the technological capabilities within the ICTS



The activity numbers of the ICTS' CLEAN ROOM

	2003	2004	2005	2006	2007*	2008	Average
Capacity ("runs")	305	340	352	400	278	377	**342**
Number of steps	5.832	6.521	7.248	6.668	3.976	5.099	**5.891**
Nb. Wafers	2.427	2.471	1.906	1.838	1.462	1.948	**2.009**

(*): Since May 2007 the Clean Room slowed down its activities because the expansion works. Now a days the activity is increasing

Note – 289 runs have been launched during 1T2009

ISI PUBLIS	2003	2004	2005	2006	2007	Total
Artl/Books Ch.	35	61	60	92	84	**332**
Congress	106	72	126	144	129	**577**
	141	133	186	236	213	909

Numbers refers to output within IMB, where the role of the ICTS has been determinant

Projects& Contracts	2003	2004	2005	2006	2007	Total
National Projects	8	7	14	31	44	**104**
International projects	1	2	4	7	1	**15**
National contracts	14	14	9	10	10	**57**
International contracts	14	11	10	7	18	**60**
Total	**37**	**34**	**37**	**55**	**73**	**236**

Numbers refers to projects / contacts within IMB, where the role of the ICTS has been determinant


IMB-CNM now a

1500 m2 Clean room

~~1000 m2 Clean room~~

- **Integrated nano &micro**
- **Combines CMOS and MST type process**
- **Fully 4”, partially 6”**

Micro and nano fabrication processes and technologies INFRASTRUCTURE

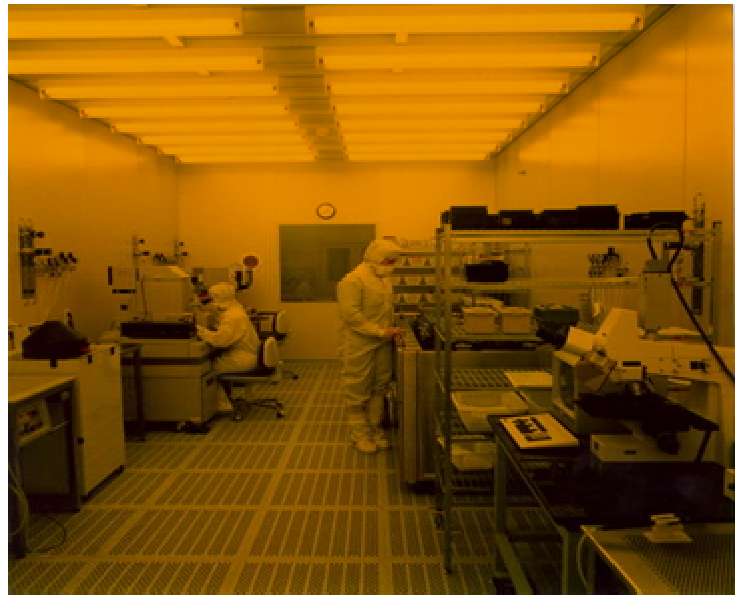
CLEAN ROOM

Main CR

- 1.500 m²
- House in house structure
- Class 100-10,000

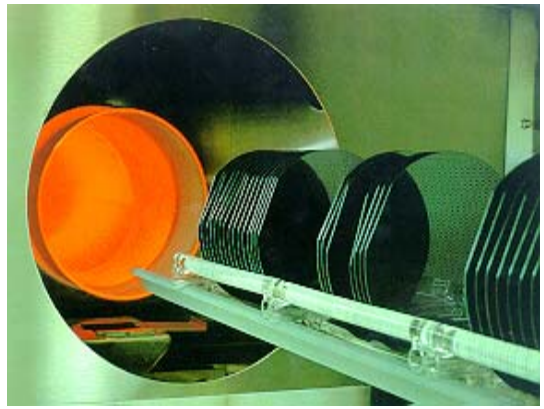
Basement CR

- 40 m²
- Class 10-10,000



Clean Room Equipment (more than 150 units)

- Thermal processes, CVD and ALD
- Ion Implantation
- PVD and Metallisation
- Lithography (proximity and stepper)
- Nano-lithography (electron beam, AFM and nano-imprint)
- FIB (*ICN owner*)
- Direct laser writing
- Dry etching
- Wet and dry micromachining
- Wet etching and cleaning
- In line test
- Wafer grinding and CMP
- Sawing & bonding
- Electrical characterization



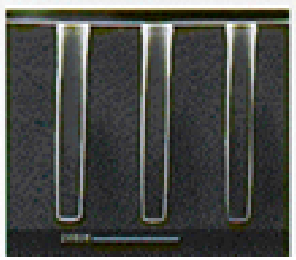
"Technologies"

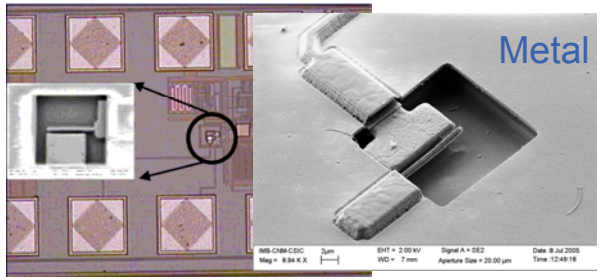
TECHNOLOGY	TYPE	CHARACTERISTICS	APPLICATION
CNM-CMOS	CMOS	2 poly - 2 Metals	Analog / Digital
CNM POWER	Lateral and vertical DMOS	Double Diffusion	Power devices
SiC	Power diodes, JFETs, MOSFETs, MESFETs, HT sensors	Planar and MESA Technology (1.8 mm)	Power, High Temperature and Biomedical devices
CNM MST	Si sensors and actuators	Piezo, Bulk / Surface micromachining	Microsystems
CNM-ISFET	NMOS	Floating Gate FETs	Chemical Transducers
MCM	Si substrstes	Active substrates and flip-chip	Multi-chip modules
CNM-TOI	Si Integrated Optics technology	Dielectrics and Polymers	Integrated Optical Components
NANOFABRICATION	Si Nano-mechanical estructures	Surface Nano-machining. Min. Feature size: 100nm	Nano-mechanical and Nano-electro-mechanical systems

Some Views of the ICTS' main Clean Room

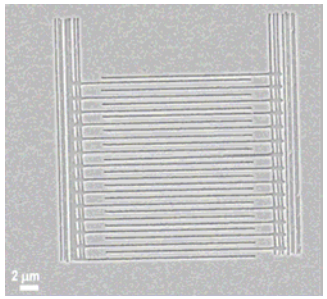
Examples of technological achievements

High aspect ratio (24:1) trenches (RIE)



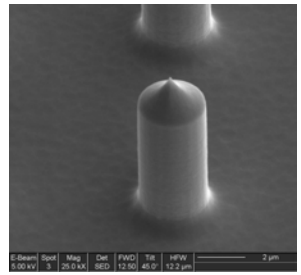


Releasing of NEMS structures on commercial 0.35-0.18 µm CMOS

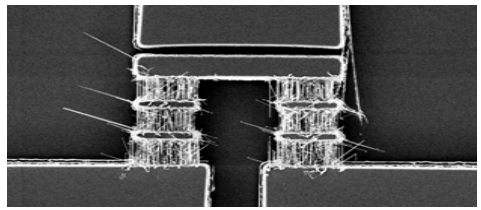


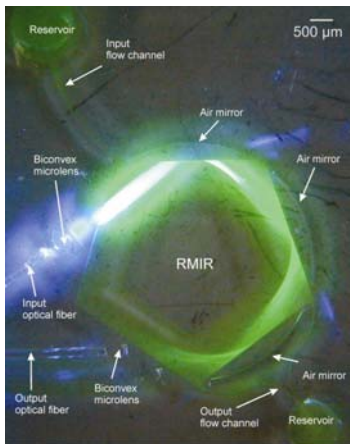
AFM nanolithography (<50 nm lines)

Mixed isotropic/ anisotropic RIE



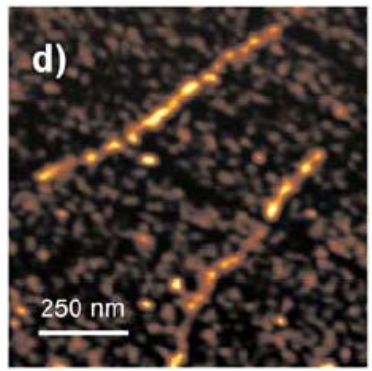
Selective growth of Si nanowires

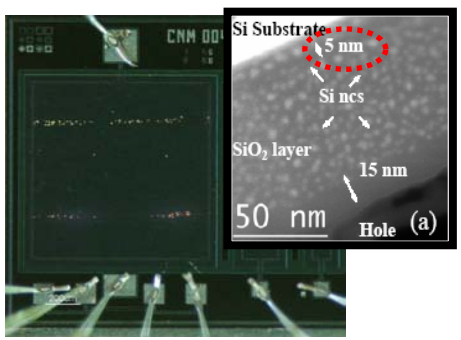




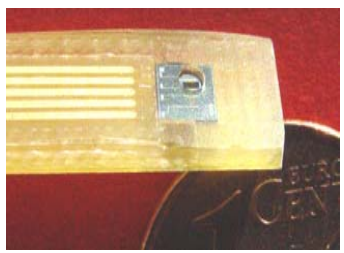
Polymer/SU-8 processing

Gas-phase soft-lithography at nm scale





Si nanodots on dielectric matrix



Specific sensor packaging

COMPLEMENTARY ICTS LABORATORIES

(under IMB-CNM management and operation)

- **Integrated Circuits** and systems Lab.
- **Power** Circuits and Systems **characterization** Lab.
- **Thermal reliability** Lab.
- Biochemical Systems **characterization** Lab.
- **Advanced packaging** Lab.
- Lab. of **systems integration**
- **General Chemistry** Lab.
- **Chemical Transducers** Lab.
- **Integrated Optics** Lab.
- **Microsystems Characterization** Lab.
- **Sensors** Lab.
- **Reverse Engineering** Lab.

ICTS selective/differential advantages

- LSF devoted to **micro and nano micro** technologies, **open access** with different modalities
- Strong **link to IMB-CNM** gives scientific support
- Recognized as **official ICTS**, former GIC (since 1994), former European LSF (2000)
- Technological **differential advantages**
  - Full CMOS line with a high flexibility
  - Integrated micro-nano fabrication
  - Monolithic integration of CMOS with MEMS and NEMS processes
  - Fully operability in 100 mm wafers and partial in 150 mm wafers
- Dynamic **entourage** and specially interesting collaboration and links (UAB, BNC, ISOM, IMM, …)
- Additional (but partial) degree of flexibility provided through **"D+T Microelectrónica, AEI"**

OPERATION OF ICTS

- **Industrial-like operation** assures stability, avaibility and repeativity of process and technologies. Development of process and equipments in this frame can be envisaged
- **Human resources** and their organization according to this premise (with unfortunately with some “lacks”)
- **Cost issues**: All the access have economical impact (no free access, even for CNM researchers). The operation of the ICTS must be self sustained (CSIC ordinary budget + access fees).
- **Process** can be classified in general terms as **standard ones** (although they can be hard and/or complicated), needing trimming or **customization** or needing **development**. According to this more or less fuzzy qualification, acceptation by ICTS will be conditioned
- All the **technology** being developed and / or applied within the ICTS, remains at **ICTS disposal** for being applied to others projects (although intellectual property belongs to the inventors). Even if some aspect is patented, free use of technology for the ICTS should be guaranteed. Only exception can be foreseen if development pre-agrees to pay real accessing costs & profits
- **Operation modality**
  - Under commandment (so called “ **encomienda**”). 20 years experience
  - Under **QUALIFIED self service**. Started 1,5 years ago. Needs normative and regulations

ACCESS TO ICTS:

- **Internal accesses :ICTS is the main experimental laboratory of IMB-CNM.** So a first duty (not necessarily a continuous priority) is to give support to IMB-CNM R&D projects and contracts

- **External Accesses to ICTS (** from any user, some rest… GICSERV modality). Aproximately 50% of ICTS wo… shift work)

Open access of ICTS is only i…

Any other way to get a… and willingness of IMB-CNM, in the f… d/or reciprocity when applies with… sitary departments (example : CSIC l… ent …).

GICSERV, the CNM's calls
(Funded by MICINN's "Access to ICTS" program)

…up temporarily linked to IMB through a common R&D …

- Specially linked groups / centers to CNM: BNC, Associated Units
- Linked to IMB spin-offs (when an specific agreement is established)
- Under contractual relationship
  - Universities and research centres (CPIs)
  - Technological centers
  - Industries and commercial companies
- **GICSERV** (no economical charges on the project)

GICSERV PROGRAM (for CNM's ICTS)

- Access projects **open** to any scientist **from UE**

- **MICINN regulation** of proposals
  - Type 1 : pre doctoral researchers with an approved Doctoral thesis Project
  - Type 2 : Postdoctoral researchers or researchers with more than 5 years of practice
  - Type 3 : Same of 2 , but researchers being involved in a research project that lacks funding for complementary assays

- **CNM's ICTS regulation** of access
  - Type A : projects "order request" ("encomienda")
  - Type B : under not qualified self service (CAD tools, mask design tools, electrical characterization equipments,…)
  - Type C : under "qualified self service" (hard to obtain)

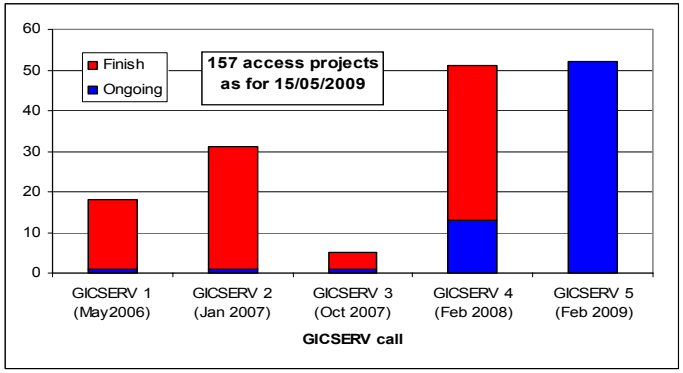
  (for types A&B one weak and traveling cost for one person is provided)

- **Project size** and magnitude aspects should tailor the proposal
  - The projects needs to be developed "approximately" within the year
  - The allocated funds for the Project should be "approximately" enough for the foreseen tasks
  - One week stage and travel expenses are paid when necessary

- **Additional materials** should be supplied by the applicant if necessary

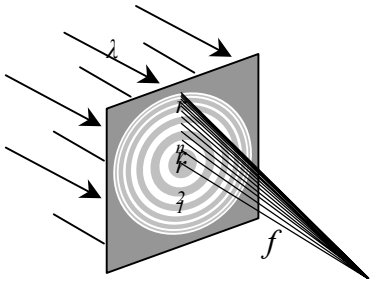
- An internal-to-CNM **"tutor" or scientific supervisor** is designed for each project .

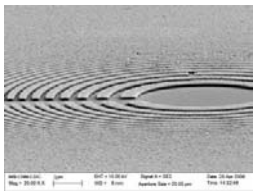
- **One call** (December year X, to be evaluated in February- March X+1 by an **External Committee**, after a **technological feasibility** advice from ICTS staff)

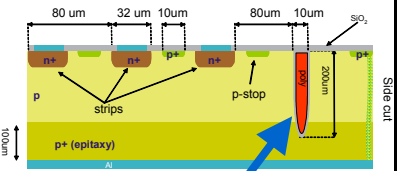


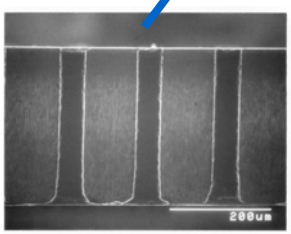
ICTS' Access Program "GICSERV"

- Funded by MEC / MICINN
- Free access to projects approved by an External Evaluation Committee









GICSERV 2006-9 Projects Thematic Field	DE	CC.AA. Andalucia	CC.AA. Aragón	BLG	CC.AA. Cantabria	CC.AA. Castilla Leon	Cataluña	CC.AA. Valencia	FNLD	Galicia	ITL	Madrid	NDL	Bask Country	UK	CC.AA. Valencia	TOTAL
Biology							5	1			3	5	1			1	16
Characterization							1										1
Design			1														1
Energy							1										1
Photodevices							6	1			1	2				2	12
High energy physics					1		1								1		3
Materials							1										1
Microelectronic devices		1		1			3			1		1			1	1	9
Microelectronic process		1				1	2					4			2		10
Microelectronic sensors	1	1	1		1		2		2		2	1		1	3		15
Nanoelectronic devices						5	18					2					25
Nanoelectronic process							1										1
Nanolithography							17	1				4				1	23
Physics							1										1
RF electronic devices							1										1
Si Micro&Nanosystems		1	1				20	2			2	2					28
Spintronics							1										1
SU-8 Microsystems		4					3										7
Training												1					1
Total	1	8	3	1	2	6	84	5	2	1	8	22	1	1	7	5	157

12,7% From Foreign country

53,5% From Catalonya (local- not CNM)

33,8% From other Spanish sites

Geogr. & Type center origin	R&D Cent	CSIC	Univ	
Foreign country	6		14	20
Rest of Spain	11	17	25	53
Cataluña ("local"-not CNM)	10	13	61	84
	27	30	100	157

Call	Dead date	Res. Date	Nb. Proj.
1st	30/03/2006	30/05/2006	18
2nd	30/12/2006	30/01/2007	31
3th	30/09/2007	15/10/2007	5
4th	30/01/2008	01/03/2008	51
5th	30/01/2009	28/02/2009	52
			157

Detailed normatives, policies and regulations

Availability: IMB-CNM intranet and/or **web** and/or “Portal of ICTS”

V 1.0 **Indice de NORMAS , PROTOCOLOS, REGISTROS Y DOCUMENTOS ICTS**

intra net	web/ porta l	Tipo	Nombre	Estado	Contenido
X	X	Nota	**GIGORG 0**	Vigente v 8.1	Requisitos y conocimientos para ACCEDER a la SB de la ICTS
X	X	Protocolo	**Protocolo 0.1**	Vigente v 7.0	Protocolo de conocimientos para acceder a SB Principal (requiere la firma del interesado)
X	X	Protocolo	**Protocolo 0.2**	Vigente v 2.0	Protocolo de conocimientos para acceder a SB Sotano (requiere la firma del interesado)
X		Nota	**GIGORG 1**	Vigente	Mandato de la Comision GICORG
X		Nota	**GIGORG 2**	Vigente	Papel de responsables de Lineas /Areas en procesos de cualificacion para Autoservicio
X	X	Nota	**GIGORG 3**	Vigente v 3.0	Descripcion del proceso a seguir para la cualificacion de usuarios
X	X	Nota	**GIGORG 4**	Vigente v 3.5	Descripcion del proceso a seguir para solicitar runes por "encomienda"
		Nota	**GIGORG 5**	construcción	Sobre la informatizacion de la documentacion ICTS
		Nota	**GIGORG 6**	construcción	Bases de calculo para tarifas de acceso a la ICTS
		Nota	**GIGORG 7**	construcción	Procedimiento para dar de alta nuevas etapas estandar para BACO+
		Nota	**GIGORG 8**	construcción	Sobre fabricación de máscaras de fotolitografía
X	X	Nota	**GIGORG 9**	Vigente v 1.0	Forms used within the ICTS
X	X	Nota	**GIGORG 10-1**	Vigente v 2.1	Bases, Procedimientos y normas especificas del Area NANO de la ICTS
X	X	Video Clip	**SAS1**	Vigente	Video clip sobre entrada en SB a traves de SAS 1
X	X	Video Clip	**SAS2**	Vigente	Video clip sobre entrada en SB a traves de SAS 2
X	X	Video Clip	**BEHAV**	Vigente	Video clip consejos de comportamiento en SB
X	X	Lista /Registro	**LIDERAC**	Vigente v 1.0	Lista de equipos abiertos al regimen de autoservicio cualificado
X	X	Lista /Registro	**EQUIPOS**	Vigente v 1.0	Lista de equipos instalados en la ICTS
		Lista /Registro	**LUC**	Vigente	Lista de usuarios cualificadis
		Lista /Registro	**REPAS**	Vigente	Lista de personas con cualificación 0.1
		Lista /Registro	**REPASS**	Vigente	Lista de personas con cualificación 0.2
X	X	Formulario	**1-190309-PR-1**	Vigente	Formulario de solicitud de la cualificación 0.1 (entrar en Sala Blanca)
X	X	Formulario	**2-190309-PR-2**	Vigente	Formulario de solicitud de la cualificación 0.2 (entrar en Sala Blanca Sótano)
X	X	Formulario	**3-170409-GO4-**	Vigente	Formulario de descripción de proyecto externo al CNM por "encomienda"
X	X	Formulario	**4-170409-MST-**	Vigente	Formulario de "Faena especial" para Microsistemas por "encomienda"
X	X	Formulario	**5-170409-NL-1**	Vigente	Formulario de "Faena especial" para Nanolitografia en un acceso por "encomienda"
X	X	Formulario	**6-150509-LUC-**	Vigente	Formulario de solicitud de cualificacion en un equipo
		Formulario	**7-180509-LIDER**	construcción	Formulario de solicitud a la Dirección de la ICTS para abrir un equipo a LIDERAC
X	X	Formulario	**8-150509-NL-2**	Vigente	Formulario para obtener la clave software para operar el equipo RAITH 150 Two

LIDERAC: Lista De Equipos abiertos al Regimen de Autoservicio Cualificado

Ultima Puesta al dia 29-abr-09

# LIDERAC	Equipo clave ICTS	EQUIPO ICTS: Descripción	Area / servicio	Responsable	Meses sin refresco	Abierto a uso de "Autoservicio cualificado" el…	Compatibilidad CMOS*: C,M,X
1	N7	FIB Zeiss 1560 XB	Nano	Xavier Borrisé	TBF	25-feb-07	M
2	K1	SEM Hitachi (no en SB)	Metal - Caracteriz	Jose Calvo	TBF	01-may-08	M
3	N2	E beam Raith 150, EBL para 4"	Nano	Xavier Borrisé	TBF		X
4	N6	E beam SEM Zeiss Leo 1530	Nano	Xavier Borrisé	TBF	25-feb-07	X
5	N8	AFM Nanoacope IV& Dim 3100	Nano	Xavier Borrisé	TBF	26-feb-07	X
6	N4	NIL- Obducat 4"	Nano	Xavier Borrisé	TBF	27-feb-07	M
7	N5	NIL- NPS 300	Nano	Xavier Borrisé	TBF		M
8	K4	Sputtering Biorad E-5000 (no en SB)	Metal - Caracteriz	Jose Calvo	TBF	01-may-08	M
9	C11	Microscopio (perfilometro) optico confocal	Microsistemas	Marta Duch	TBF	dic-08	X
10	F23	SB6 Karl Suss sustrate bonder	Microsistemas	Marta Duch	TBF	26-feb-09	M
11	N9	Optical Microscope in Nano Area	Nano	Xavier Borrisé	TBF	29-abr-09	X
12	C1	Ellipsometer	Caract.- Furnaces	Miguel Zabala	TBF	29-abr-09	C

Notas:

La Sala Blanca tiene una tecnología CMOS de referencia y se deben garantizar las condiciones adecuadas para poder mantenerla. Igual ocurre con otras tecnologías equivalentes o compatibles. Por ello se deben evitar los posibles riesgos de contaminación en equipos y otros utensilios. Estos riesgos son básicamente de dos tipos: a) Iones alcalinos (Na, K), y b) Contaminantes metálicos tales como algunos metales nobles (Au, Pt, Pd, Ag) porque son casi imposibles de eliminar por medio de los procesos de limpieza convencionales que usamos en SB. Los equipos más críticos son los hornos de oxidación-difusión. Se aplica un criterio basado en la clasificación siguiente de los equipos:

a) Equipos limpios **(C)**: únicamente pueden procesar muestras compatibles con la tecnología CMOS.
b) Equipos MNC **(M)**: pueden procesar muestras “contaminadas”, por ejemplo con metales nobles.
c) Equipos mixtos **(X)**: pueden ser considerados como limpios o como MNC según usemos unos accesorios u otros.

Main axes of the ICTS strategic Plan

The actuations to perform are directly derived from the **objectives** and the **strategies**. They follow three axes:

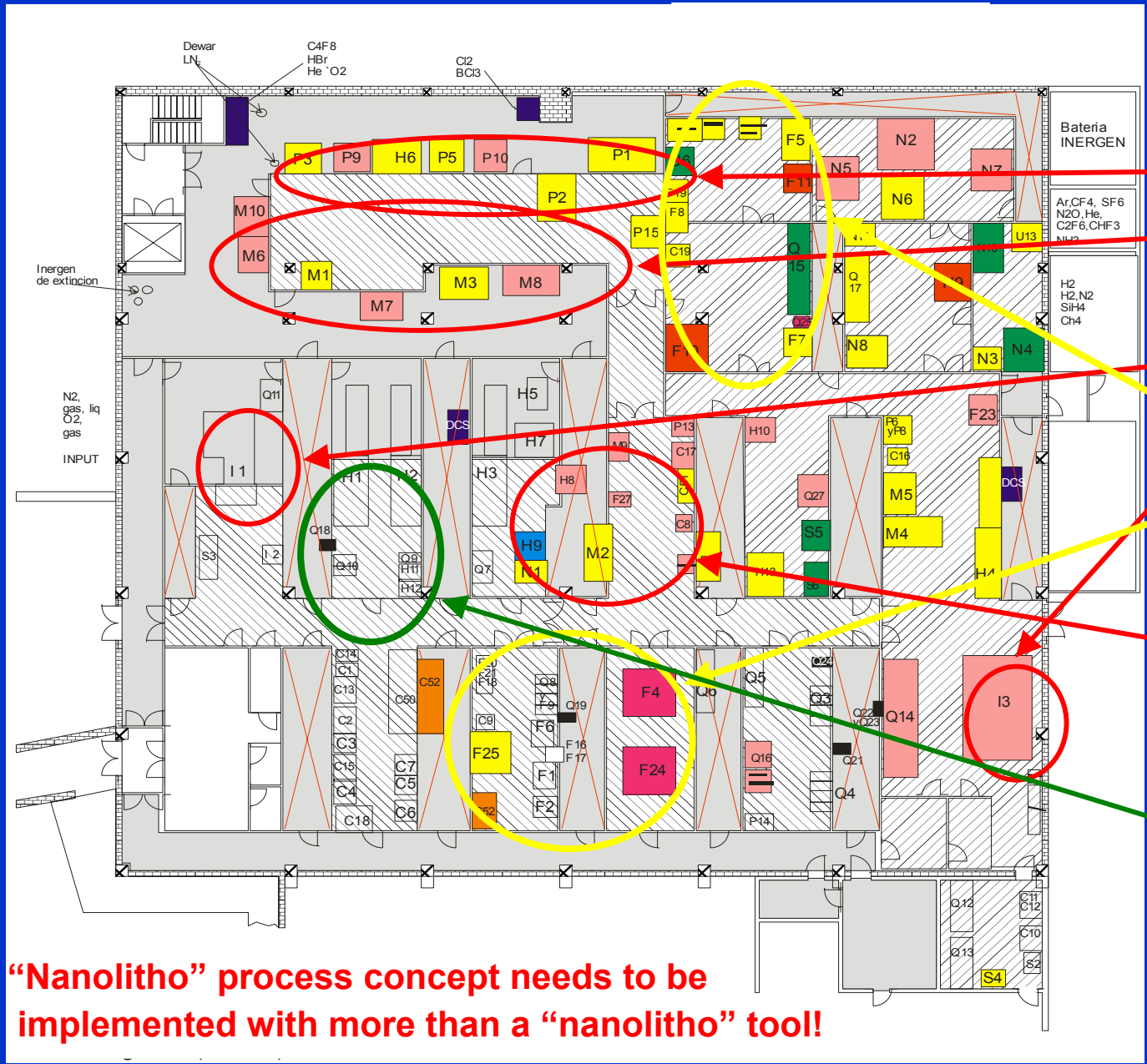
1- To **increase and stabilize a team of 50 people** fully dedicated to the ICTS and to maintain a dynamic group of around 10 trainees to fulfill eventual opportunities to join the team.

2- To **increase the capability of the ICTS** by addressing specific issues of compatibility microsystems-CMOS, nano-micro integration and both 100 mm and 150 mm wafer handling standards.

3- To **reorganize the ICTS structure** and to informatize it as much as possible, by addressing issues such as access, advisory and users committees, etc...

"Equipments of the NANOLITHOGRAPHY AREA – ICTS"

May 2009



"Nanolitho" process concept needs to be implemented with more than a "nanolitho" tool!

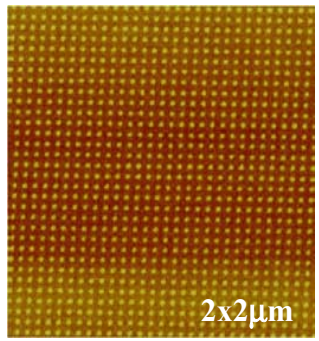
Atomic Force Microscopy

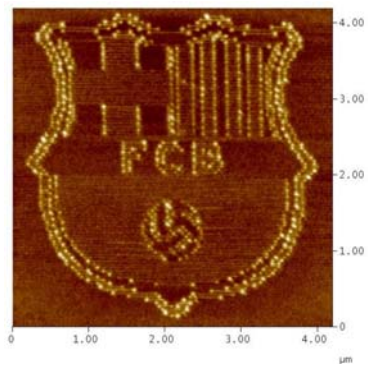
Nanoscope V & Dimension 3100 (Veeco Instruments)

Characterization:

- Topography
- Potential
- Electric Field
- Magnetic Field
- Friction,…

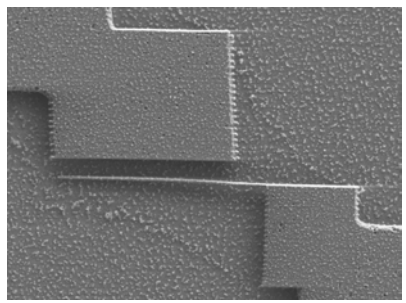
AFM NanoLithography



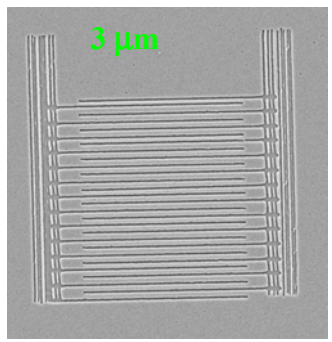


Ranges: Forces: 0,1-100nN
Distances: <50nm
Stage: up to 6” wafers

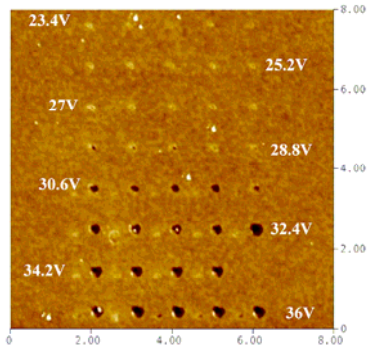
Si, Al, Si_3N_4, PMMA…



Al mask of 10 nm



Si_3N_4 (IDElectrode)



Holes en PMM

Electron Beam Lithography

LEO1530 SEM & ***RAITH ELPHY PLUS*** Pattern Generator

- Energy: 0,1-30 keV
- Working Field: Tipically 100 x 100 μm^2
- Stage: 1 μm accuracy
- Manual Focusing
- Samples: up to 6" (75mm acces)
- Ultra High Resolution: 1nm@20kV

Dedicated system: ***RAITH 150TWO***

Interferometric Laser Position

Stitching & Overlay < 40nm

Automatic Height Sensor (pseudo auto focus)

Drift Compensation (few nm/hour)

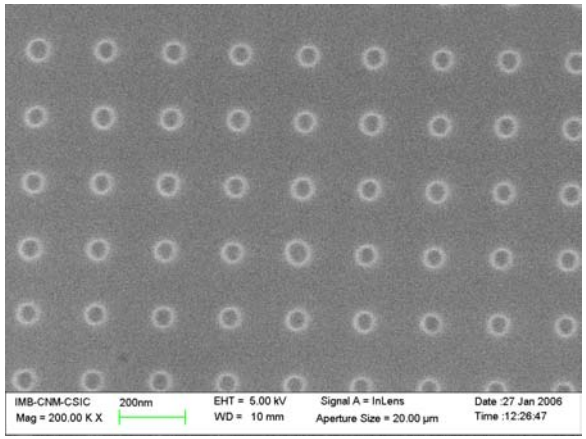
FBMS (fixed beam moving stage)

PECS (proximity effects correction)

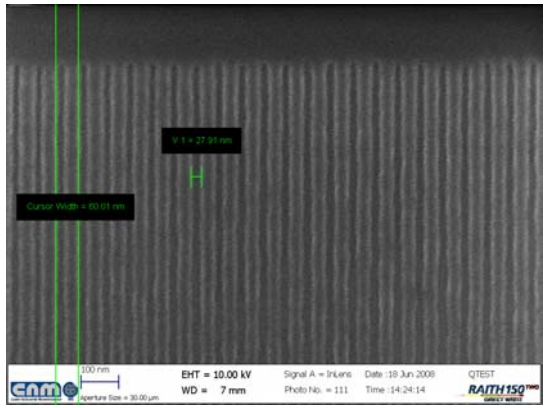
3D lithography sofware

Electron Beam Lithography Fabrication

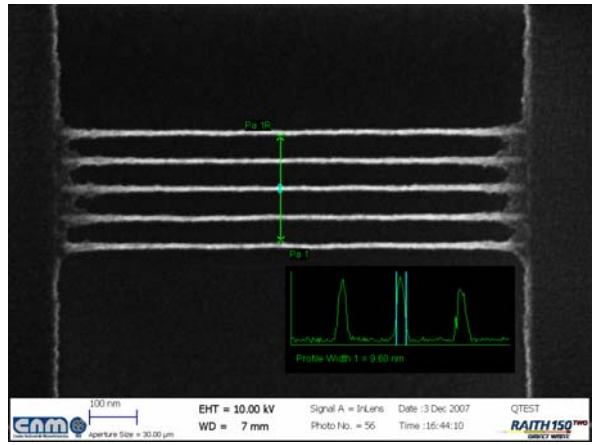
50nm holes (200nm pitch)
on 100nm PMMA



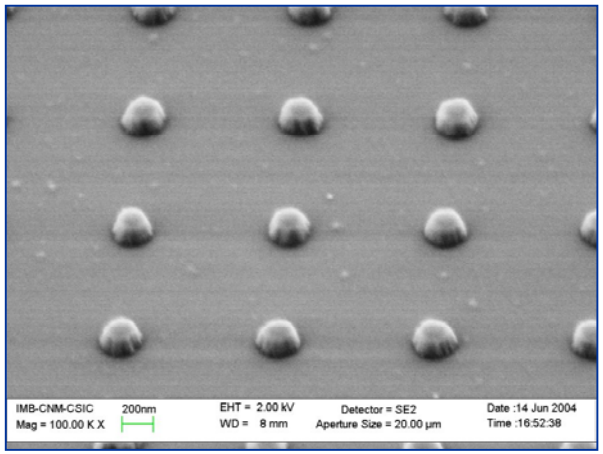
28 nm PMMA lines with 60 nm pitch
on 50 nm PMMA



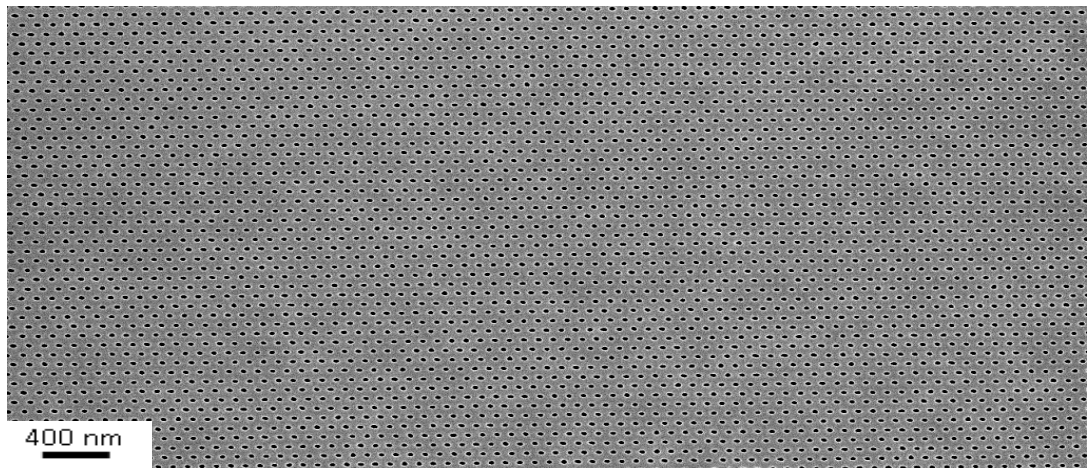
9,8 nm lines (High resolution pattern)
on 20 nm HSQ



Pattern transfer on Si:
200 nm Si pilars, 200nm high

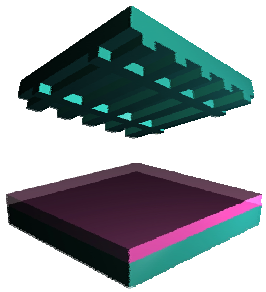


- Pattern transfer on Si:
- 300 nm depth holes, <50nm diam.



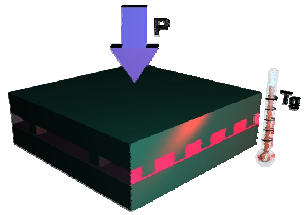
Thermal NanoImprint Capabilities

Obducat 4"
-Temp: up to 350ºC
-Pressure: up to 80bars
-Up to 4"
-Soft Imprint (air)



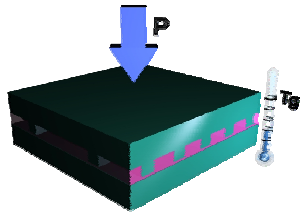
Hard stamp

Substrate with a polymer layer



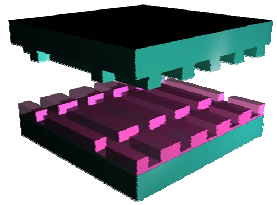
Heat,

Pressure



Cool down

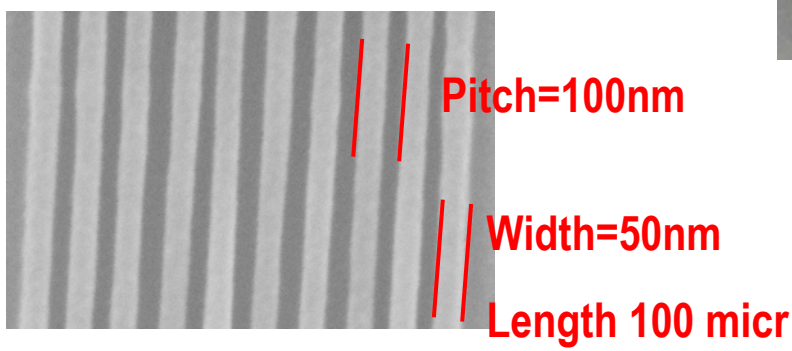
(with the pressure)



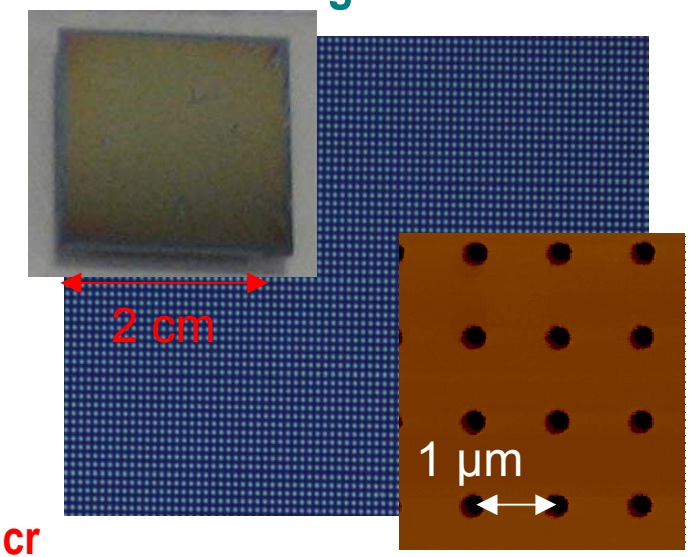
Separate

PMMA polymer (Different than the one used for e beam)

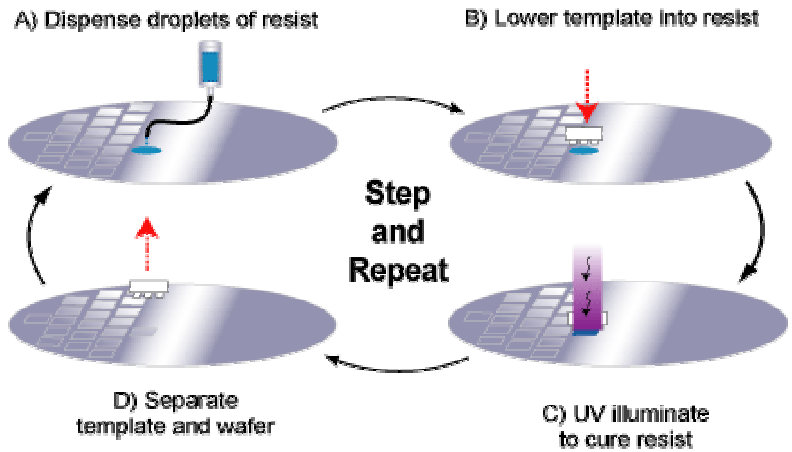
High Resolution (lift off Al on Si)



Large areas



New UV-NIL: NPS300 (in start-up process)

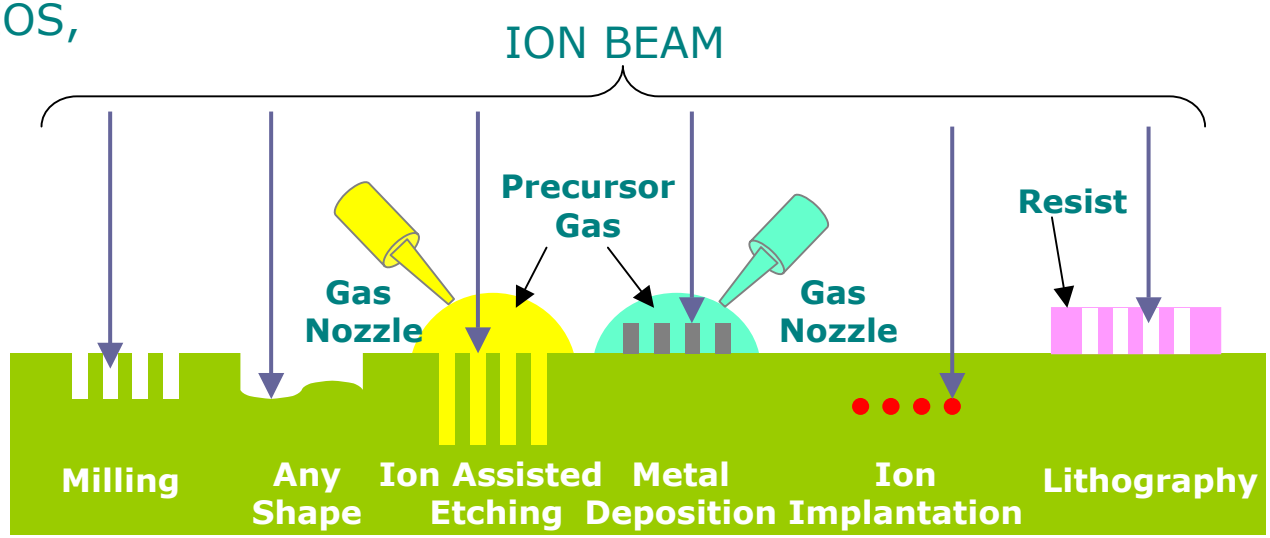


Aligment Capabilites
(<250nm accuracy)
UV and Thermal Imprint
Up to 6” wafers
Single drop dispenser
(minimum drop 3nl)
Programmable multinozzle drop
dispenser
(minimum drop 90pl)

Focused Ion Beam Fabrication

CROSS BEAM: Combination of electron and ion columns which allows "real-time" SEM monitoring of FIB modifications (***Zeiss 1560XB***)- ***ICN owned***

- FE-SEM column (0,1-30kV)
- FIB column (5-30kV)
- 6" chamber
- GIS (5 precursors: TEOS, Pt, C, H2O, XeF2)
- 3 Nanomanipulators (electrical contacts)
- Raith lithography



FIB: Many applications