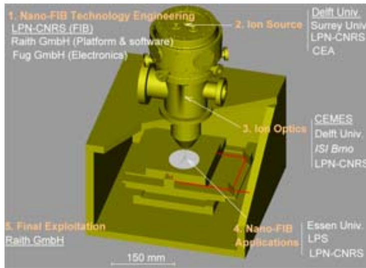
4th Round Table on Micro/Nano Technologies for Space
20-22 May 2003
ESTEC, Noordwijk, The Netherlands

Contract G5RD-CT2000-00344
J.L. Viviente-Sole (Scientific Officer)
European Commission, DG 12 - C1.2 - MO 75, rue de la Loi 200, B-1049 BRUXELLES

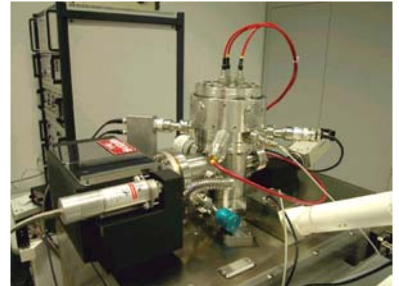
# Nano-fabrication with Focused Ion Beams

J. Gierak[1], J.J Van Es[1], D. Mailly[1], R. Jede[2], L. Bruchhaus[2], P. Hawkes[3] and the Nano-FIB partners[4]
[1] LPN/CNRS, route de Nozay, F-91460 MARCOUSSIS
[2] RAITH GmbH, Hauert 18, Technologiepark, D-44227 DORTMUND
[3] CEMES/CNRS, 29 rue Jeanne Marvig, BP 4347, F-31055 TOULOUSE CEDEX
[4] Growth Project "Nano-fabrication with Focused Ion Beams", see www.http://dbs.cordis.lu/

2001




**Abstract:** Controlled and reproducible fabrication of nano-structured materials will constitute one of the main industrial challenges for the next ten years. Because of the severe limitations of existing nano-fabrication techniques, we are developing an innovative Focused Ion Beam instrument (FIB) with improved capabilities in terms of nano-patterning. In this work we present preliminary results obtained with this instrument. We exploit the simple, direct, clean and reproducible nano-structuring potential of a "Nano-FIB" system, which is enabling studies of new physical phenomena.

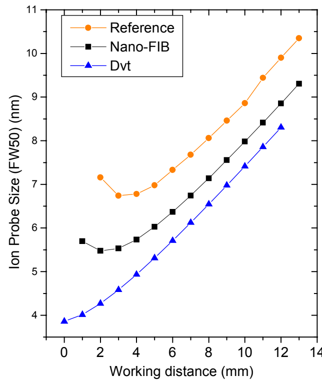


Nano-FIB prototype at LPN

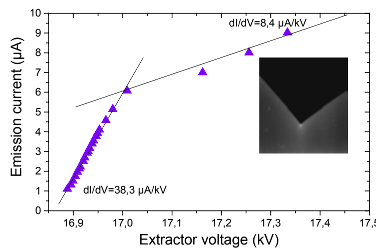
## High resolution & selectivity Ion optics

Calculated column optical properties using finite element software (program: ELD by B. Lencova).
**Conditions:** Beam energy (E): 30 kV, source size (δ): 50 nm, energy spread (ΔE): 5 eV, opening angle (a): 0.15 mrad, working distance: 2 mm.

| | Ref. | Nano-FIB | Dvt. |
|---|---|---|---|
| **Source magnification** | 6.33 nm | 4.95 nm | 2.98 nm |
| **Aberrations** | 1.76 nm | 2.45 nm | 2.92 nm |
| | 0.03 nm | 0.06 nm | 0.33 nm |
| **Total Ion Probe** | 6.57 nm | 5.53 nm | 4.27 nm |




## Enhanced Ion emission stability

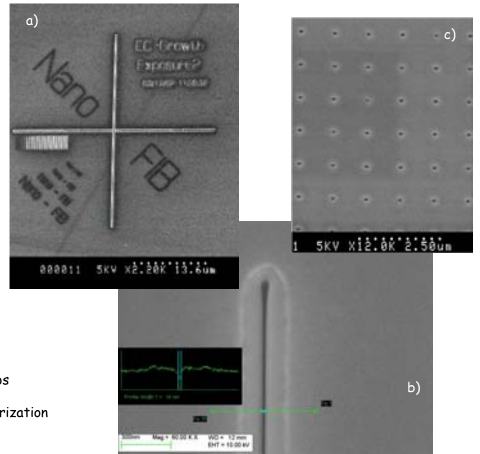



## High probe current

**(dI /dΩ > 50 µA/srd)** $I_p$ ~ 2 to 5 pA

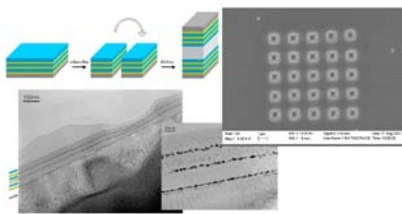
## Extended patterning capabilities

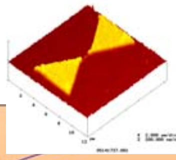
- Very high positioning accuracy (13 nm) with 2 nm steps
- Field Stitching (Max. wafer diameter 150 mm)
- Multi level and unattended batch processes characterization
- 10 Mhz/16 bits pattern generator
- GDSII file format




## Nano-FIB test results

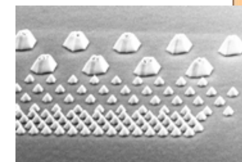
**a)** SEM image of FIB etched lines on a GaAs sample. **b)** High resolution FIB etched line
**c)** SEM image circular holes drilled in a 10 nm thick SiO2 on a Silicon substrate





"Top down" approach

"Bottom-up" compatibility



Carbon nanotubes

Nanoelectronics

Frontiers of knowledge
Ion source Research

Test tool (Nano-FIB)
Instrument research

Atomic patterning & deposition

Nano-composites

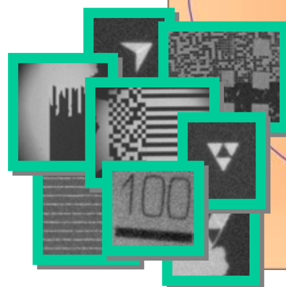
Quantum dot
LEDs and lasers

Envisioned application spectra

Nano-structured catalysts

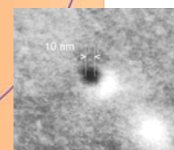
Nanomagnetism

Bio-catalysis



Nano-sensors

DNA analysis




Bio sensors
Biochip

Emerging challenges

Nanobiotechnology

Self assembly/organisation