

CoSi₂ – nano wires synthesized by FIB processing

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Outline

Introduction

IMSA-OrsayPhysics FIB

Co - alloy LMIS

IBS of CoSi_2 – nano-wires

- Mask technology
- Direct writing

Conclusions

Motivation

DFG Project in „Nanowires & Nanotubes“

Synthesis of Nanowires and Nanochains by Fine-Focused Ion Beams

Objectives:

- Fabrication of semiconducting & metallic nanowires (NWs)/nanochains (NCs) by ion beam synthesis (IBS), MOCVD and templating using fine-focused ion beams (FIB)

↓

Combination: *bottom-up approach* („self-assamblly“ during IBS) + *top-down approach* (FIB)

↓

FIB-processing would be compatible with standard Si CMOS technology

- NWs/NCs to be fabricated:

Semiconducting:	Si, Ge in SiO ₂
Metallic:	Au in SiO ₂



CoSi₂ in c-Si

IMSA-OrsayPhysics FIB

Energy: 10 – 30 keV (I^+)

Ions: Si, Cr, Fe, Co, Ni, Ga, Ge, In, Sn, Au, Pb, Nd, Er,...

Current: 0.001 – 22 nA $J_{\max} > 20 \text{ A/cm}^2$

ExB: $m/\Delta m = 35$ switchable

Spot: min. 14 nm (Ga)

Chemistry: - metal deposition W, (Au)
- etching - metals, insulators

Sample: 6"- wafer, 7"- masks, special size

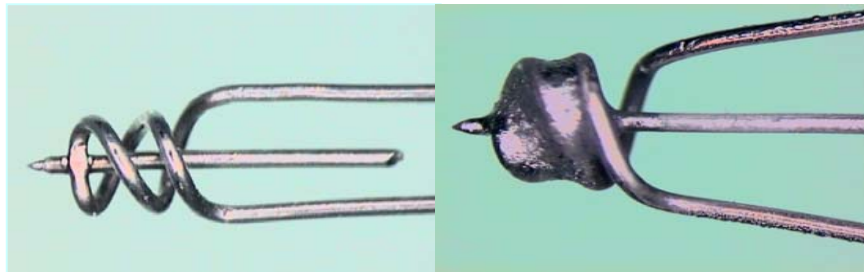
Stage: Laser-interferometer controlled, $\Delta x \sim 20 \text{ nm}$

Options: Heating up to 700 °C, cooling, $\Delta T = -60 \text{ grd}$, sample rotation, 2π ; $\text{inc} = 0.28^\circ$
in-situ measurements, acoustic sensor, charge neutralisation, ASCII, AutoCAD,
bmp data input for pattern design, full PC beam control, optical control (IR - CCD)



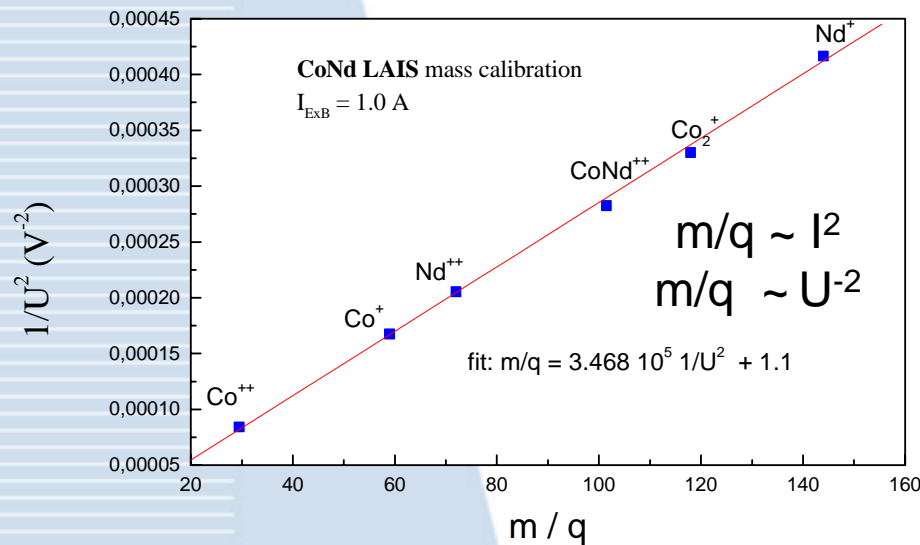
red = not standard

Alloy Liquid Metal Ion Source

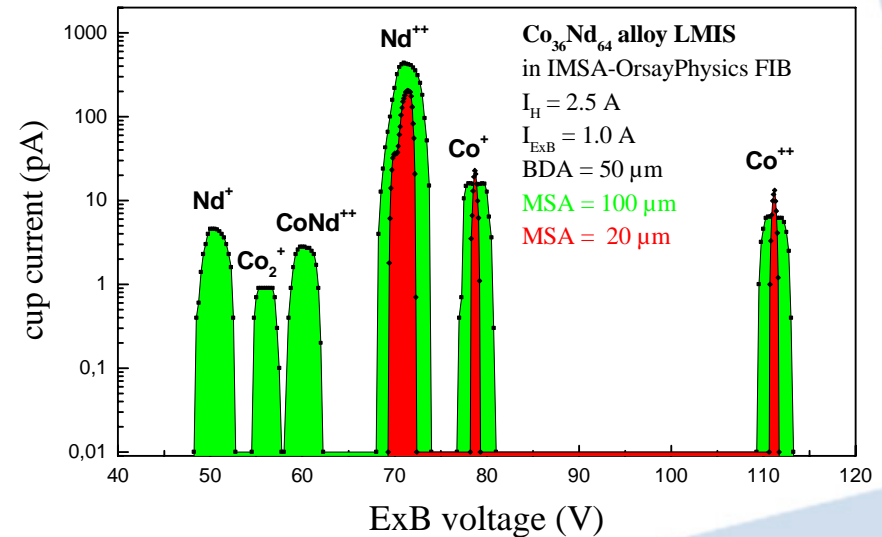


Alloy: $\text{Co}_{36}\text{Nd}_{64}$

$T_m = 566 \text{ }^\circ\text{C}$



Calibration



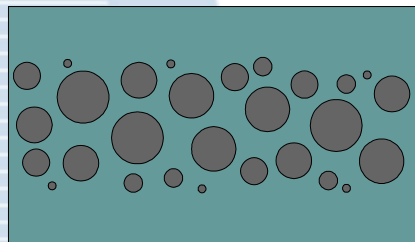
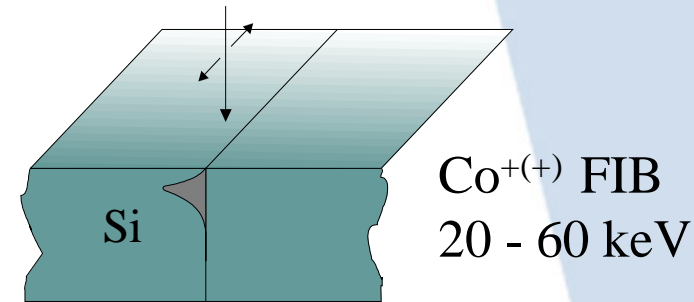
Mass spectrum

Ion Beam Synthesis – IBS

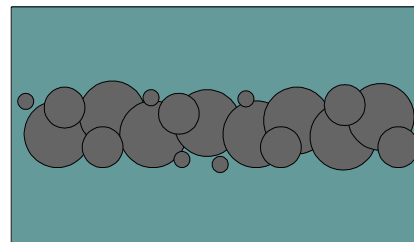
CoSi₂ microstructures

Writing FIB

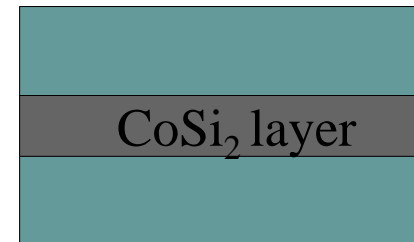
Co – implantation into a **heated** Si target (~ 400 °C) to **prevent amorphisation**



growth



coalescence



buried layer

nucleation

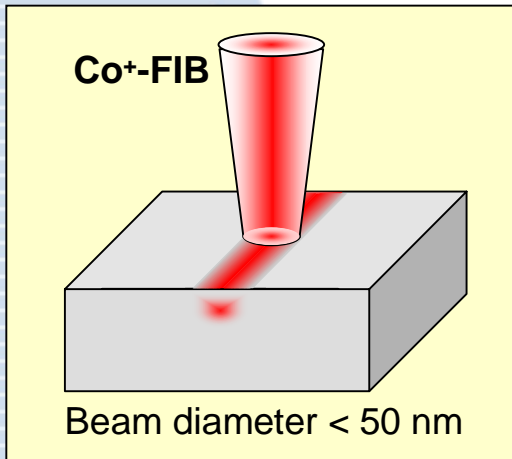
Ostwald ripening

annealing 600°C, 60 min and 1000°C, 30 min in N₂

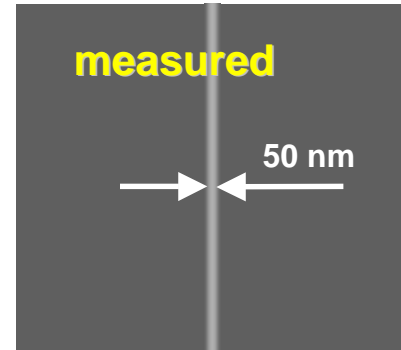
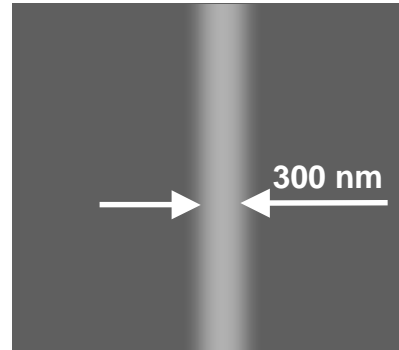
→ time

FIB: Application of very short pixel dwell times (< 1 μs) due to damage accumulation and dynamic annealing

Previous Experiments & current work

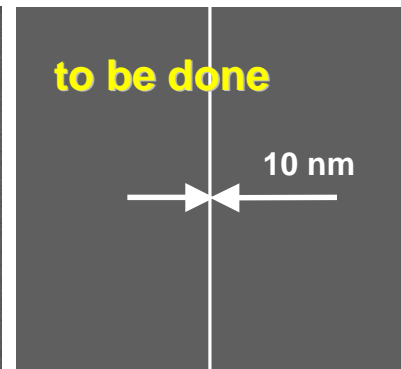
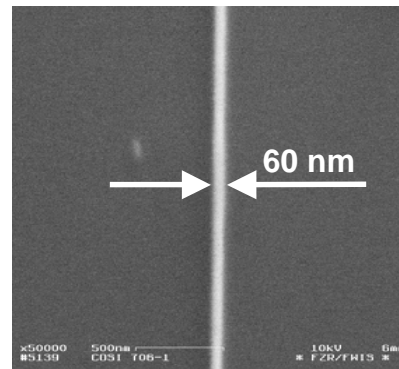


CoSi₂ nanowires can be formed by annealing. Diameter of 60 nm has been synthesized.



FIB implantation:

Co²⁺ in to (100)Si,
aligned to <110>,
E = 70 keV
D = 1x10¹⁷ cm⁻²
T_i = 415 °C



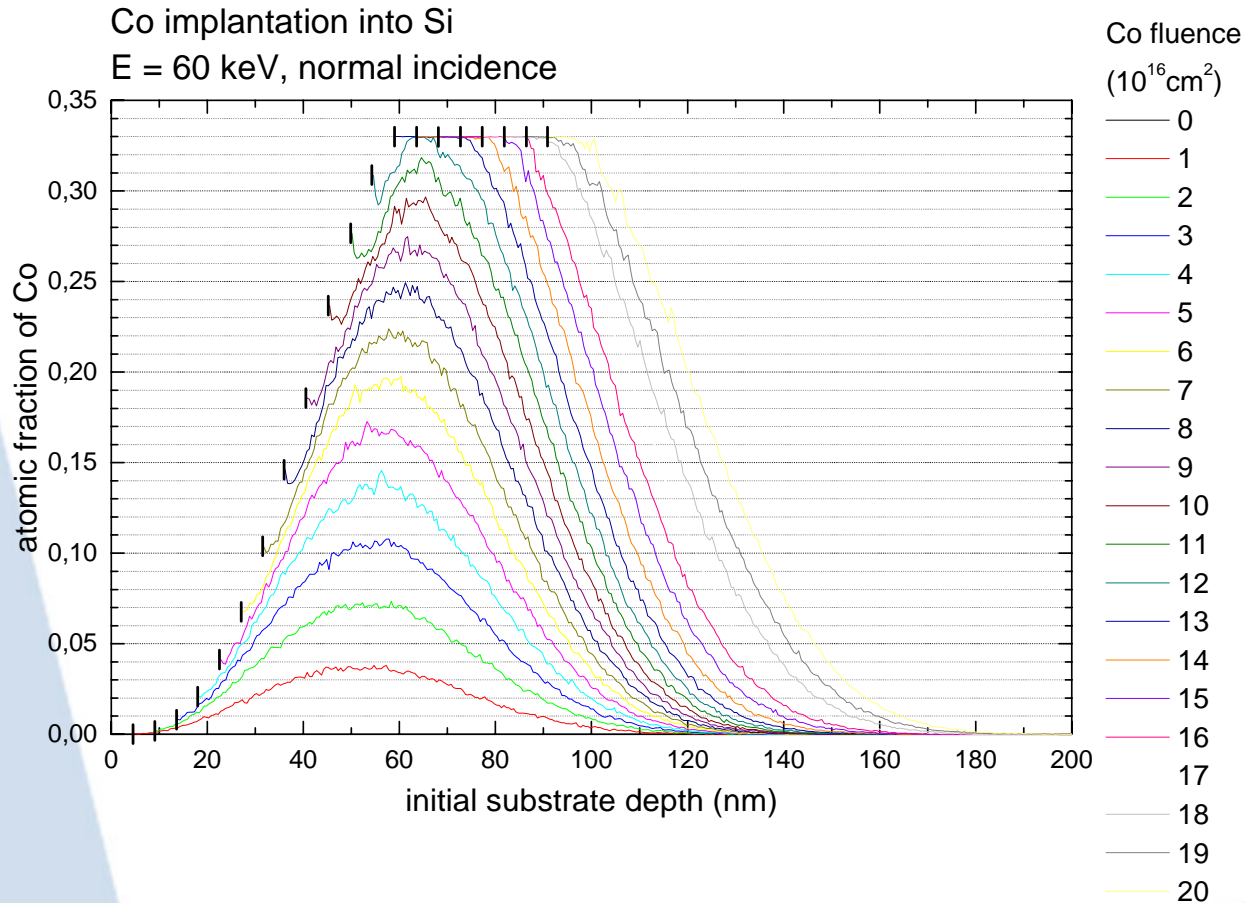
Annealing, N₂:

T_A = 600 °C, t = 60 min +
T_A = 1000 °C, t = 30 min

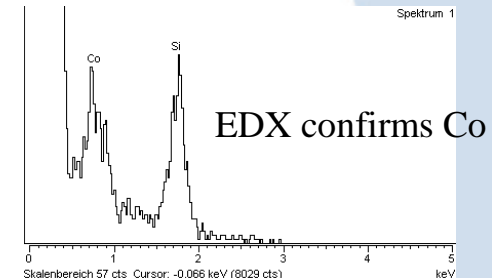
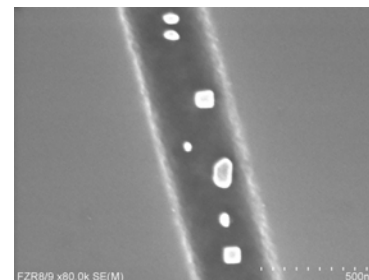
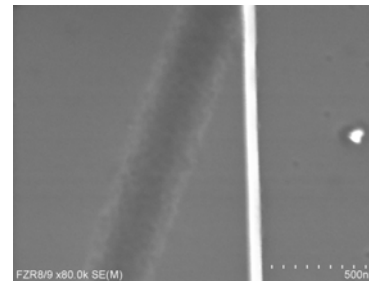
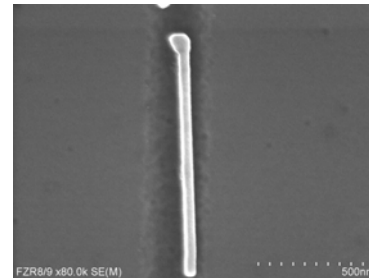
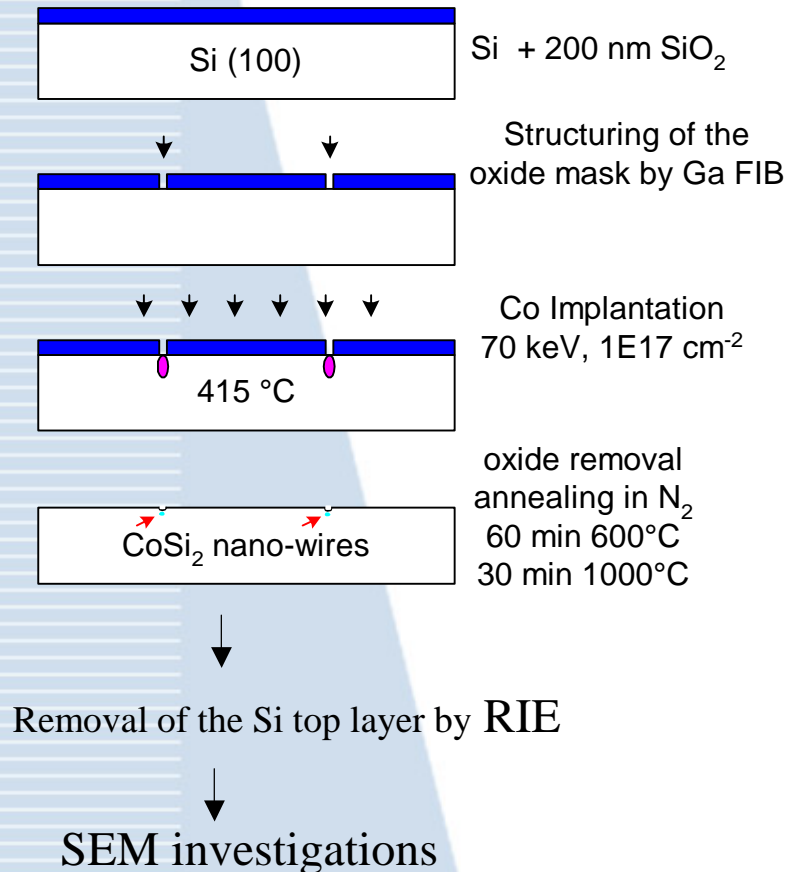
IMSA-100 FIB

new FIB !!!

Tridyn simulations



Experimental *a) Mask Technology*



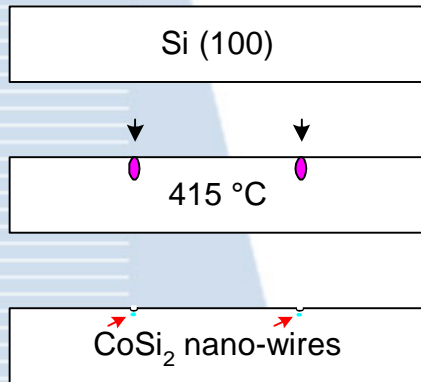
CoSi₂ nano-wires

- as small as 40 nm
- aligned to (110) direction
- certain conditions

Chains of pearls

Process optimisation
is still under investigation

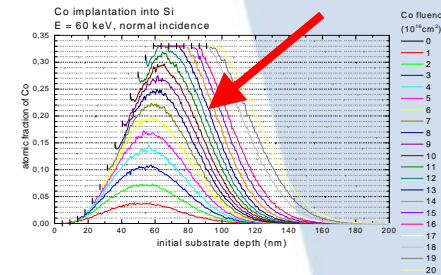
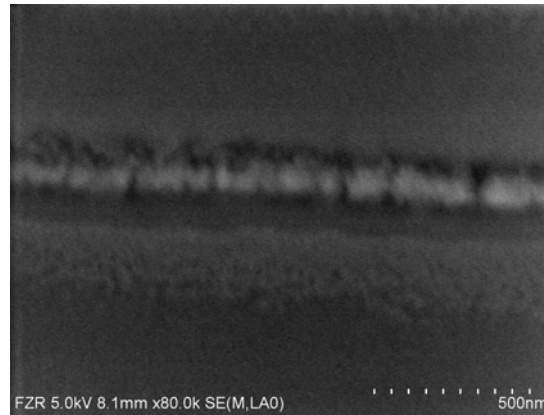
Experimental *b) Direct FIB Writing*



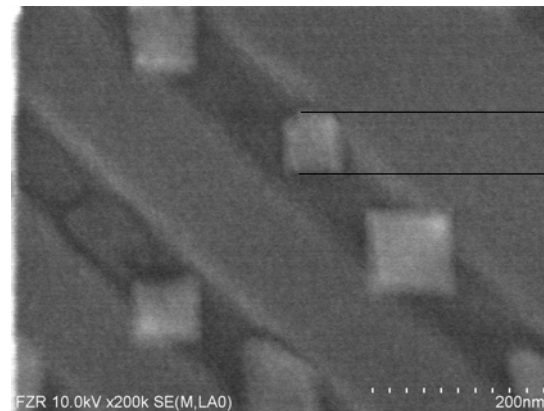
Si
Structuring of the chip by writing FIB
Co⁺ 25 keV
Co⁺⁺ 50 keV
D = 1E17 cm⁻²
annealing in N₂
60 min 600°C
30 min 1000°C

Removal of the Si top layer by RIE

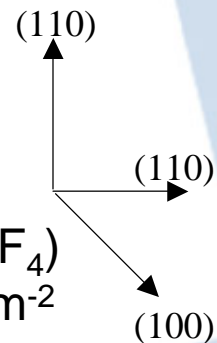
SEM investigations



as-implanted
50 keV, 1e17 cm⁻²



60 nm
annealed
30 s RIE (CF₄)
D = 2e16 cm⁻²



Conclusions

FIB technology is a promising method for the fabrication of nano-wires or chains of nano-pearls, which is of great interest in the fields of plasmonics, nano-optics and nano-electronics.

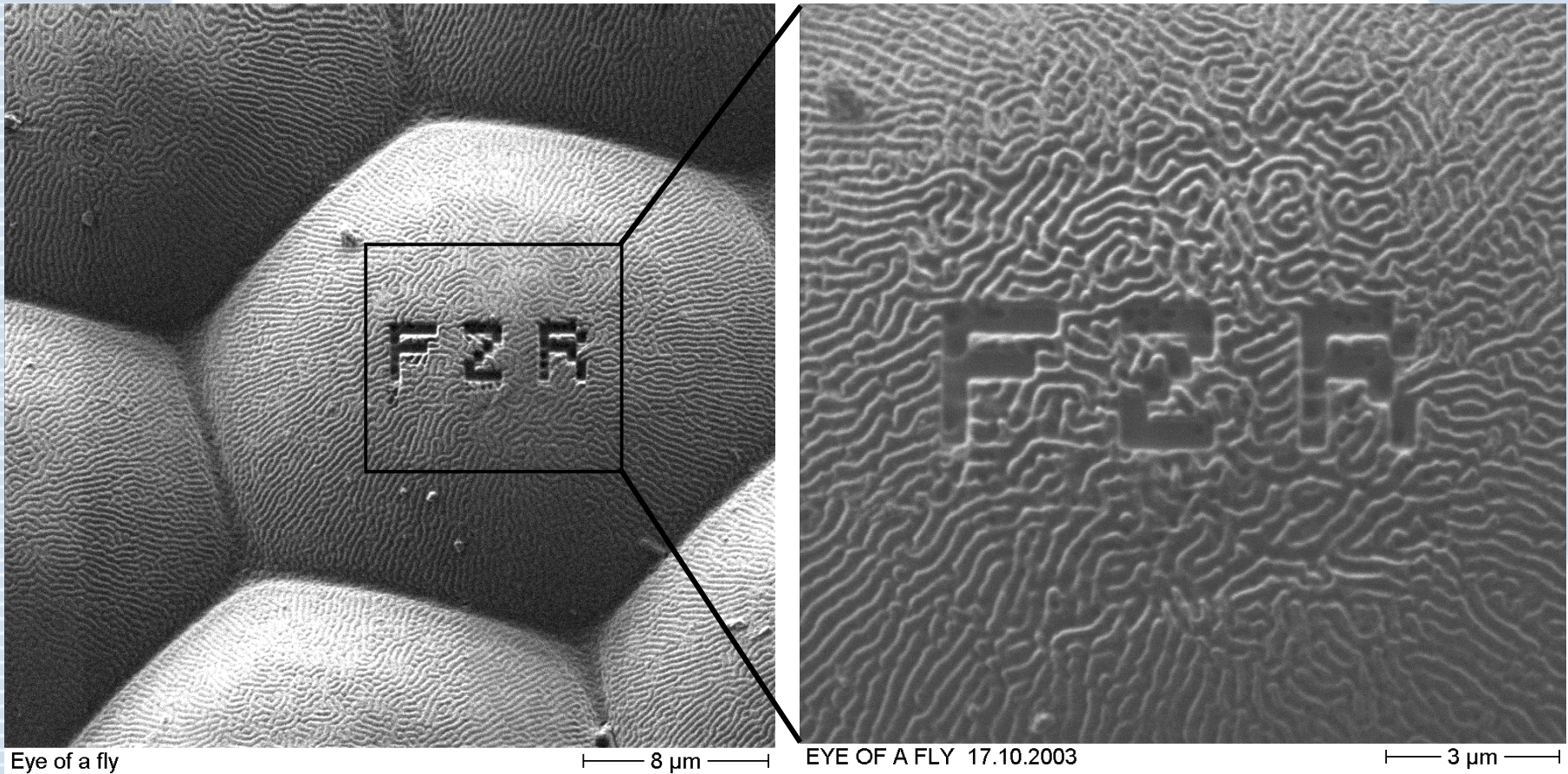
Preliminary results of CoSi_2 nano-structure synthesis are very promising.

To obtain continuous wires as well as regular chains of dots, the process has to be optimised with respect to the

- pixel dwell time**
- implantation dose**
- annealing conditions**

Acknowledgement

The authors would like to thank the Deutsche Forschungsgemeinschaft for financial support under contract No. SCHM 1490/6-1 and Dr. K.-H. Heinig for helpful discussions.



FIB – ART, FZR logo written in an eye of a fly

IMSA-OrsayPhysics FIB (2003)