Status of ITC-irst activities in RD50

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Outline

Materials/Pad Detctors

- Pre-irradiated silicon – *INFN Padova and Institute for Nuclear Research of NASU, KieV;*
- Detectors on MCz, Cz and Epitaxial silicon – *SMART collaboration: INFN of Bari, Firenze, Padova Perugia, Pisa and Trieste;*

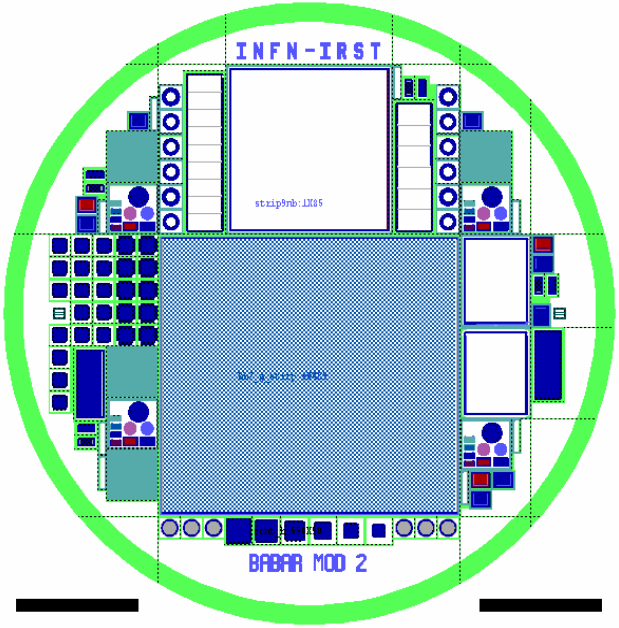
New detectors

- Thin Detectors - *INFN of Firenze and Padova;*
- 3-D detectors – *Glasgow and CNM Barcelona.*

Pre-irradiated material

Layout

- BaBar detector masks (single side)
- Diode + test structure



Silicon

- Fz <100> n-type 6 kΩ
- MCz <111> n-type Okmetic >500Ω

Pre-irradiation

- Pre-irradiation by fast neutrons at Kiev reactor, fluence 10^{17}n/cm^2
- annealing at a temperature of 850°C
- Polishing, lapping

Process

- Fz material = standard Irst (LTO, sintering@420°C)
- MCz material = No LTO and sintering @380°C.

Electrical Characterization

Type	n		V_{dep} (V)	N_{eff} (10^{11} cm^{-3})	ρ (kΩcm)	j_D (μA/cm^3)
Fz	1	reference	60	6	7.7	5–15
	1	Pre-irradiated	75–115	8–12	4–6	2–3
	2		70–110	7–11	4–7	0.5–4
	3		65–110	6.5–11	4–7	0.4–0.9
	4		70–95	7–9.5	5–6.5	2–8
	5		60–125	6–12.5	4–8	4–16
MCz	1	reference	450	85	0.55	0.7
	1	Pre-irradiated	800	150	0.3	1-2
	2		490–730	90–140	0.33–0.5	0.6–6

Data from INFN Padova

activities in progress:

diodes have been tested on wafer and cut

now:

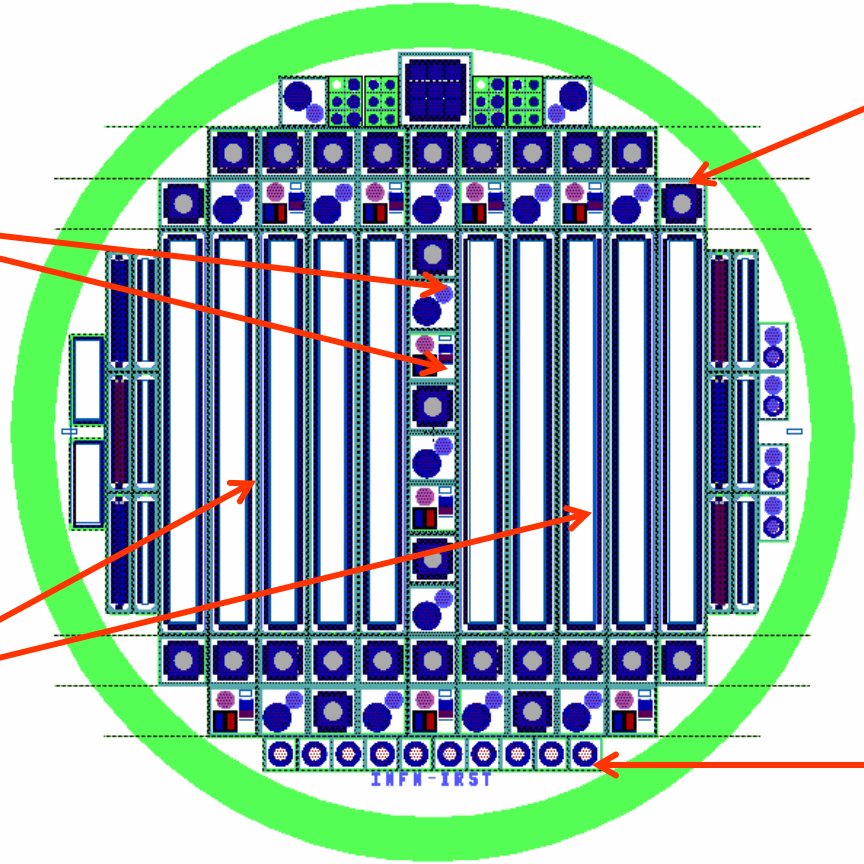
Irradiation by:

1. 24 GeV protons at CERN;
2. Fast neutrons at Kiev and Lubljana Research Reactor;
3. 58 MeV Li ions at LNL INFN Tandem Padova.

Run SMART

SMART collaboration: INFN groups of Firenze, Pisa, Trieste, Bari, Padova, Perugia and ITC-irst

- Test structure: diode, MOS, gated diodes, resistor, etc.
- Microstrip detectors AC coupled, poly-resistor biased



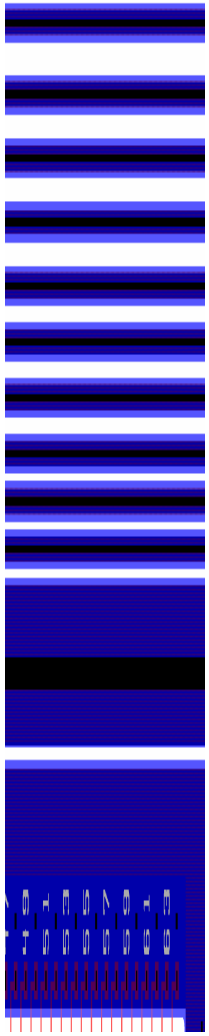
SMART layout

5 + 5 Microstrip detectors per wafer
AC coupled, poly-resistors biased

external dimension of about 6x47mm

pitch	Implant width			number
50	15	20	25	64
100	15	25	35	32

Width/pitch	field plate		
15/50	2	4	6
25/100	4	6	8

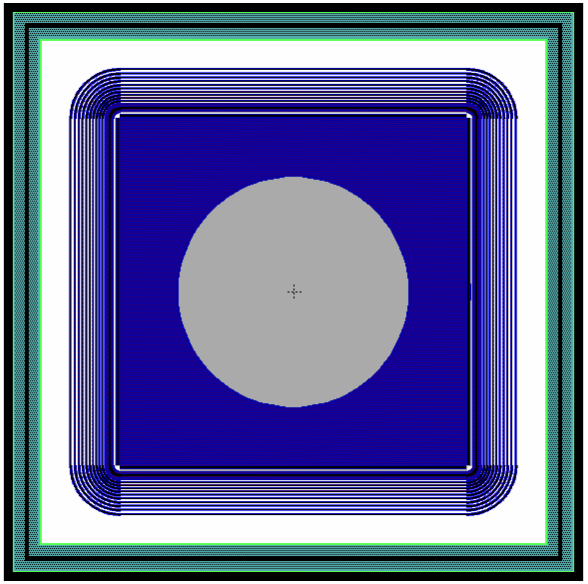


SMART layout

Square Diode

Area 13.6 mm2
DIE 6x6mm
Multiguard structure

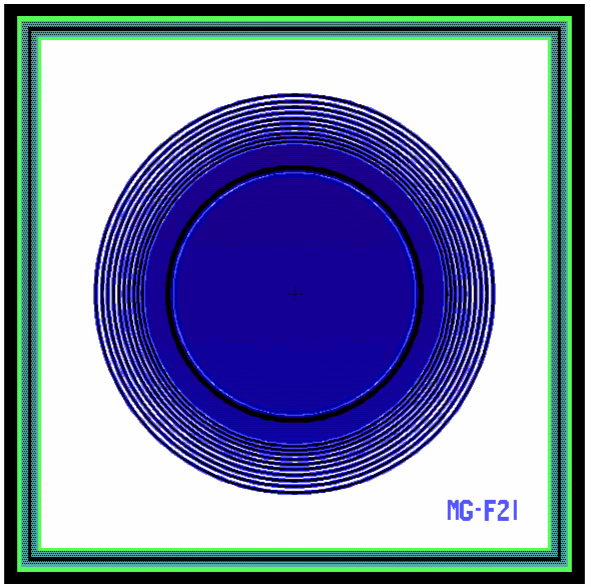
27 per wafer



Circular Diode

Area 4 mm2
DIE 4x4mm
Multiguard structure

10 per wafer



SMART layout

ITC irst
CENTRO PER LA RI
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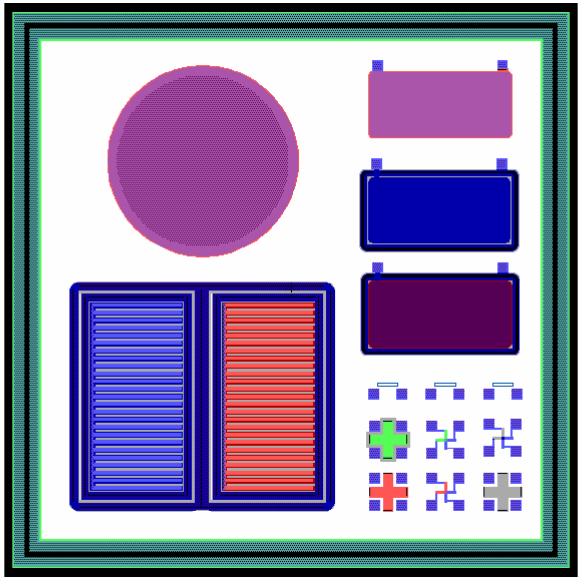
Test Structure

MOS capacitor (Poly)
Gated Diode, Capacitors, resistors, ..
DIE 6x6mm

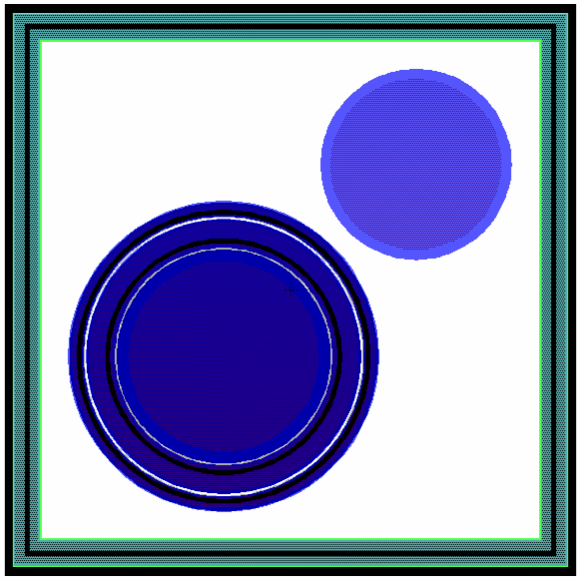
9 per wafer



Test Structure

Diode area 4 mm2, double G
MOS capacitor (Metal)
DIE 6x6mm

13 per wafer



Run SMART

Process

- STANDARD (LTO as passivation layer, sintering@420 °C)
- NO passivation, sintering @380°C or @350°C

Silicon

- Fz n-type 6 kΩ-cm <111>
- MCz n-type >500Ω-cm <100>
- Cz n-type >900Ω-cm <100>
- Epi ITME (50 and 75 mm 0.02Ω-cm)

Process Status

- Process just completed

New Detectors

- Thin Detectors

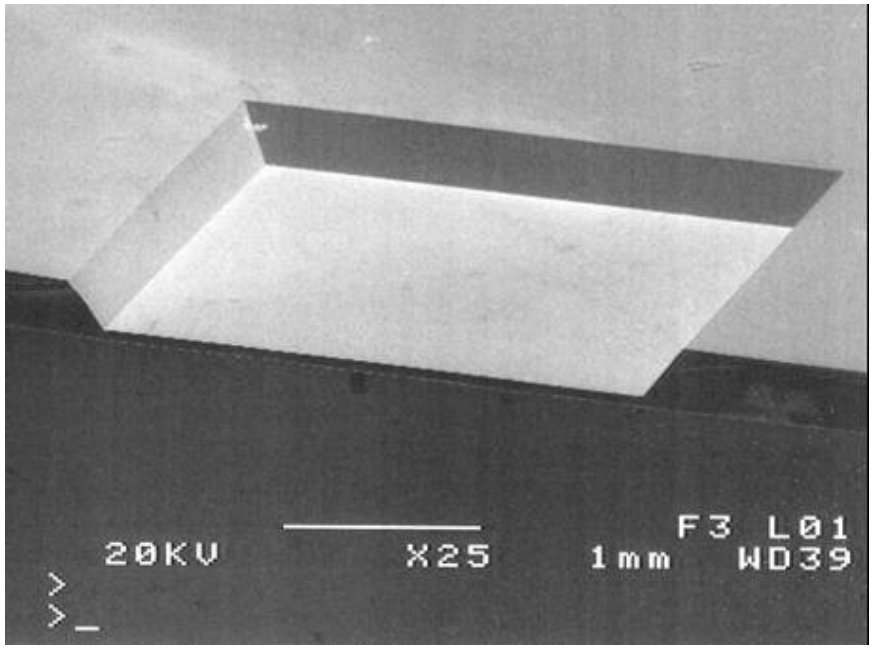
  in collab. With *INFN of Firenze and Padova;*

- 3-D detectors

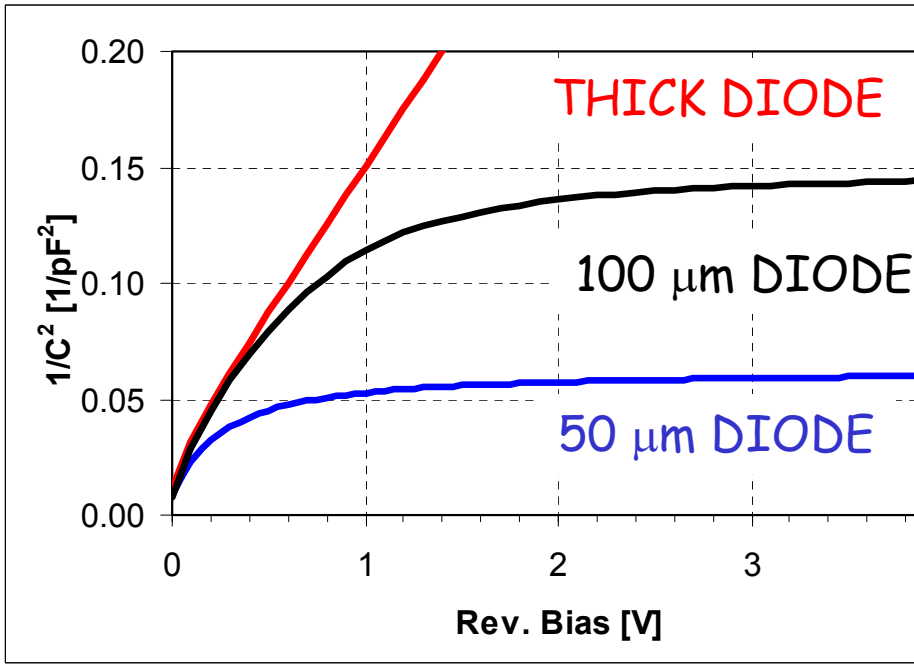
  in collab. With Glasgow and CNM Barcelona.

Thin Detectors

- Standard process (single side)
- Silicon wet etching (TMAH Si <100>)
- From 300 μm to 50 μm

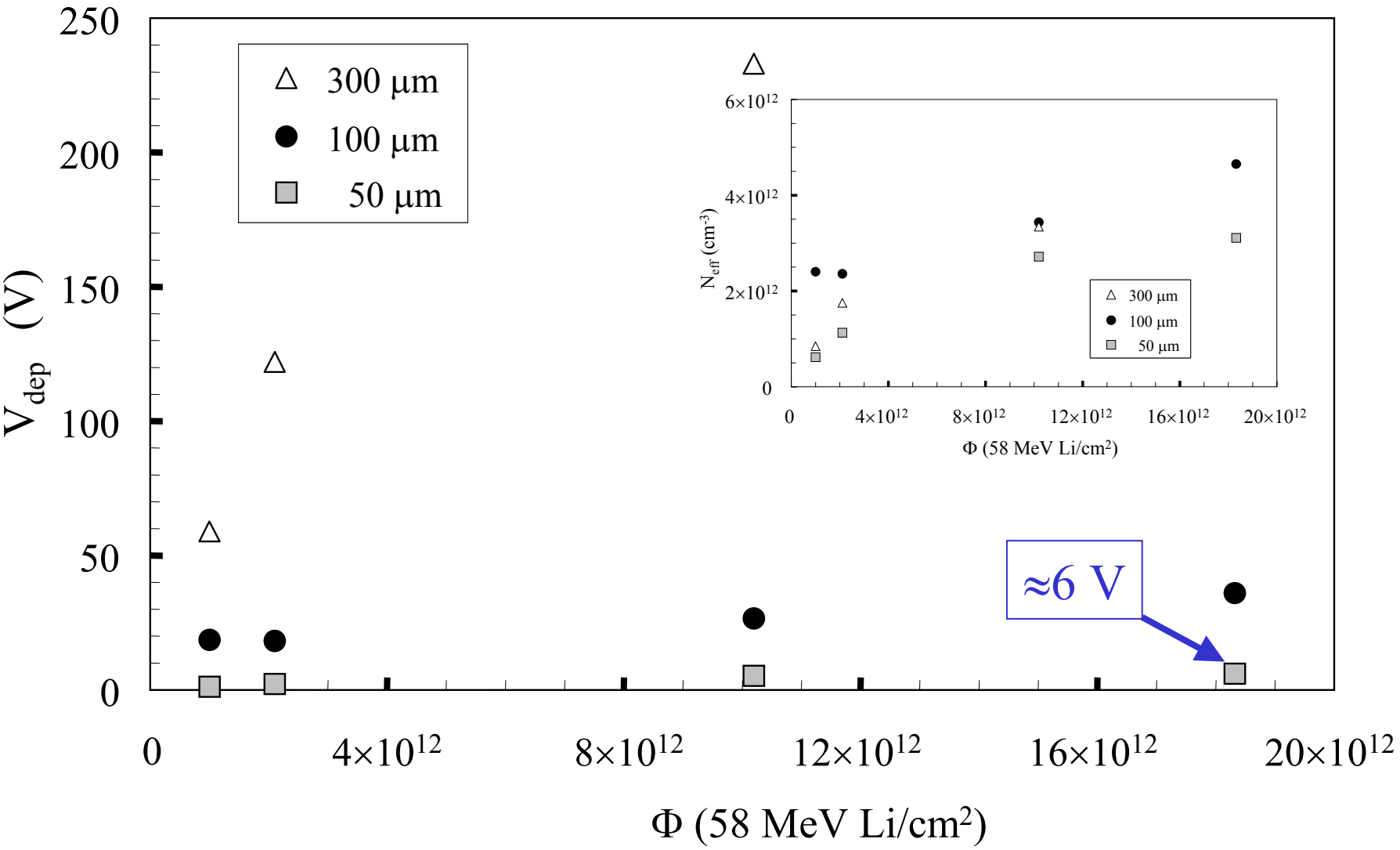


$1/C^2$



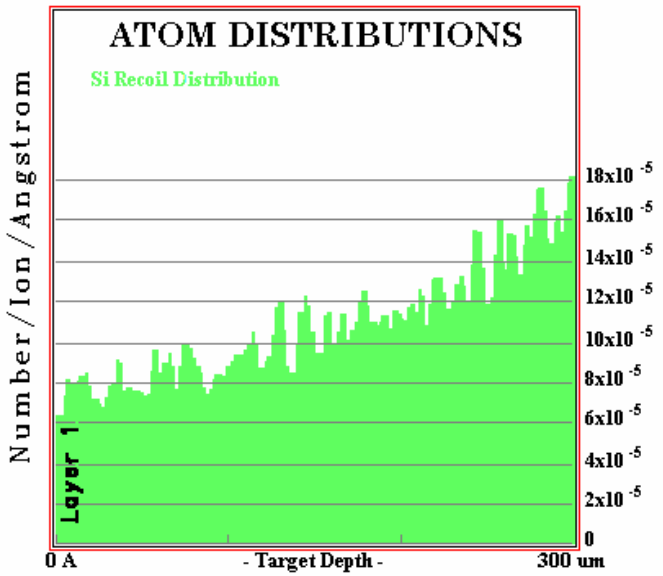
square diodes (1.9 mm^2)

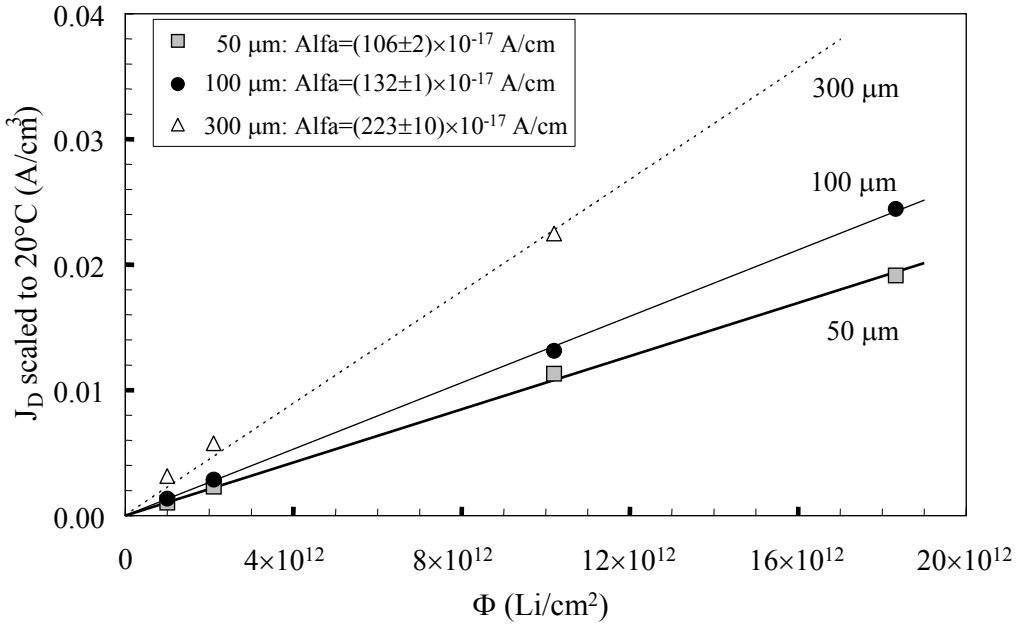
Irradiation with Li ions: depletion voltage and N_{eff}



Data from INFN Section of Padova

Thin silicon diode irradiation: leakage current





Radiation source	Devices	Radiation Fluence	α after 4 min at 80°C (A/cm)
This experiment			
58 MeV Li	IRST (FZ) 300 µm	0-1.02×10^{13} Li/cm^2	(223±10)×10^{-17} A/cm
58 MeV Li	IRST (FZ) 100 µm	0-1.83×10^{13} Li/cm^2	(132± 1)×10^{-17} A/cm
58 MeV Li	IRST (FZ) 50 µm	0-1.83×10^{13} Li/cm^2	(106±2)×10^{-17} A/cm
Other experiments			
58 MeV Li	ST (FZ) 300 um CNM (FZ) 280 um	0-0.52 ×10^{13} Li/cm^2	(206±2)×10^{-17} A/cm
58 MeV Li	Hamburg (Epi) 50 µm	0-2.12×10^{13} Li/cm^2	(114±5)×10^{-17} A/cm
1 MeV neutrons	----------	----------	4.56×10^{-17} A/cm

Data from INFN Padova

Thin silicon diode: future activity

- Irradiation by 24 GeV protons at CERN:
  $\Phi = 10^{15}$ p/cm^2-10^{16} p/cm^2 (7-28 May 2004)

- Irradiation by 58 MeV Li ions at Padova:
  $\Phi = 8 \times 10^{13}$ Li/cm^2-16×10^{13} Li/cm^2 (23 May 2004)

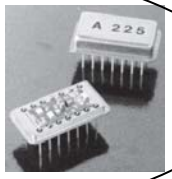
- Comparison of the damage induced by 24 GeV protons and 58 MeV Li ions in diodes with different thickness (50μm - 100μm - 300μm):
  - -depletion voltage;
  - -leakage current density at full depletion;
  - -CCE;
  - -annealing characteristics.

CCE - Florence set-up

- is a low noise charge integrator with
  - shaping factor = 2.4μsec
  - ENC = (280+5.6C/pF)e-

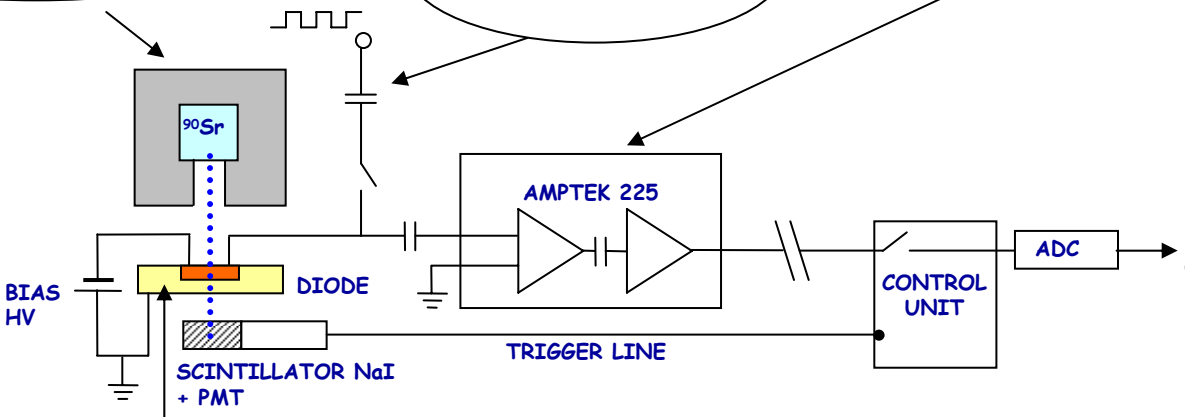
- is optimized for single channel detectors

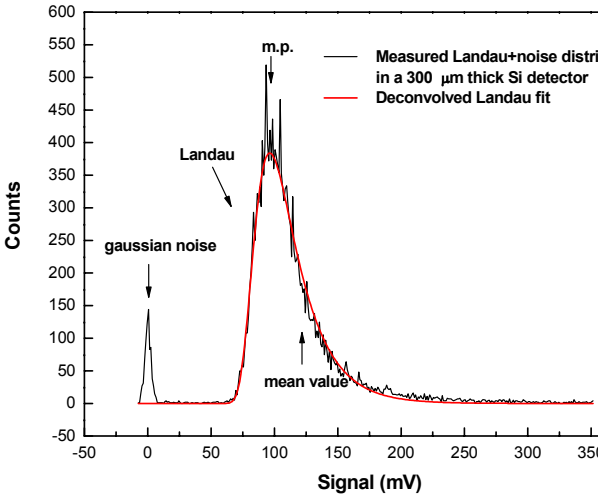
single channel
charge sensitive preamplifier
+ shaping amplifier



- ^{90}Sr source + collimator

calibration circuit
1mV = 226.5 e$^-$

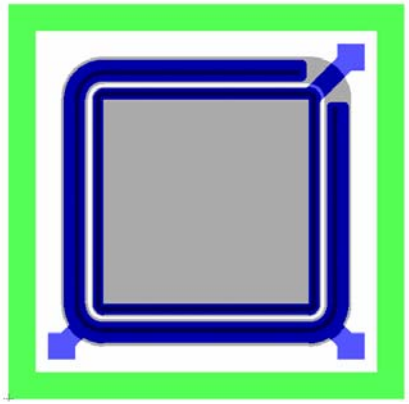




diode

Data from C. Tosi, F. Fasolo, M. Pruzzi (INFN Firenze)

Devices under test: single diode - single guard ring



non irradiated diodes	50μm	100μm	300μm
1.9 mm^2	3	3	3
3.5 mm^2	1	1	2

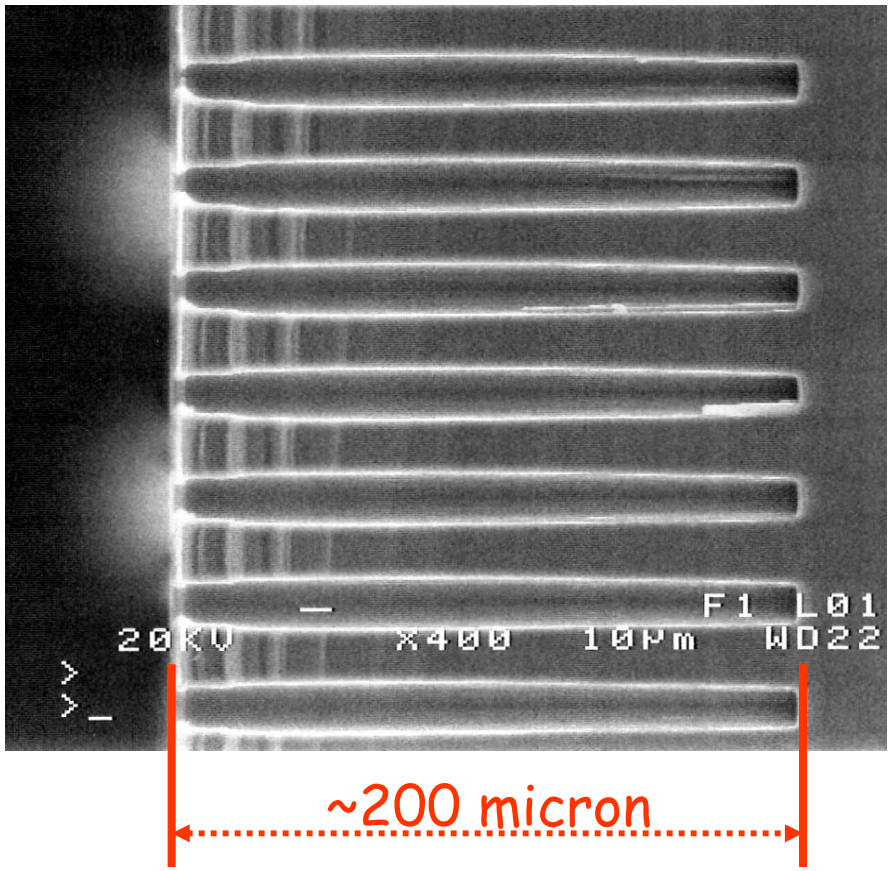
Diodes irradiated with Li iones at 58MeV and 10^{13} cm^{-2}
Annealing at 80°C for 4 min

Li^+ irradiated Diodes	50μm	100μm	300μm
1.9 mm^2	1	1	2

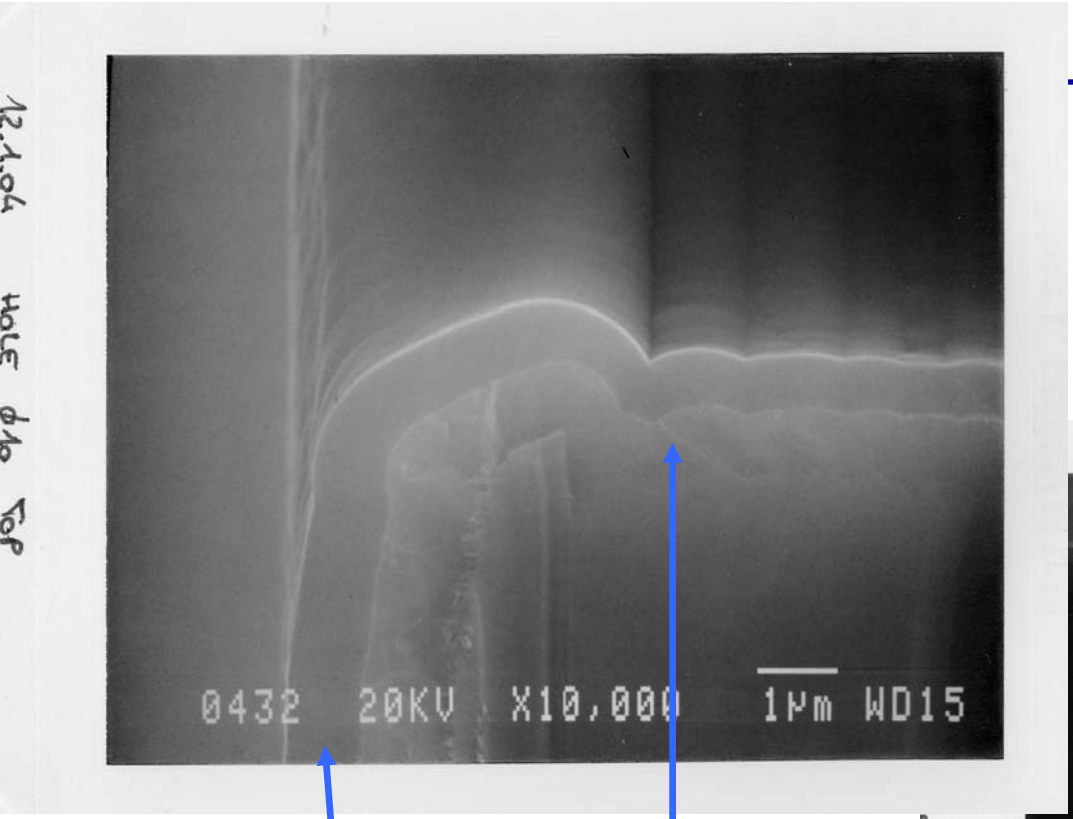
3-D detector

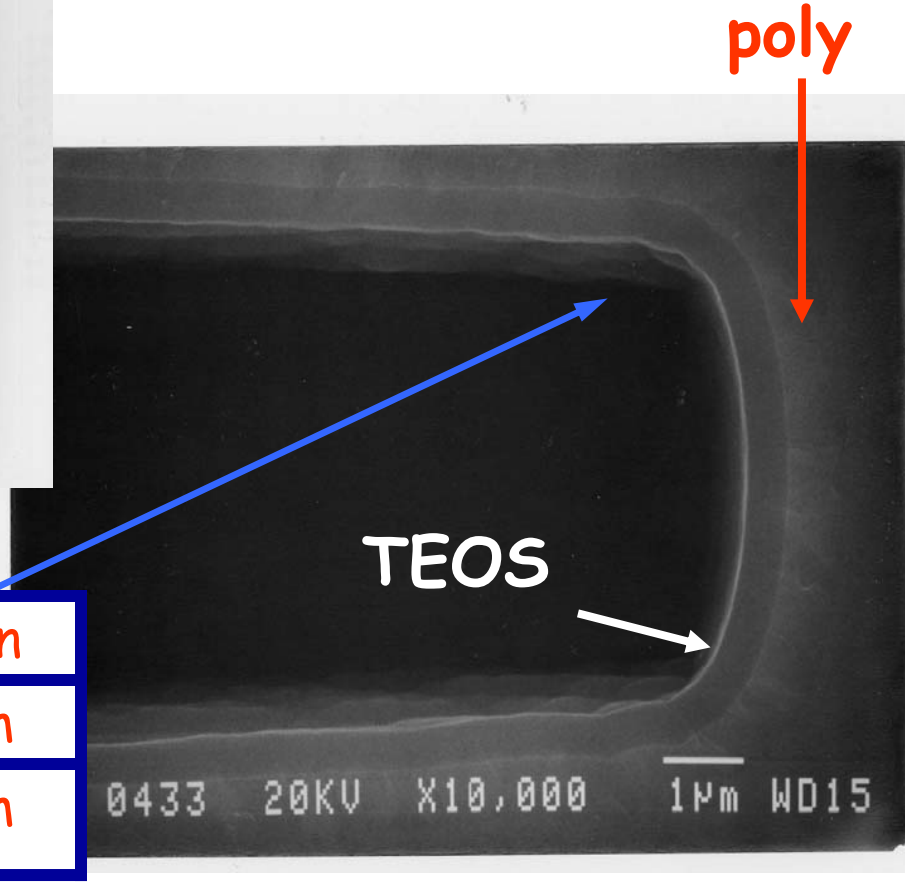
diameter 15 μm

- Mask: Glasgow
- CNM Barcelona: deep-trench
- Irst: process



3-D poly and TEOS deposition



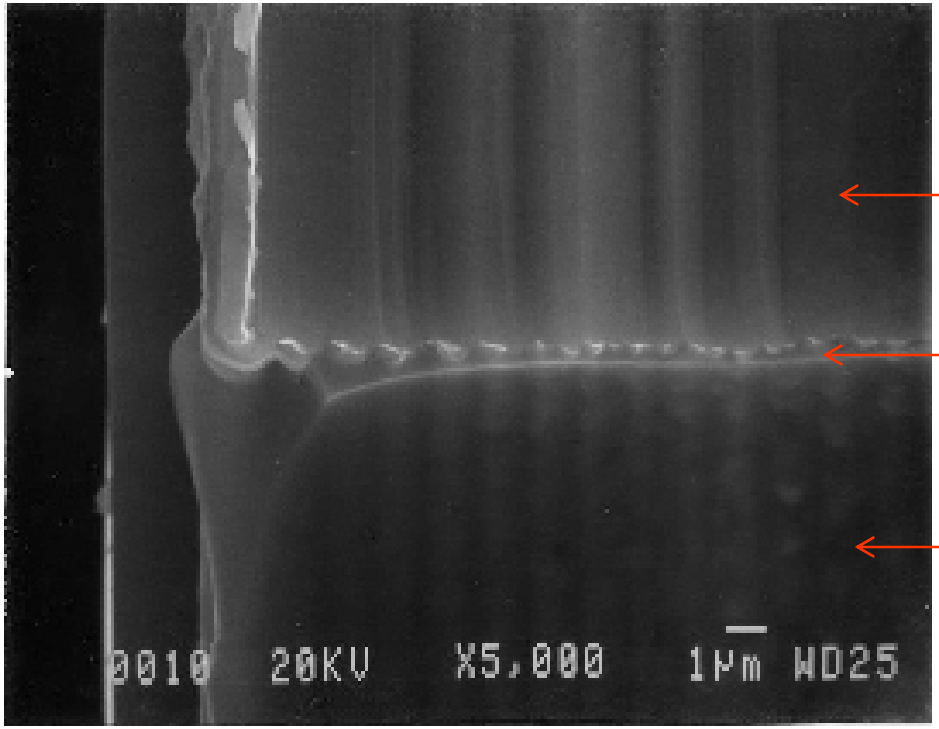


	Surface	Top	botton
Poly	1.05µm	0.8µm	0.7µm
TEOS	0.96µm	0.7µm	0.6µm

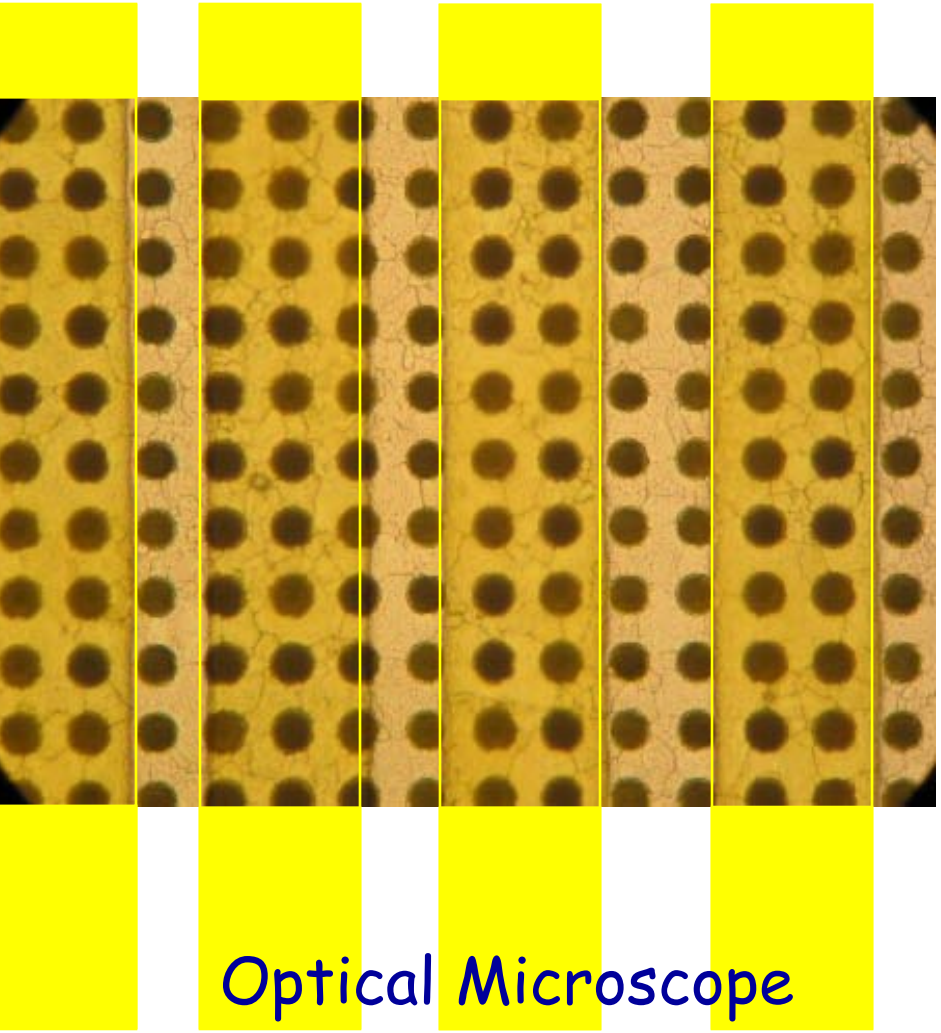
Metal deposition

Aluminium sputtering

luminium is deposited
to the first
0-30 μm

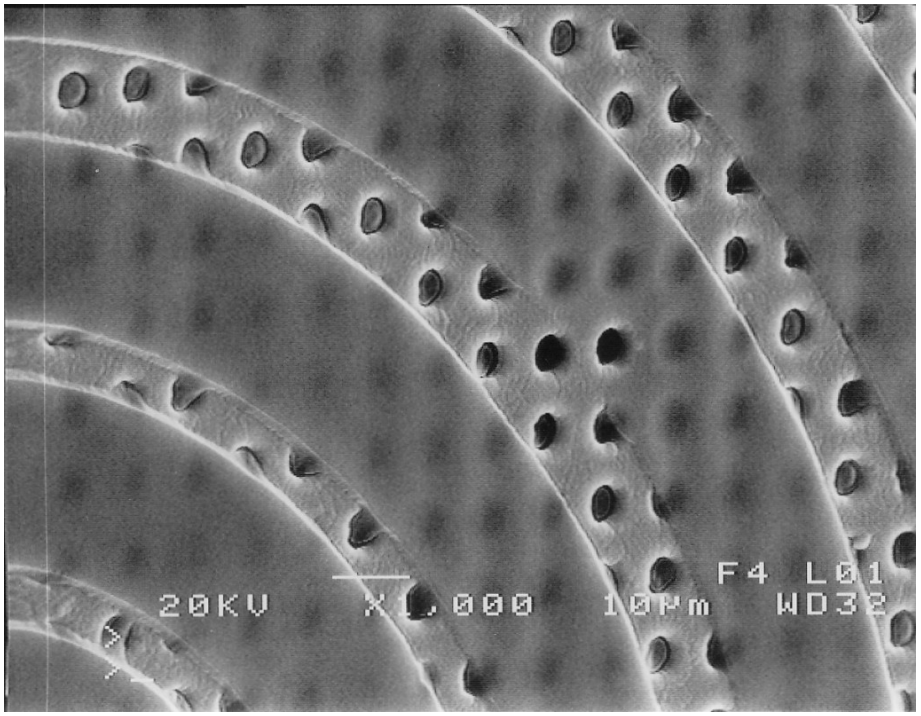


3-D photoresist definition



Optical Microscope

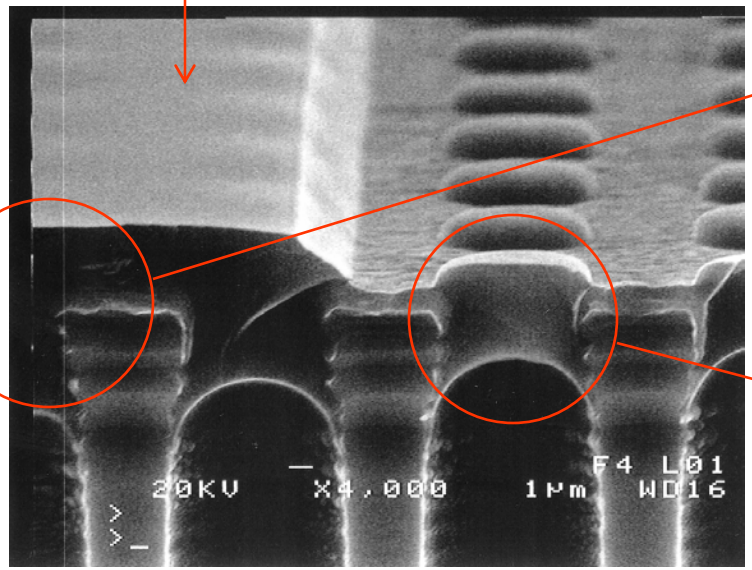
Hole
- diameter 5μm
- distance 5μm

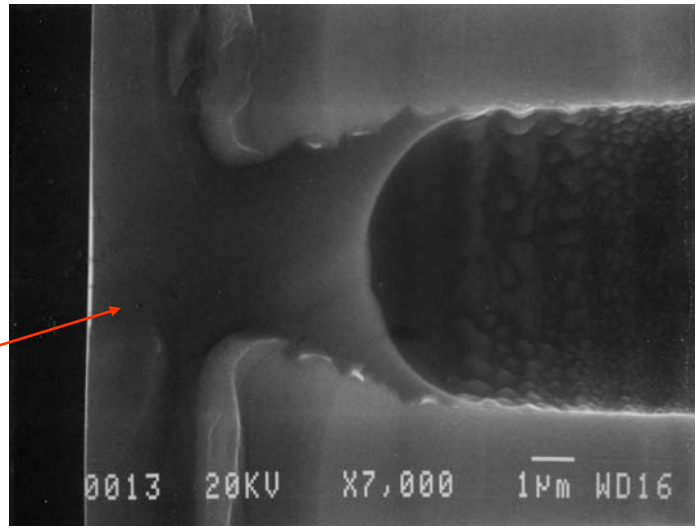


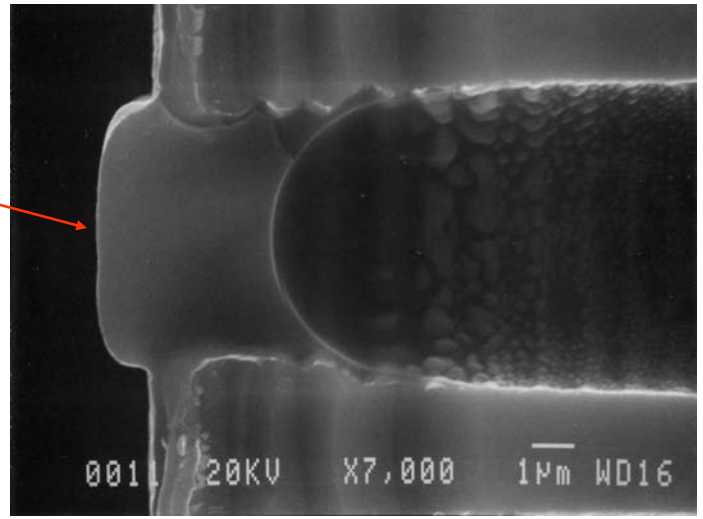
SEM picture

3-D photoresist definition

Photoresist line







First results on MCz silicon at Irst

Process:

1. standard Irst process for detector realization (sintering @ 420°C)
2. no LTO deposition (sintering at 380°C)

	Fz <111> n-type 6 Kohm		MCz <100> n-type >0.5 Kohm	
FDV (V)	23.2	23.9	> 1700 *estimated*	367 - 450
Q_{ox} (1/cm²)	1.56E+11	3.40E+11	2.68E+10	4.63E+10
I @ 100V (nA/cm²)	0.50	2.67	0.97	0.78
s_0 (cm/sec.)	0.9	1.5	0.4	0.7