# Detector processing for RD50 at IMB-CNM

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## Technology

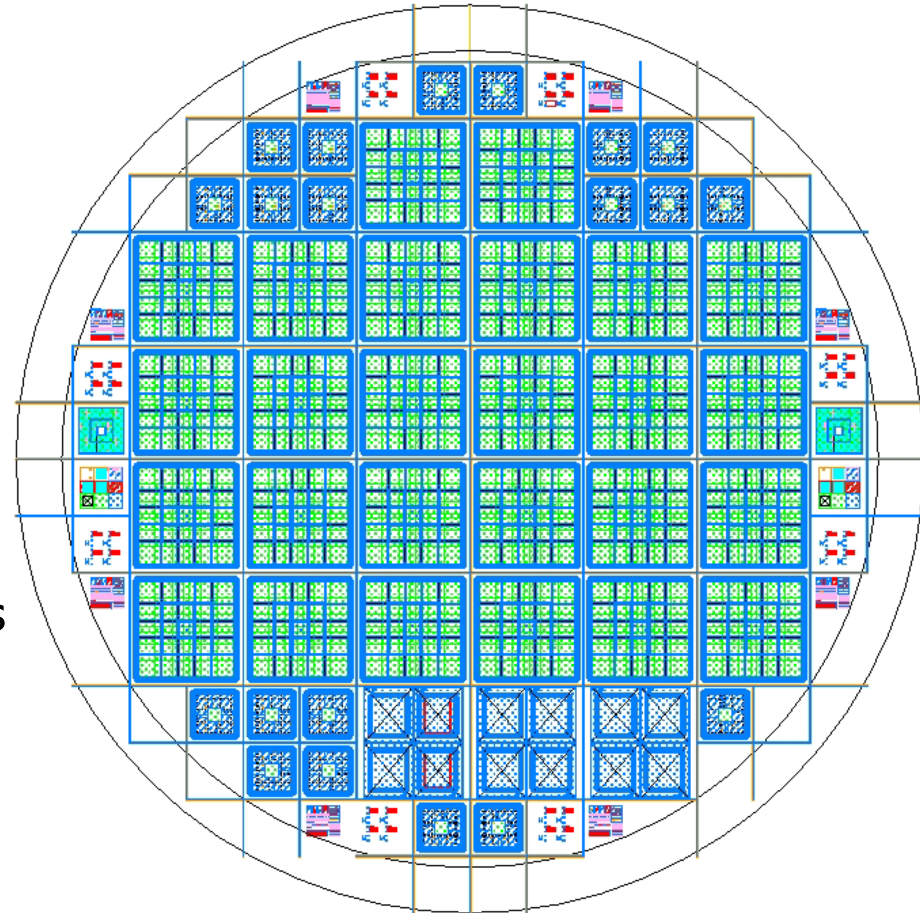
- P-in-N and N-in-P

## Mask set

- Designed by the RD50 Collaboration
- Double-side processing
- One metal layer

## Structures

- 26 microstrip detectors
  - Polysilicon biasing resistors
  - Capacitive coupling
  - P-spray insulation
  - No p-stops
- 20 pad detectors
- 12 pixel detectors
- 8 test structure sets



## Masks

| Layer | Name | Field | Side | Align |
|---|---|---|---|---|
| **1** | P-DIFF | DK | Front | |
| **2** | RES-CON | DK | Front | P-DIFF |
| **3** | POLY | CL | Front | P-DIFF |
| **4** | WINDOW | DK | Front | P-DIFF |
| **5** | METAL | CL | Front | WINDOW |

- Layer number 6, Passivation, is designed but not fabricated yet.
- Layers 7, 8, and 9 are for the back side (N-in-N technology). They will not be used this time.

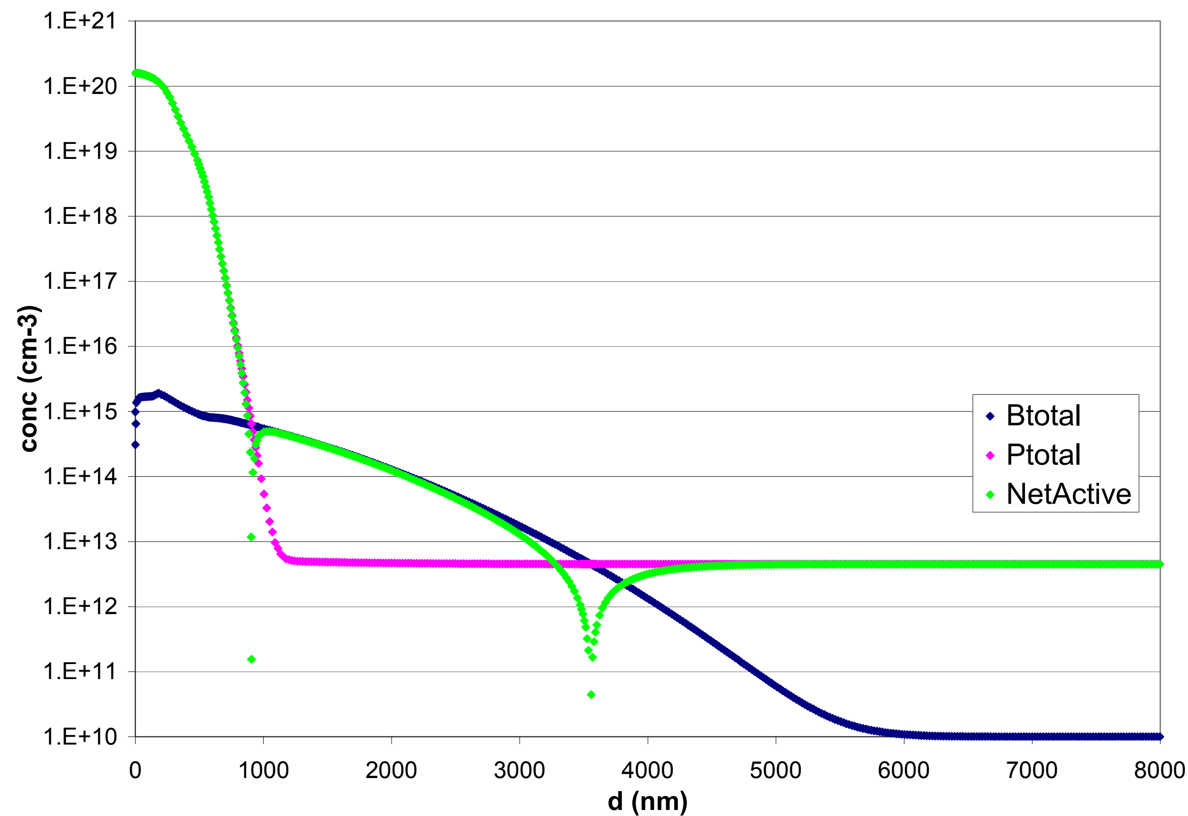
# Wafers

| Technology | Number | Growing method | Type | Wafer origin | Comments |
|---|---|---|---|---|---|
| P-on-N | 4 (+1*) | MCZ | N-type | RD50 | >500 Ω•cm, 300 µm |
| | 2 (+1*) | EPI | N-type | RD50 | thickness: 151.6;151.8;151.7 µm |
| N-on-P | 4 (+1*) | MCZ | P-type | RD50 | >2K Ω•cm, 300 µm |
| | 4 | FZ | P-type | CNM | 20 kΩ•cm, 300 µm, <100> |
| | 4 | FZ | P-type | CNM | 20 kΩ•cm, 300 µm, <100><br>Oxygen enriched (DOFZ) |
| | 2 (+1*) | EPI | P-type | RD50 | thickness: 152.7;151.1;151.0 µm |
| | **20** | | | | |

*There is one additional spare wafer of each type that is not going to be processed. If after processing they are not needed, they will be returned to RD50.

# Previous studies: p-spray (N-in-N)

- Insulation between strips provided only by p-spray (no p-stops)
- Dose optimization: The limit is fixed to avoid buried junction in the microstrip area
- Only technological simulation necessary



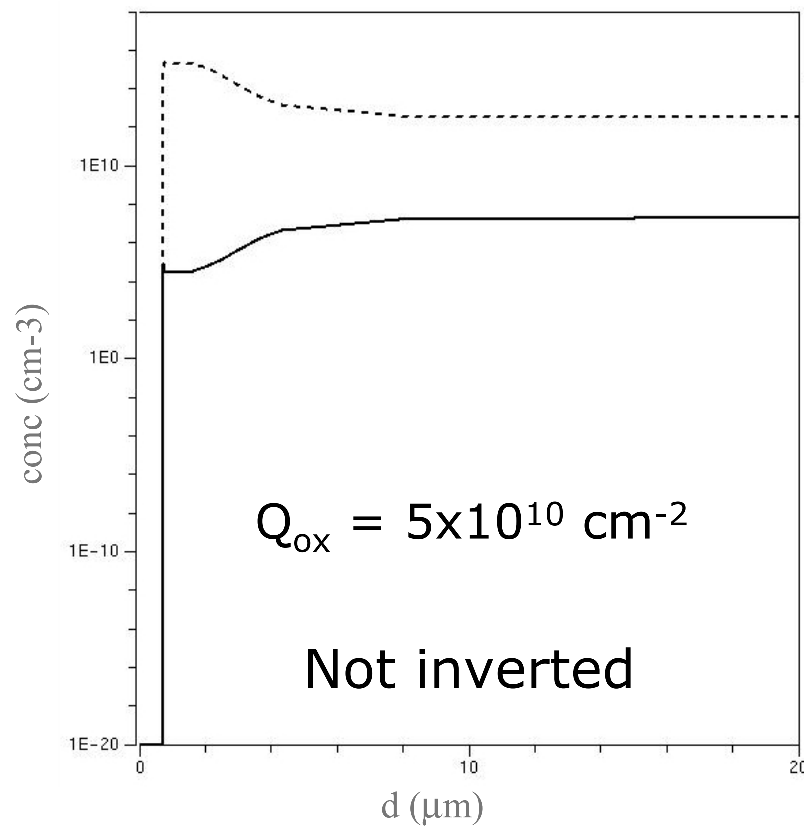

N-P-N profile!!

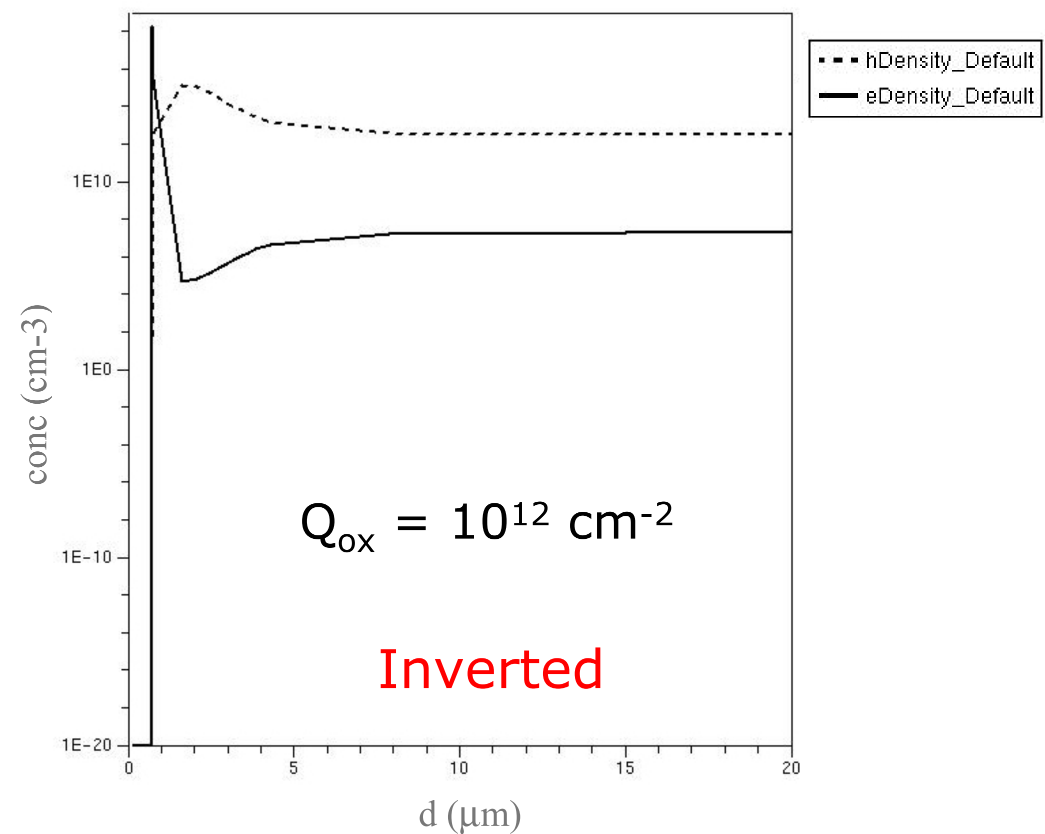
## Previous studies: p-spray (N-in-P)

- Double junction structure is not possible
  - Not technological limit to the maximum p-spray dose
  - The limit is fixed by electrical considerations
- Technological *and* electrical simulation needed. Objectives:
  - Avoid inversion at the silicon surface
  - Breakdown voltage as high as possible
- Have carried out a systematic simulation process (ISE-TCAD)
- P-spray parameters:
  - Implantation energy
  - Implantation dose
  - Implantation oxide thickness
- Very time-consuming --> beginning of run has been delayed!

## Inversion at the Si surface (N-in-P simulations)

- Provides a first approximation for the p-spray parameters
- Example: p-spray energy=25 keV, dose=$10^{12}$ $cm^{-2}$, oxide implant thickness=150 nm



# Inversion at the Si surface (N-in-P simulations)

- Oxide charge:

| | |
|---|---|
| $5\times10^{10}$ | very good oxide quality |
| $10^{11}$ | standard fabrication process |
| $10^{12}$ | irradiated oxide |

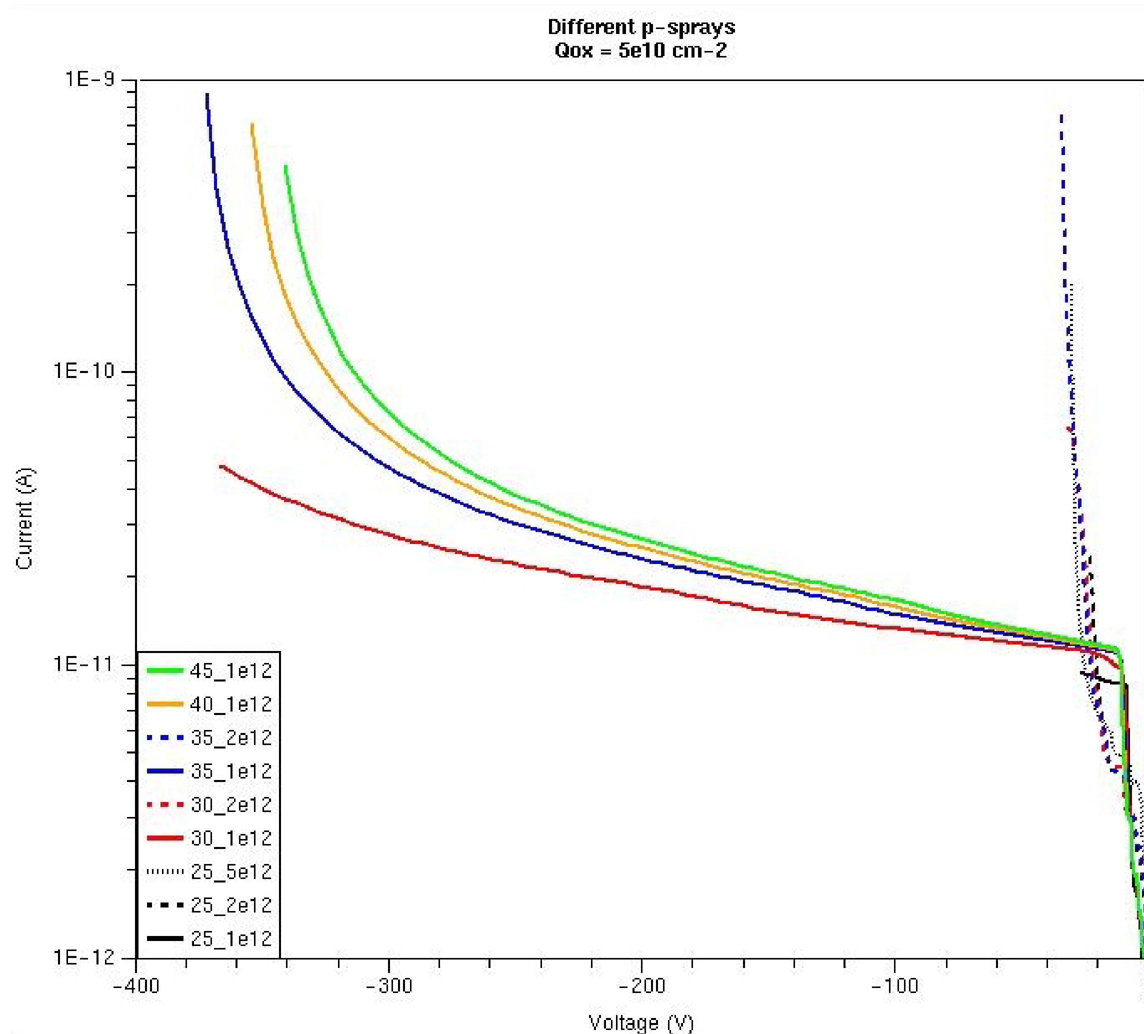
Inversion is <u>not a major concern</u> in heavily irradiated detectors

| | | $Q_{ox}$ (cm$^{-2}$) | | |
|---|---|---|---|---|
| | | **$5\times10^{10}$** | **$10^{11}$** | **$10^{12}$** |
| **p-spray energy (keV)** | **25** | NO | YES | YES |
| | **30** | NO | NO | YES |
| | **35** | NO | NO | YES |
| | **40** | NO | NO | YES |
| | **45** | NO | NO | YES |

Implantation dose = $10^{12}$ cm$^{-2}$

Oxide thickness = 150 nm

# Breakdown voltage (N-in-P simulations)




- Dramatic decrease in breakdown voltage as dose increases, for the same energy

P-spray implant dose as low as possible, play with implant energy

Technical lower limit $10^{12}$ $cm^{-2}$

**The final dose will be the highest compatible with high breakdown voltage**

# Test run

- We prefer to optimize the p-spray implant parameters with a test run before processing RD50 priceless wafers
- CNM has launched a test run for the N-in-P technology to verify the simulation results
- 6 wafers in process
  - 25 keV, $10^{12}$ cm$^{-2}$
  - 25 keV, 1.4x$10^{12}$ cm$^{-2}$
  - 25 keV, 2x$10^{12}$ cm$^{-2}$
  - 30 keV, $10^{12}$ cm$^{-2}$
  - 35 keV, $10^{12}$ cm$^{-2}$
  - 45 keV, $10^{12}$ cm$^{-2}$
- 2 control wafers (p-spray homogeneity)
- Calibration process already started. One month delay in RD50 run, but more confident about technology.

- **Run at CNM expenses**
- **We can give samples to interested groups.**