Karlsruhe Institute of Technology

Proposal for a new RD50 project "Strip sensors made of N-rich FZ silicon (NitroStrip)"

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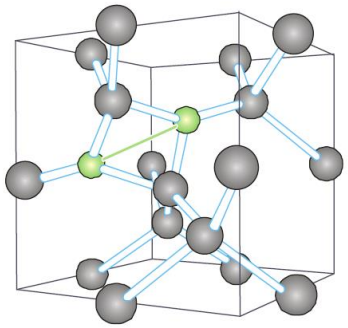
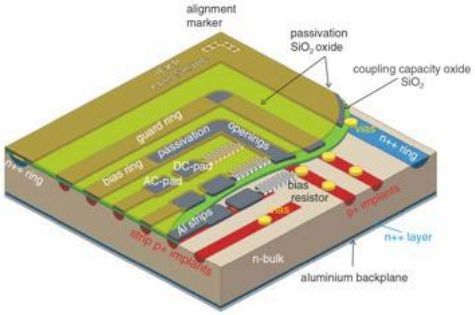
INSTITUT FÜR EXPERIMENTELLE KERNPHYSIK





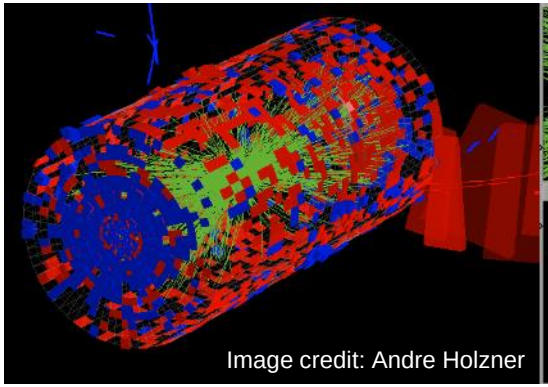
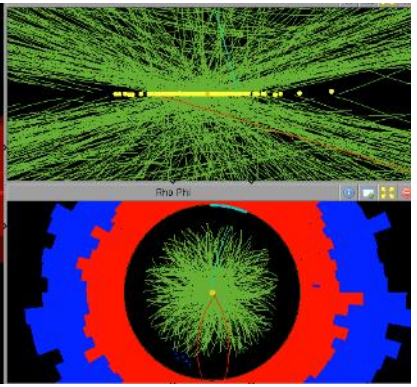


Image credit: Andre Holzner



Recap N-rich Si (NitroSil Project)

- See talks by Topsil and ITME in last RD50 workshop
- Nitrogen effective in reducing vacancy related defects
- Development of N-rich silicon wafers with high resistivity and homogeneity
- We now want to go a step further from microscopic measurements to sensor properties

FZ Si nitrogen-doped, high-resistivity samples

Sample label	Orien-tation	ρ (300 K) (Ωcm)	[N] ($x10^{15}$ cm^{-3})	[O] ($x10^{16}$ cm^{-3})	[C] ($x10^{15}$ cm^{-3})
A (2.1)	<100>	4700	0.98	0.6	1.0
B (1.1)	<111>	1700	2.26	1.1	1.0
C (4.2)	<100>	500	1.42	< 1	< 1
D (6.1)	<100>	4100	2.0	0.5	< 1
E (8.1)	<100>	5300	0.92	0.2	< 1
F(10.2)	<111>	1700	2.5	0.9	3.0

Nitrogen atoms in Si lattice

- W. von Ammon *et al.* Journal of Crystal Growth 226 (2001) 19–30

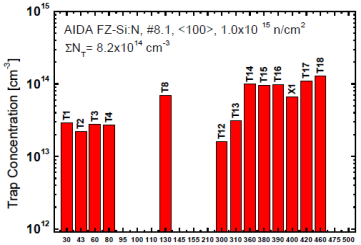
- N-N pairs are stable up to 1270 °C
- Interaction of N-N pairs rather than single nitrogen atoms with vacancies leads to suppression of vacancy aggregation

The following reactions are proposed to be responsible for vacancy annihilation:

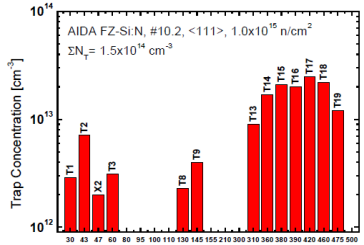
- (1) $I+V \rightleftarrows 0$
- (2) $2N_i \rightleftarrows N_2$
- (3) $N_s+N_i \rightleftarrows N_2V$
- (4) $N_2+V \rightleftarrows N_2V$
- (5) $N_2V+I \rightleftarrows N_2$

Concentrations of radiation defect centers
$\Phi = 1\times10^{15}\ n_{eq}/\ cm^2$

Sample E, [N] = 9.2×10^{14} cm^{-3}



Sample F, [N] = 2.50×10^{14} cm^{-3}



Total traps concentration: 8.2×10^{14} cm^{-3}

Total traps concentration: 1.5×10^{14} cm^{-3}

High-Resolution Photoinduced Transient Spectroscopy (HRPITS)

16
11/19/2014

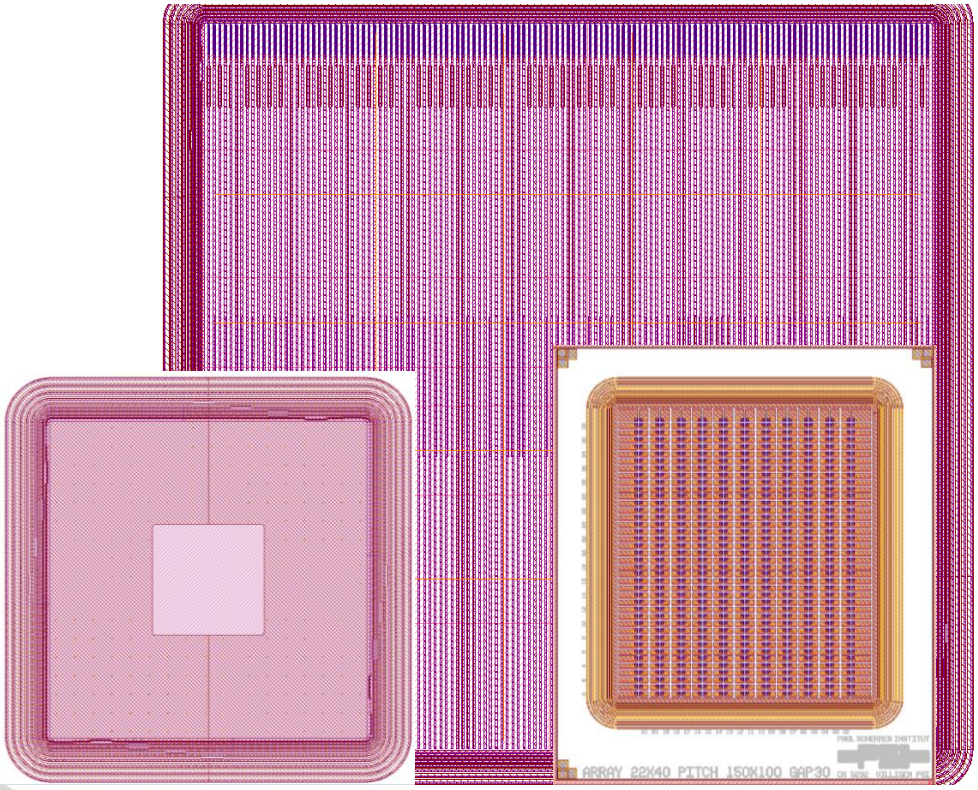
16 Presentation of Topsil TOPSIL

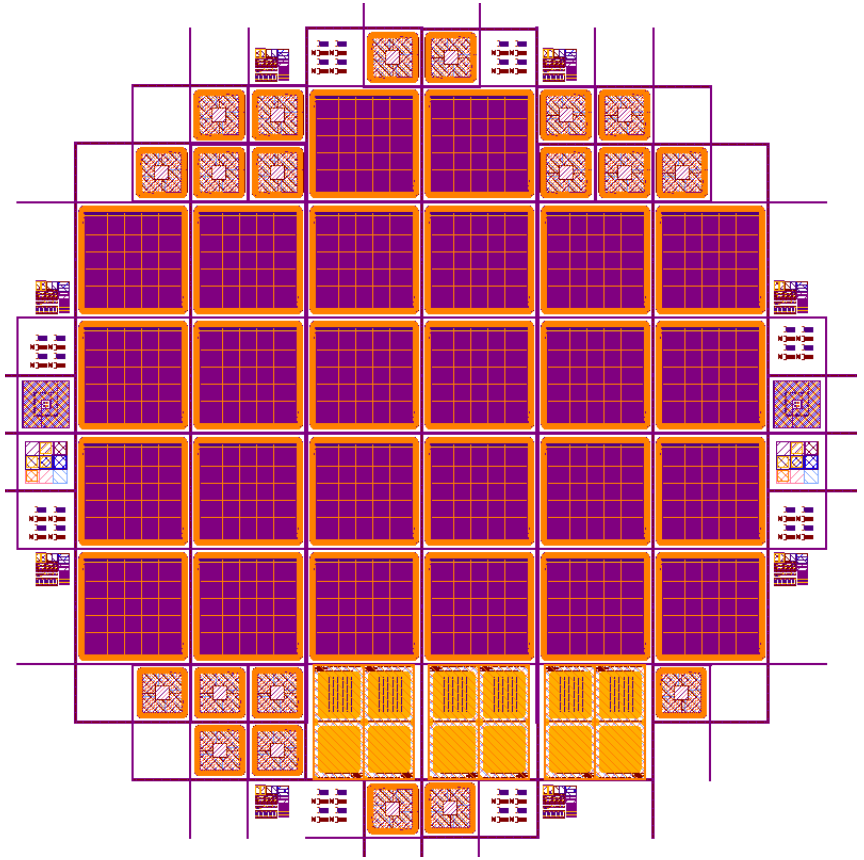
Ingredients

- As partners of the NitroSil project we get 20 4” n-type wafers (300µm)
  - 10 standard FZ
    - ρ ~ 2kΩcm
  - 10 N-rich FZ
    - [N] = (1.3-1.6)x10^{15} cm^{-3}
    - [O] < 1x$10^{16}$$cm^{-3}$
    - ρ ~ 2kΩcm (N_{eff} ~2x$10^{12}$$cm^{-3}$)
    - “In the nitrogen-enriched wafers the shallow donors related to N-O complexes can be formed at temperatures 600 – 900°C. The concentration of them is estimated to be in the range from 10^{11} to 10^{12} cm^{-3}. So, to some extent they can affect the material resistivity.”
- I got quotes from D+T and CiS to process these 20 wafers (~20k€)
  - further wafers at ~600.-/wafer
- One could use “old” masks of a previous project (0€) or produce new ones to benefit from new/optimized layouts (~5k€)
- Costs for irradiations within this project could be >2k€ (if AIDA2020 TA does not apply)
- At the moment there are four institutes interested to participate
  - KIT, CERN, ITME (contribute the wafers), CNM (offered to add DOFZ and MCz; maybe 4x5 wafers?)
- Who else is interested to join? (at a share of < ~2250€?)

Previous RD50 mask at CNM (RD50-C for n-in-n)

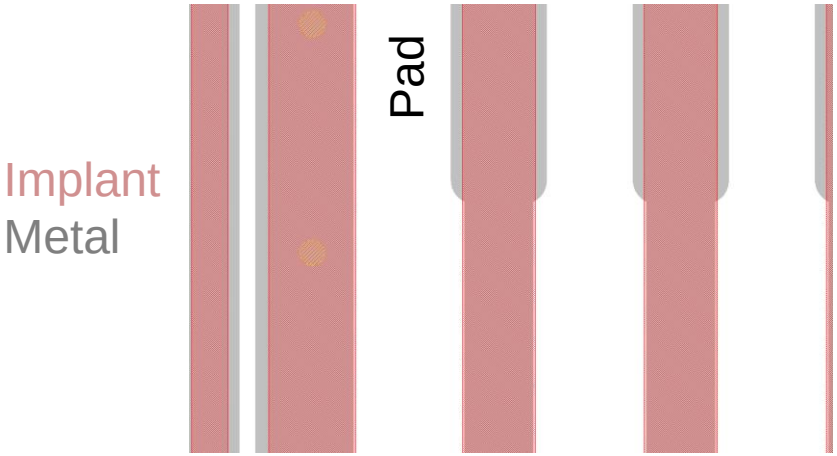
- 20 diodes (6.3x6.3mm²)
- 26 strip sensors (1.25x1.25cm²)
- 12 pixel (gap30, array 22x40) for PSI46
- Several test-structures

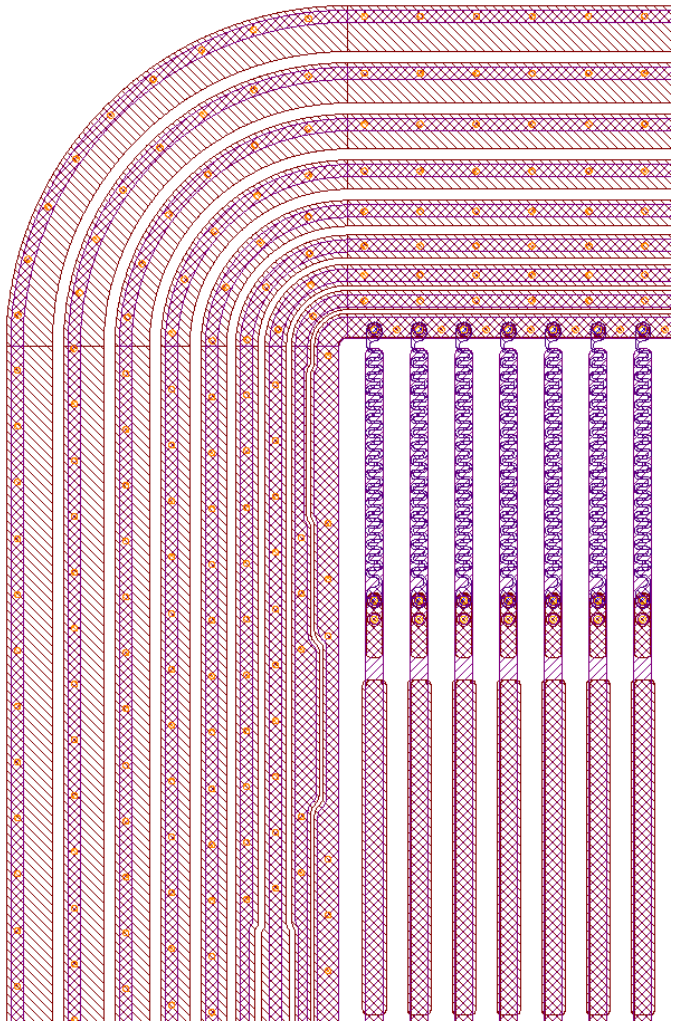




Strip sensor details

- Strips length: 10.5mm
- Pitch: 80µm; width: 30µm
- # strips: 131
- Negative metal overhang (-1µm)
  - better have pos. ~5µm overhang?
  - → just modify metal layer
- Multi-guard ring structure OK?
  - Previous measurements available?



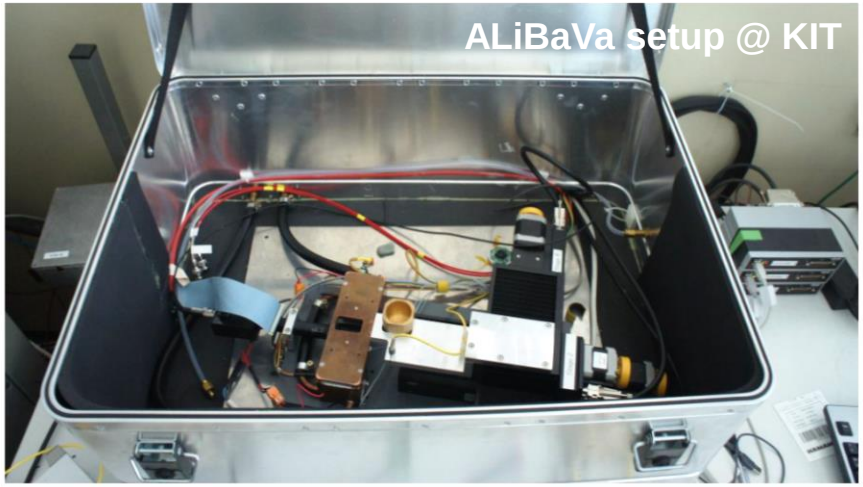


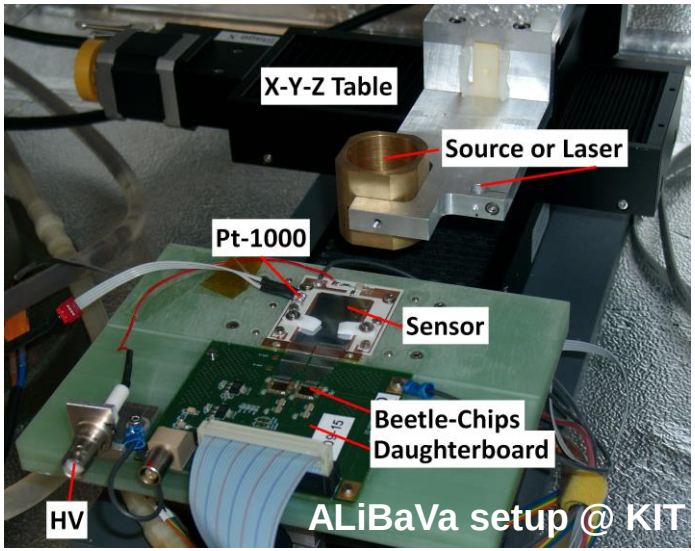
Irradiation plans

- Material: FZ, N-FZ, (DOFZ, MCz)
  - maybe 4x5 wafers, 130 sensors for each material
- Fluences: 1e14, 5e14, 1e15, 5e15n_{eq}/cm^2
- Particles:
  - 25MeV protons (KIT/Birmingham)
  - 300/800MeV protons (FNAL/Los Alamos)
  - 24 GeV protons (CERN)
  - reactor neutrons (JSI/Vienna/Brown)
- Initial program:
  - 2 sensors each irradiated with single particle type
    - Total: 2/4 x 4 x 4 x 2 = 64/128 sensors (1/4 of production)
- Then: let's see…

Measurements

- Sensor characterization
  - IV, CV on all
  - Strip measurements on samples
- Read out strip sensors with
  - ALiBaVa setup
  - Sr90 source
  - @ -20°C
- CC, cluster size, noise
  - vs. voltage
  - vs. annealing
    min. steps: initial, 2w@RT, 20w@RT
- Min. program ~2 days per sensor!
  - Participants need measurement capacity!





Tentative schedule

- Wafers already available
- Two weeks to finalize list of participants (8.7.15)
  - please contact me: alexander.dierlamm@kit.edu
    or later in the coffee break…
- Decide on mask layout by end of July
  - or hopefully earlier if RD50-C mask is sufficient
- Order beginning of August
- Wafer delivery ~November
- Initial qualifications Nov – Dec
- Start of irradiation program Jan.'16
- …