Investigation of nitrogen enriched silicon detectors

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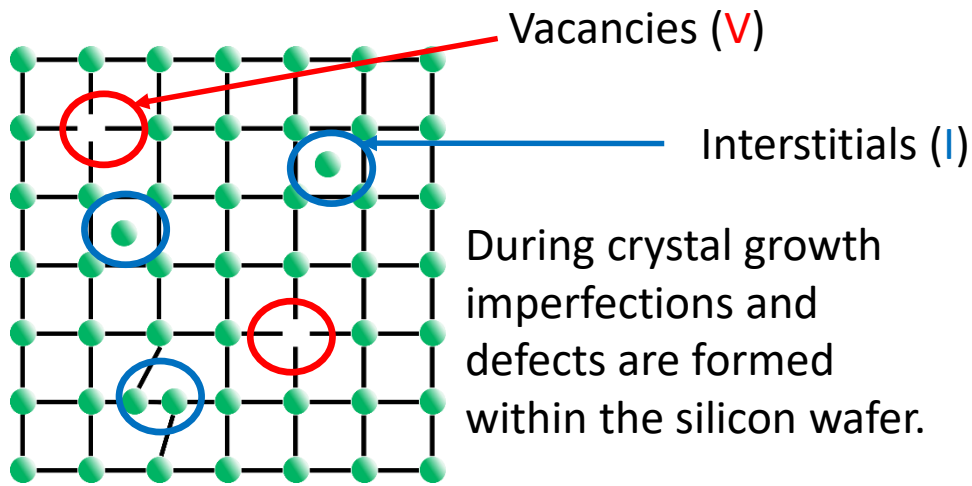
Nitrogen doping - effect on silicon



During crystal growth imperfections and defects are formed within the silicon wafer.

(1) $I + V \leftrightarrow 0$

(2) $2N_i \leftrightarrow N_2$

(3) $N_s + N_i \leftrightarrow N_2V$

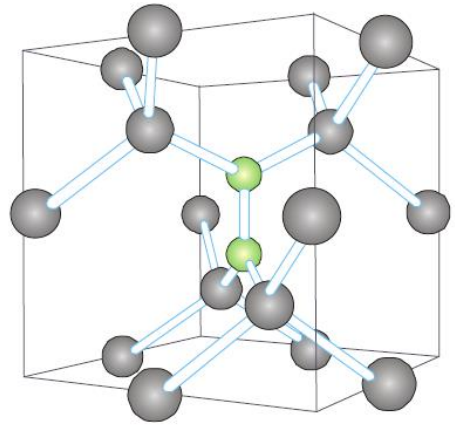
(4) $N_2 + V \leftrightarrow N_2V$

(5) $N_2V + I \leftrightarrow N_2$

N_i=single interstitial nitrogen

N_s=substitutional nitrogen

Nitrogen enrichment replaces some of these defects with more stable defects.



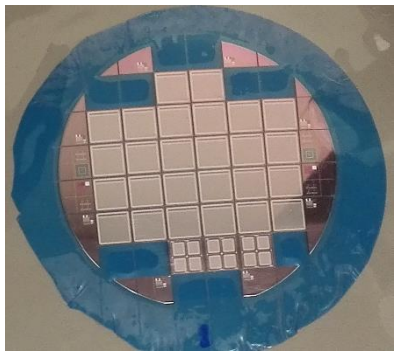
M. Kwestarz, RD50 Workshop, November 2014

Samples and irradiation

Wafers	Label	Substrate	Type	Resistivity [Ω·cm]
1-6	FZ	Floatzone	n-type	2000-2400
7-12	NIT	FZ Nitrogenated	n-type	1500-1900
13-18	DOFZ	FZ Oxygenated	n-type	2000-2400
19-24	MCZ	Magnetic Czochralski	n-type	800-1000

Irradiation performed at:
Ljubljana reactor neutrons
KIT 25 MeV protons
CERN 24 GeV/c protons

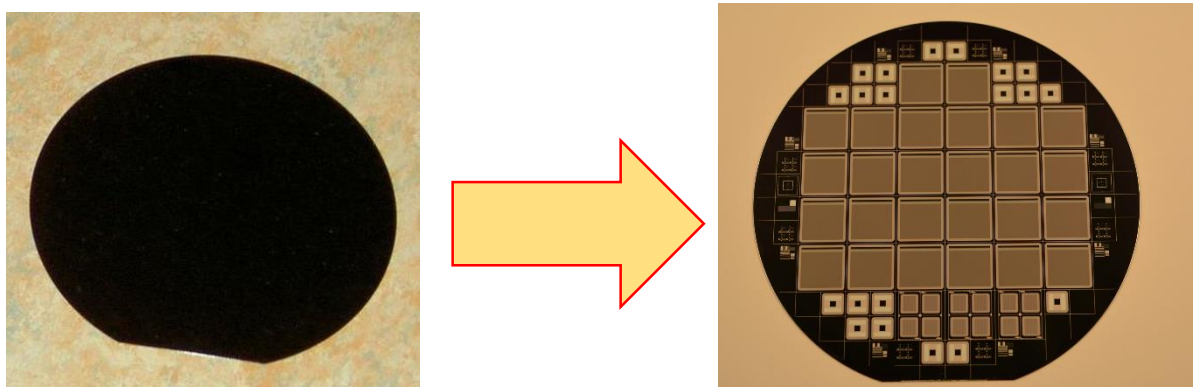
Sensor fluences:
$1{\cdot}10^{14}\mathrm{n_{eq}/cm^2}$, $3{\cdot}10^{14}\mathrm{n_{eq}/cm^2}$, $6{\cdot}10^{14}\mathrm{n_{eq}/cm^2}$, $1{\cdot}10^{15}\mathrm{n_{eq}/cm^2}$.

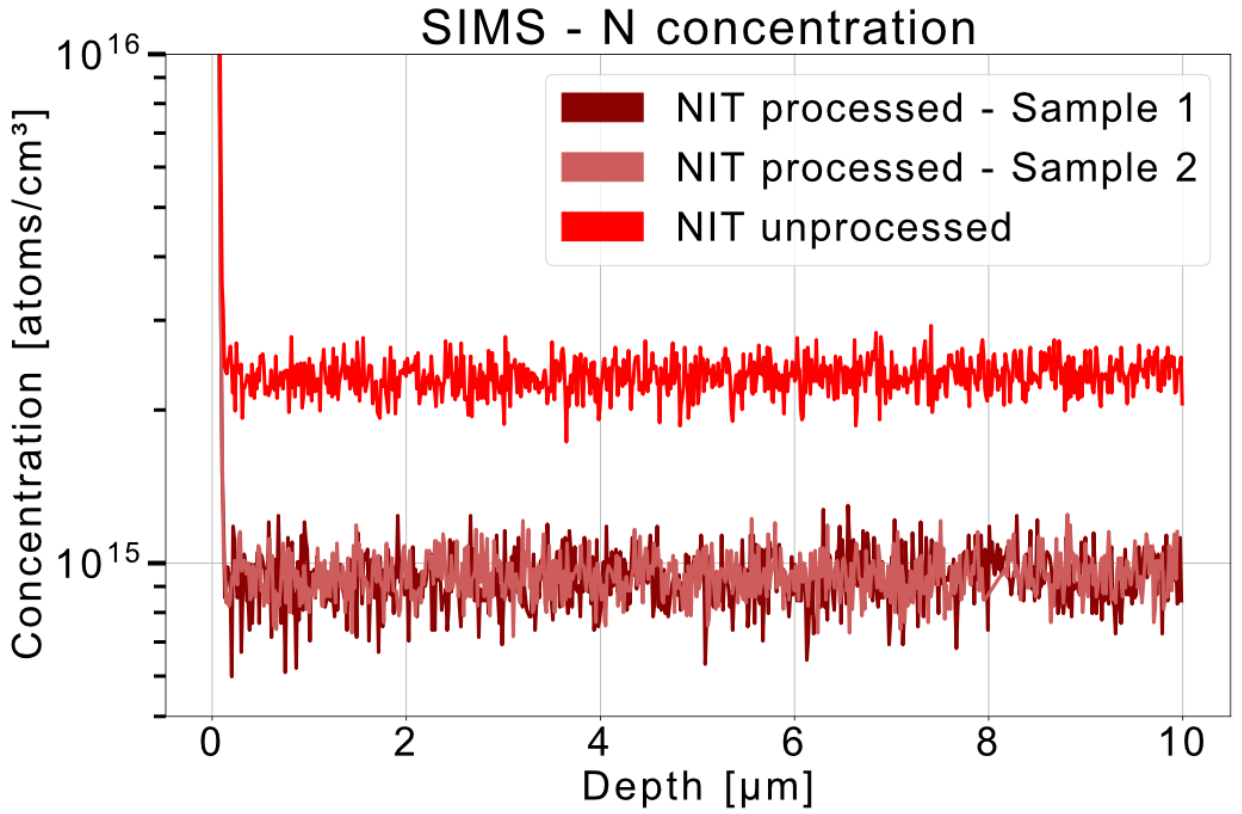


RESULTS

Nitrogen concentration measurements

- Samples are measured using the secondary-ion mass spectrometry (SIMS) technique to determine nitrogen concentration, before and after processing.
- Wafer processing lowers nitrogen content to or below detection limit.

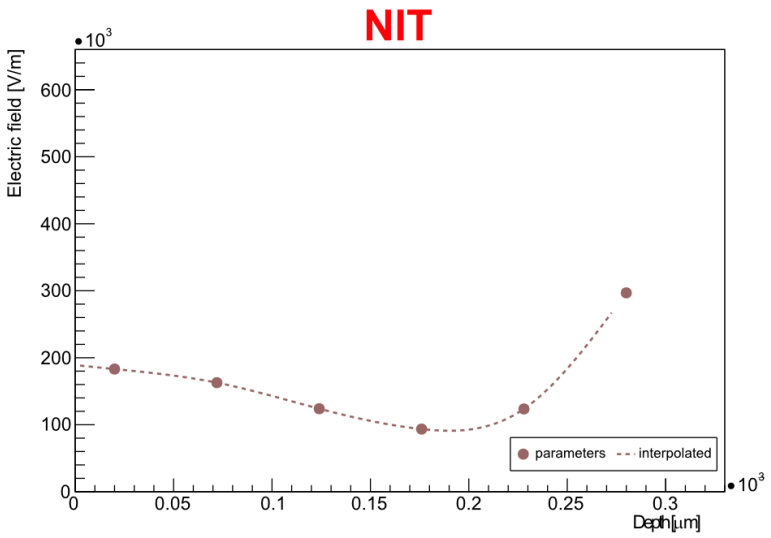


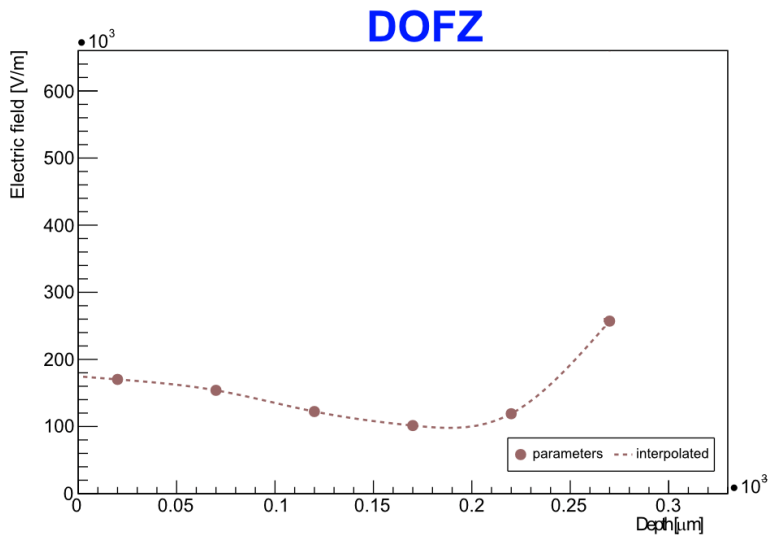


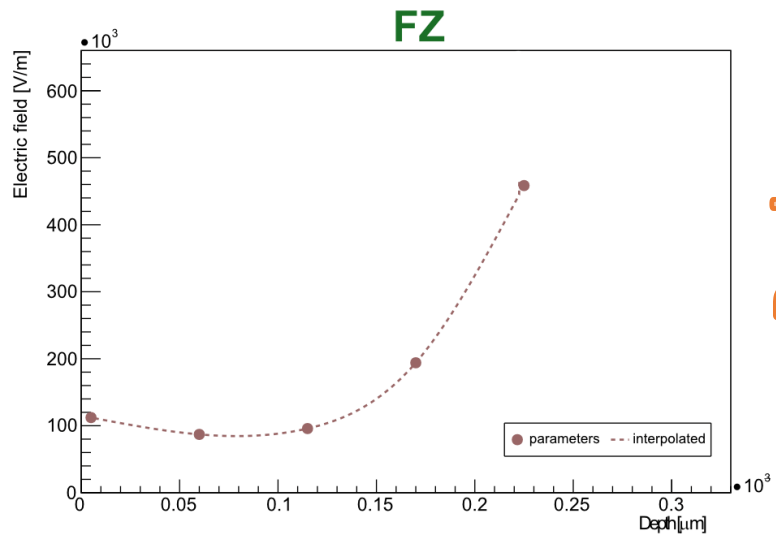
Field configuration

Results obtained from laser measurements with a laser illuminating the sensor edge (EdgeTCT).

Front







Back

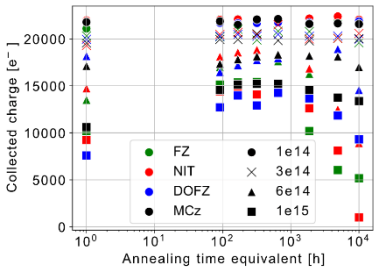
Plots show E-field calculated at 40 V bias voltage. NIT and DOFZ show similar behaviour, while FZ E-field is growing almost exclusively back to front.

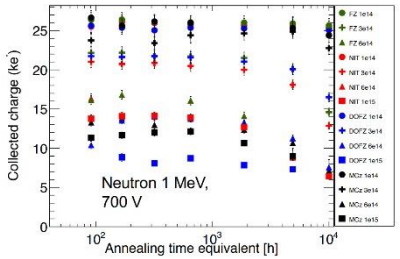
Strip sensor **irradiated to 10^{14} n_{eq}/cm^2** with **protons** (CERN 24 GeV/c) measured @ -20 °C .

This effect was not present under irradiation with neutrons!
NIT and DOFZ behave similarly across the measurements.

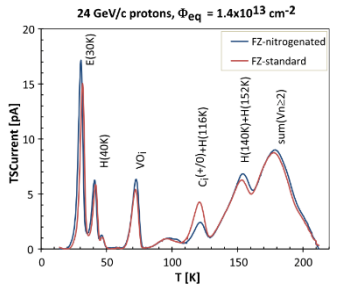
Much more to see …

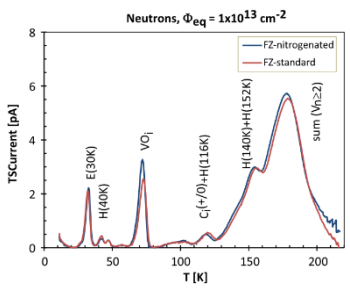
Source measurements



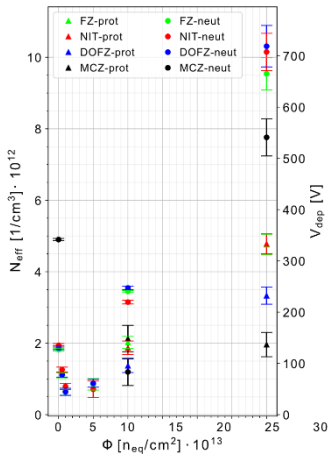


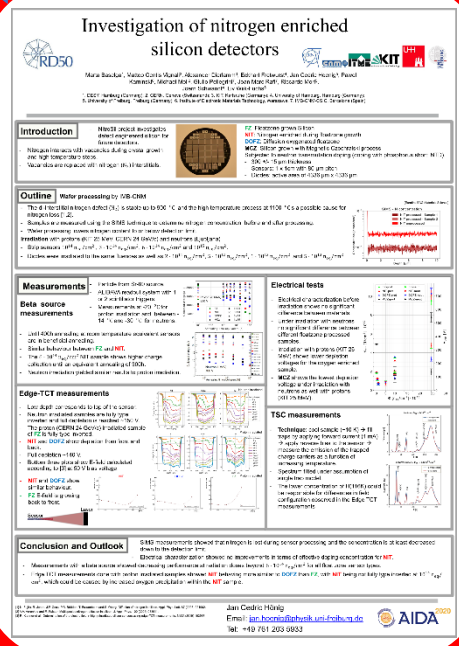
TSC measurements





Electrical testing

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RD50

Introduction

Outline

Measurements

Beta source measurements

Electrical tests

Edge-TCT measurements

TSC measurements

Conclusion and Outlook

Jan Cedric Hönig

AIDA

Laser measurements