CMS-HPK-Campaign: IV/CV-characteristics of the first sample of irradiated diodes

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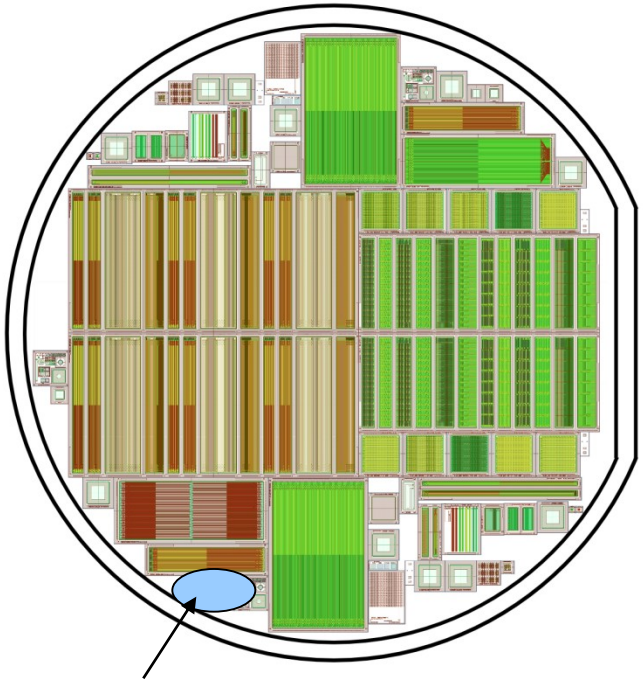
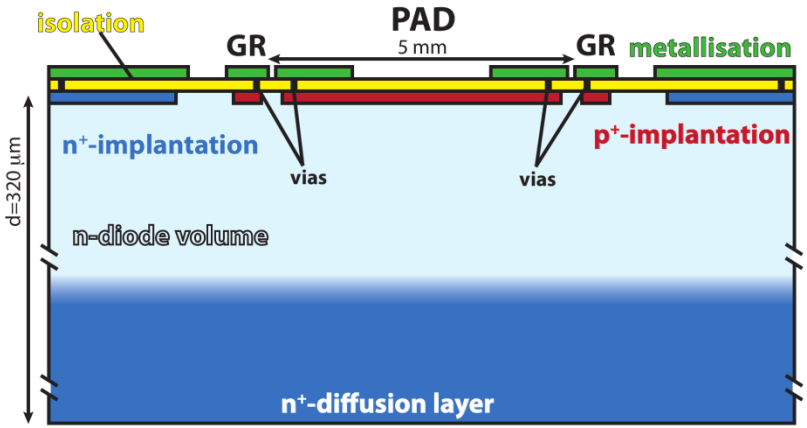
Overview

- Introduction to material and irradiation
- Characteristics of the unirradiated diodes
- Results of irradiated diodes current-voltage measurements
- Results of irradiated diodes capacitance-voltage measurements

Material Overview



Used Diodes
(L_05: A=0.25 cm^2
S_15: A=0.044 cm^2)



Active thickness:
120 µm, 200µm, 320 µm

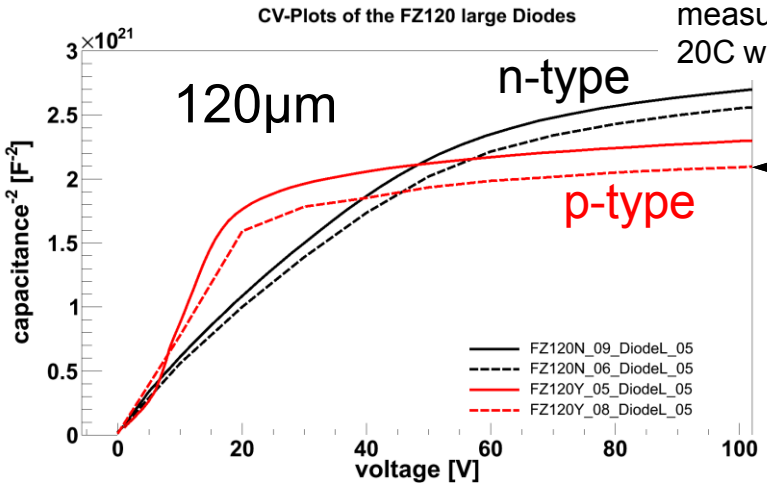
Alexandra Junkes

wafer	n-Typ	p-Typ (p-spray)
FZ 320 µm	X	X
FZ 200 µm	X	X
FZ 120 µm	X	X

Irradiation Overview

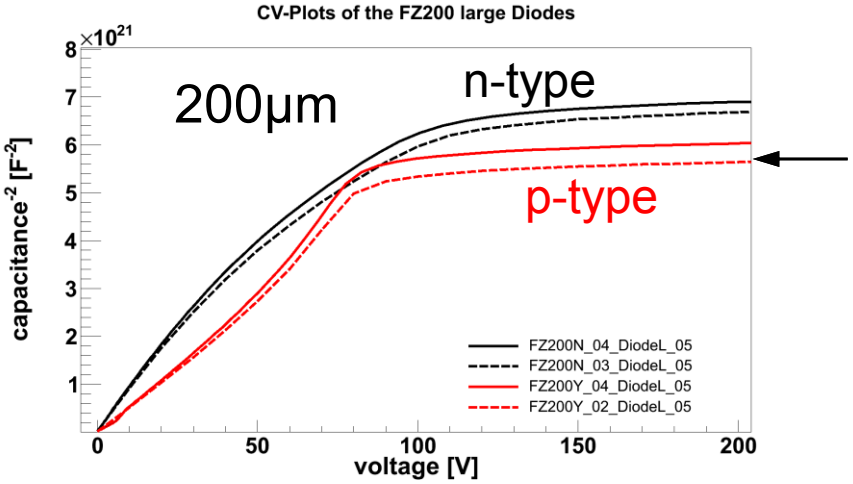
- This first irradiation a special step to check if the deep-diffusion material works, before starting the whole campaign
- p-type and n-type Floatzone material of three thicknesses: 120µm, 200µm and 320µm
- One large and one small Diode per type and irradiation-set
- Three irradiation sets, with a fluence of 10^{14} neq:
  - neutron (reactor, 10^{14} neq)
  - proton (25 MeV, $1.09*10^{14}$ neq)
  - mixed (neutron (reactor, 10^{14} neq) + proton (25 MeV, $1.09*10^{14}$ neq))

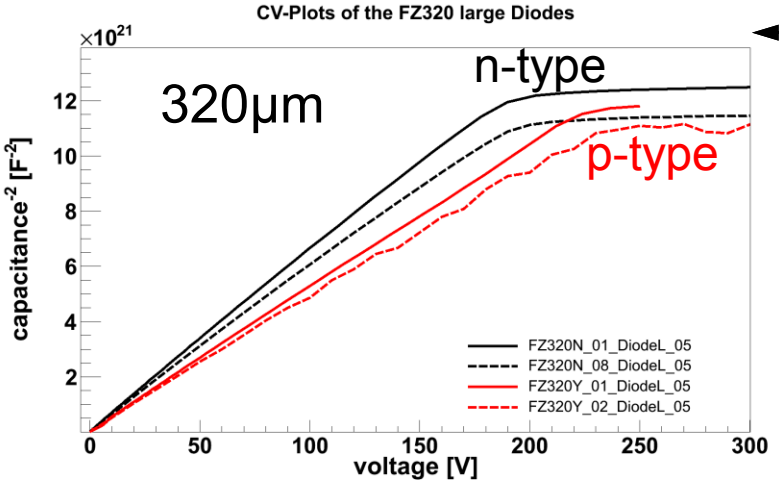
Characteristics of the unirradiated Diodes



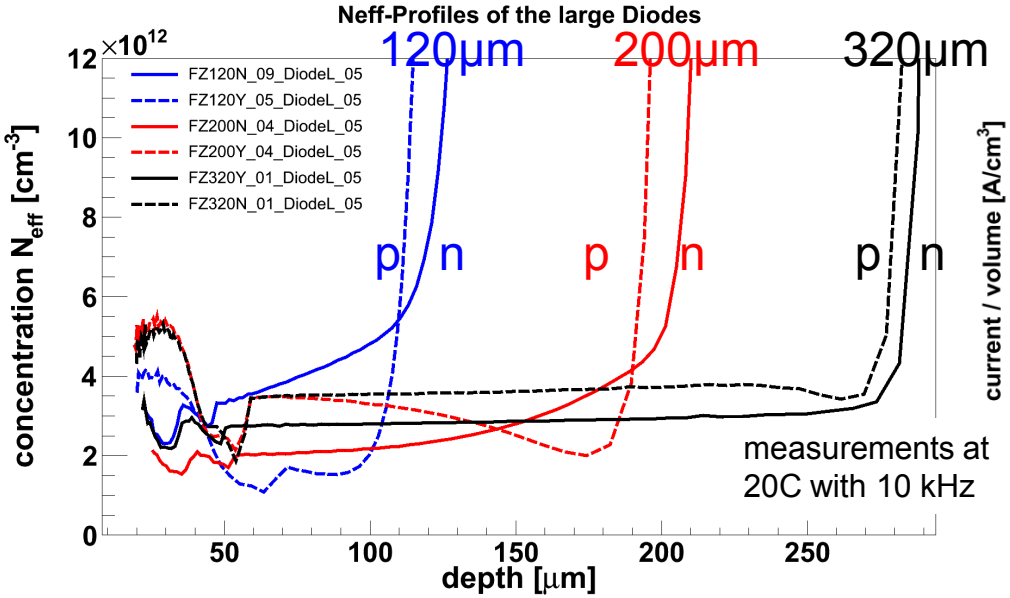
measurements at 20C with 10 kHz

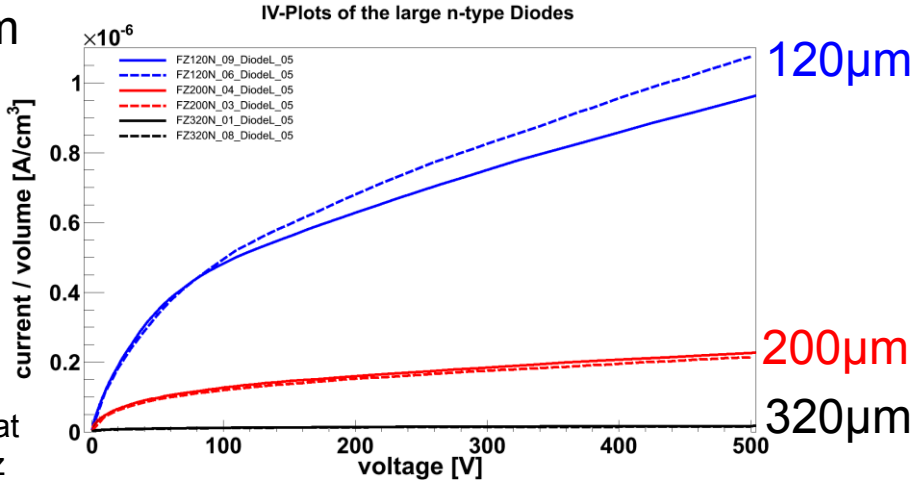
- n-type has generally lower capacitance than p-type
- 120µm and 200µm have very different shapes (see Talk of Alexandra Junkes)

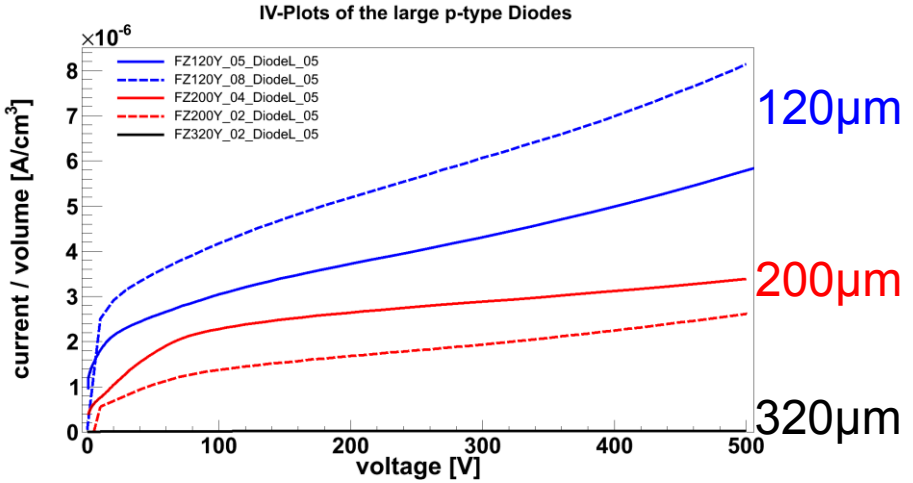




Characteristics of the unirradiated Diodes II



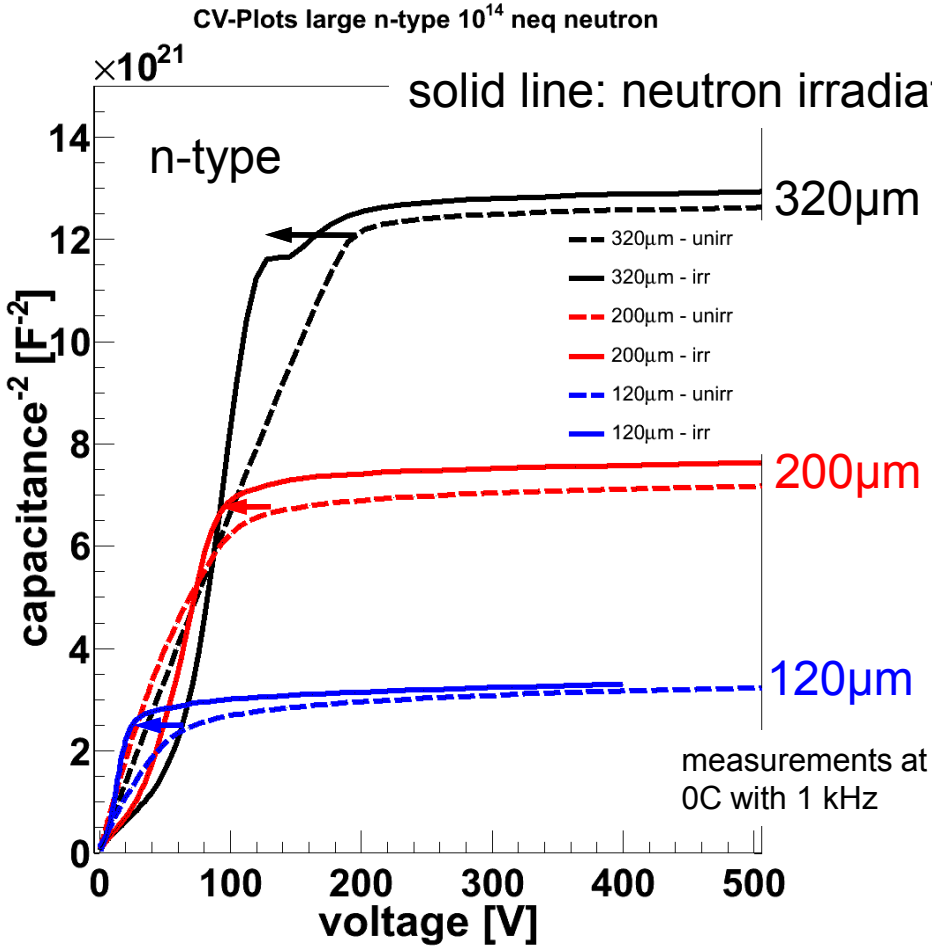


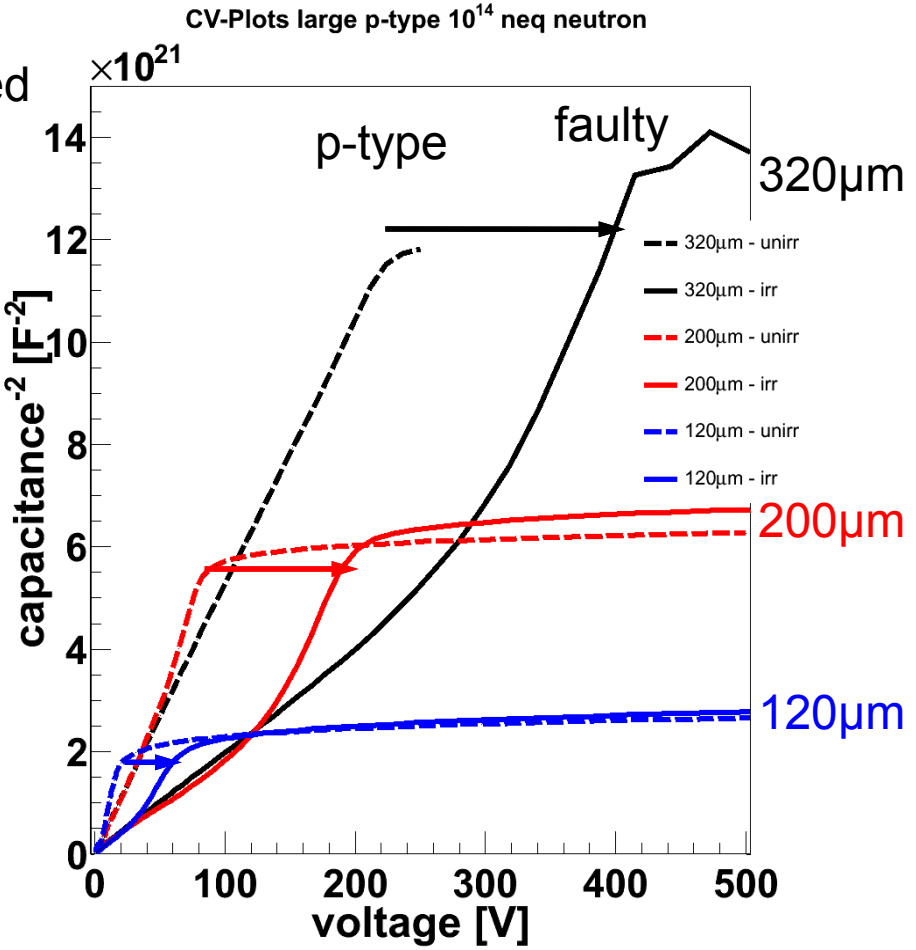


Neff-Profile:
- Very different active thicknesses
- N-type: Neff increases with depth
- P-type: Neff decreases over volume

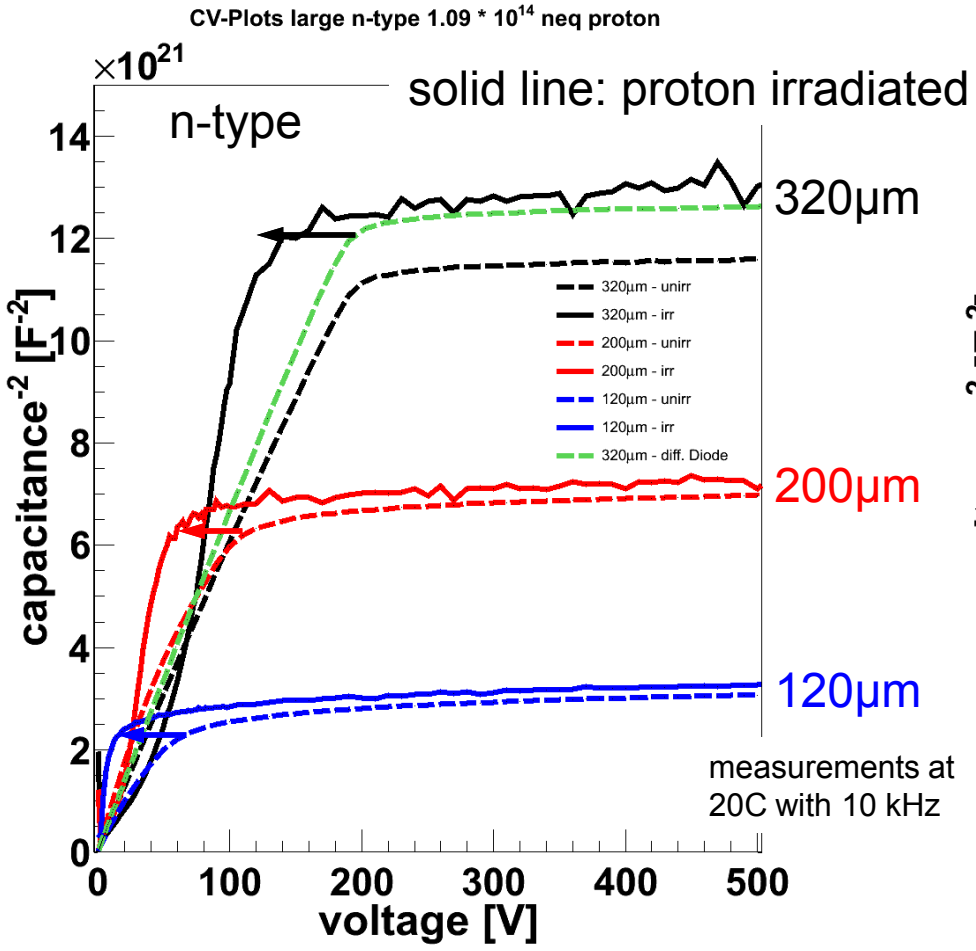
IV-Plots:
- Current decreases with thickness
- Spread in material from different wafers

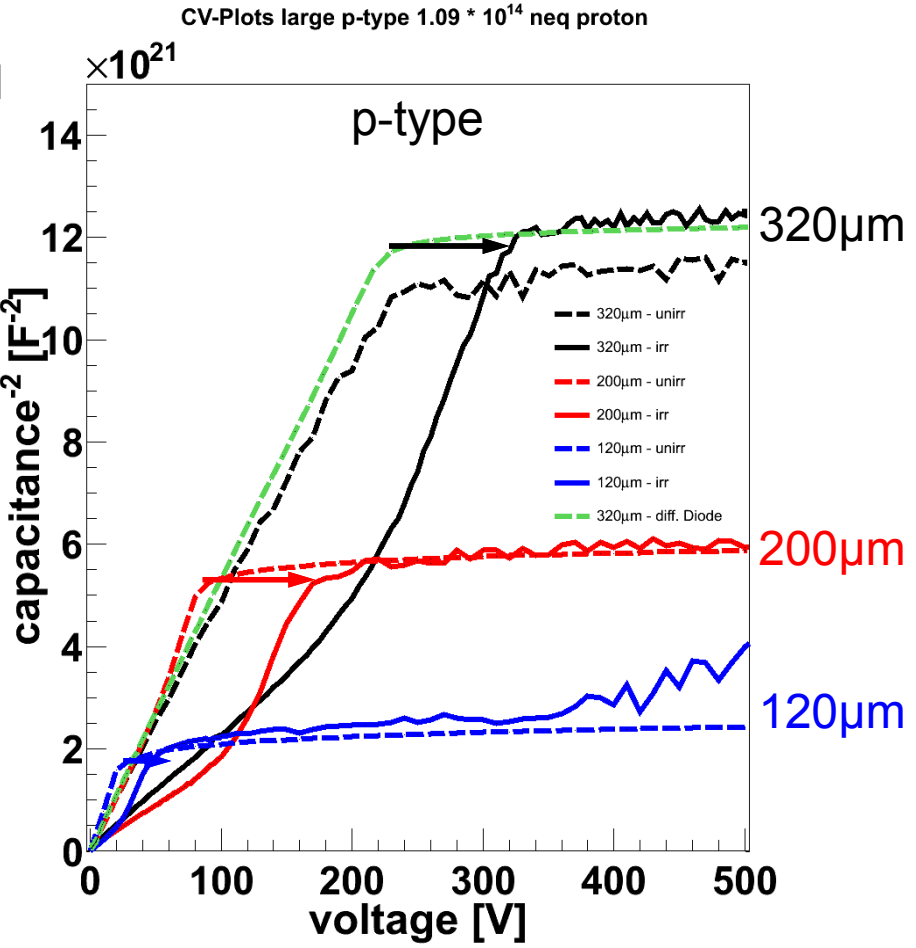
Neutron irradiated - CV



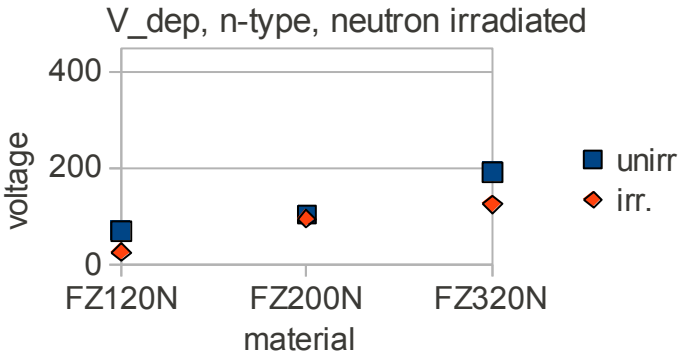


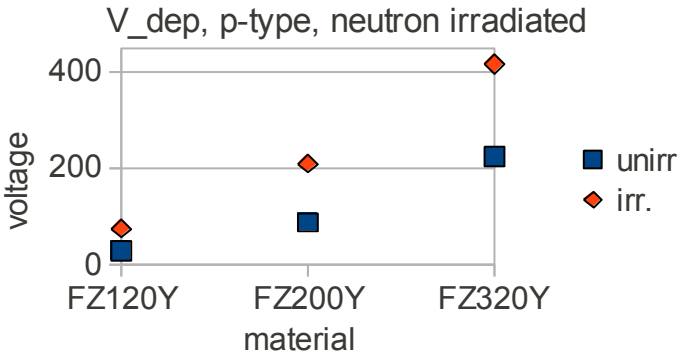
Proton irradiated - CV

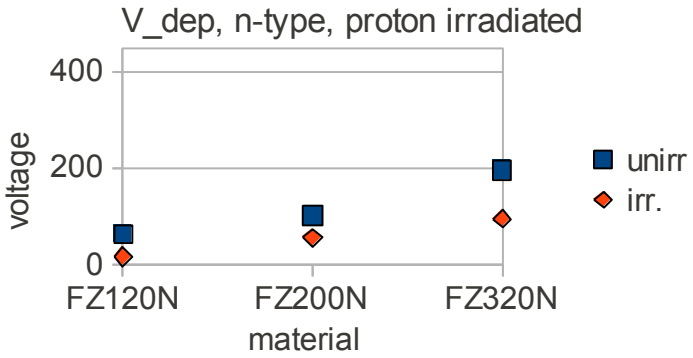


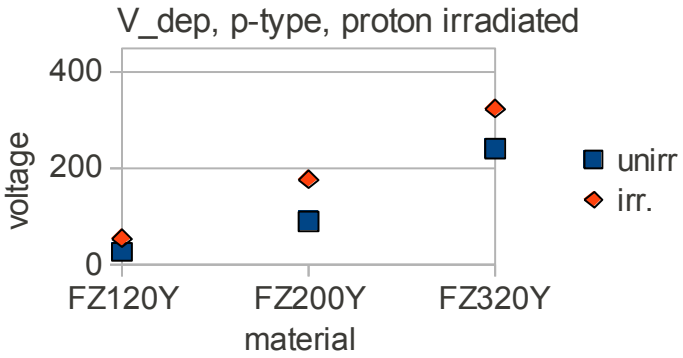


CV - summary







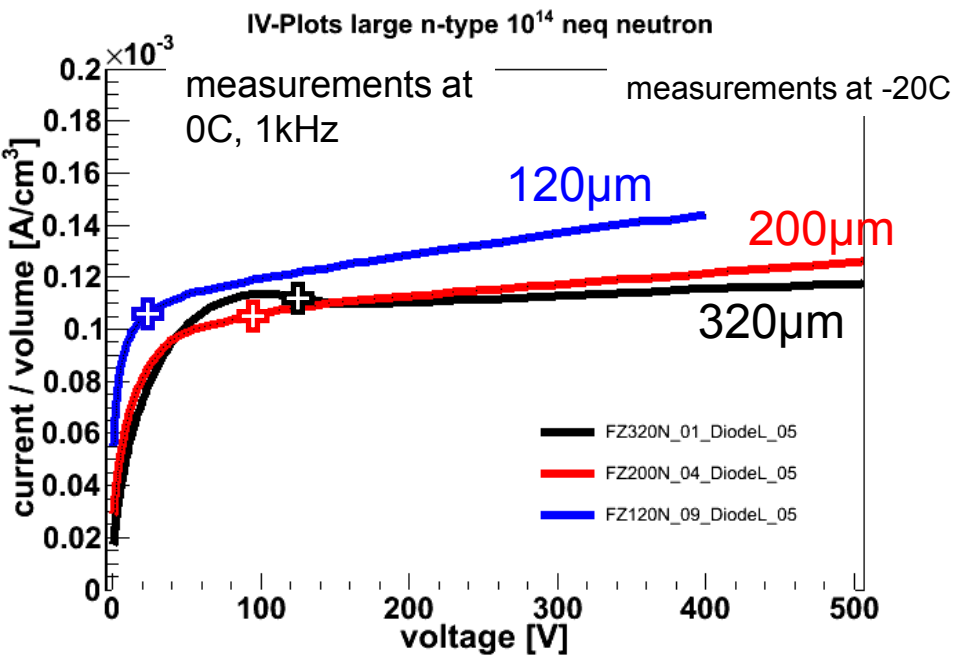


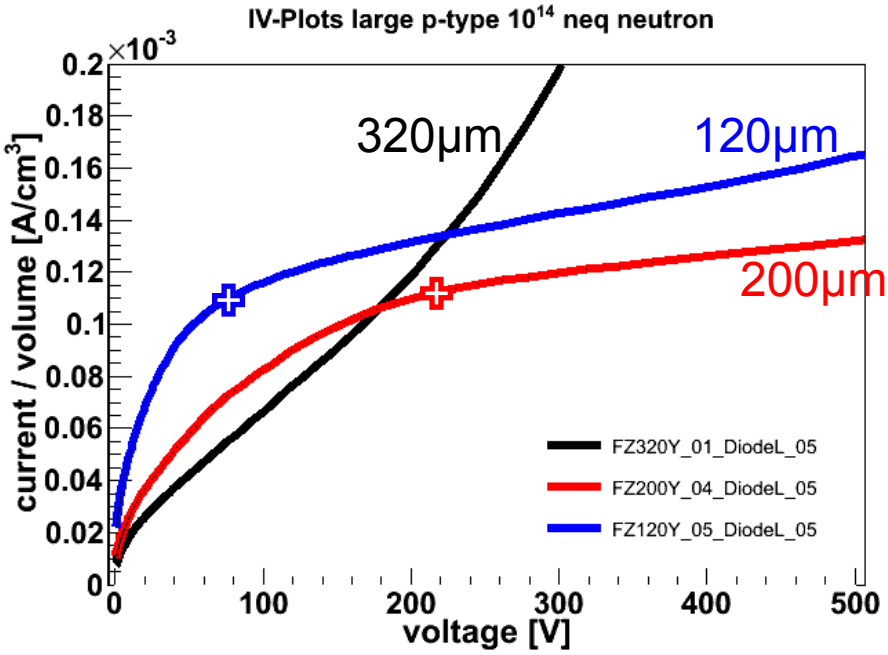
N-type: decreasing depletion voltage

P-type: increasing depletion voltage

No difference between proton and neutron irradiation

Neutron irradiated - IV

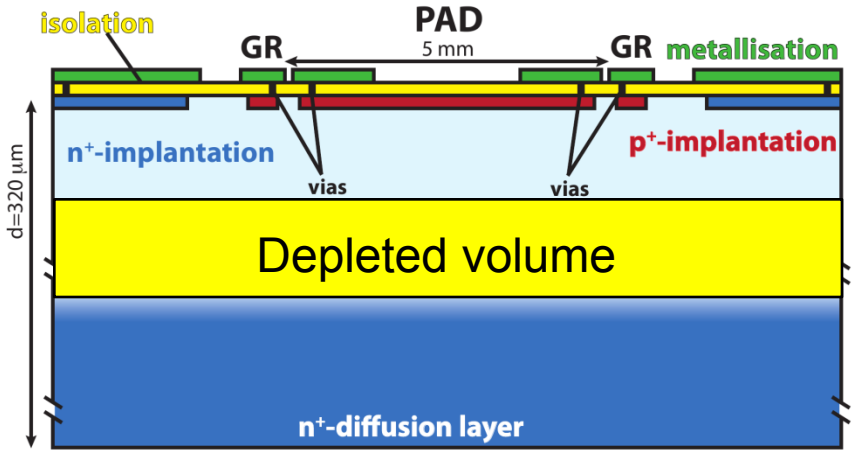




Small bump in the front for 320µm
→ a hint for type-inversion

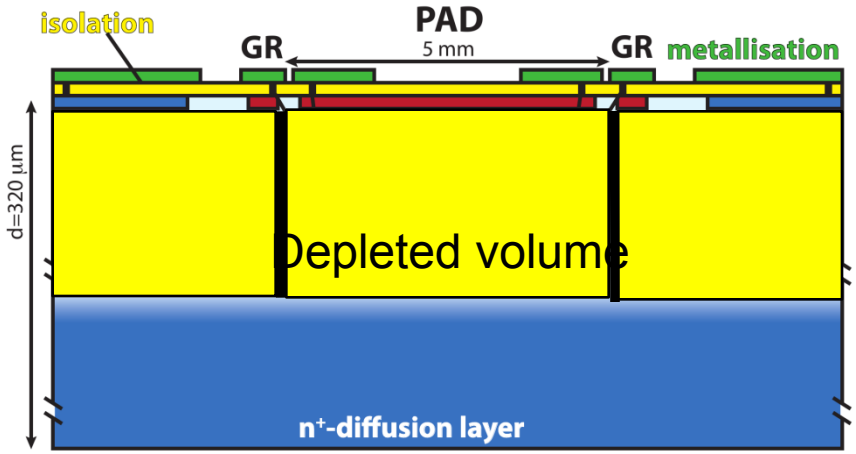
- Volume-currents are all in same range
- Slope of current above depletion is stronger for thinner diodes

Depletion after type-inversion

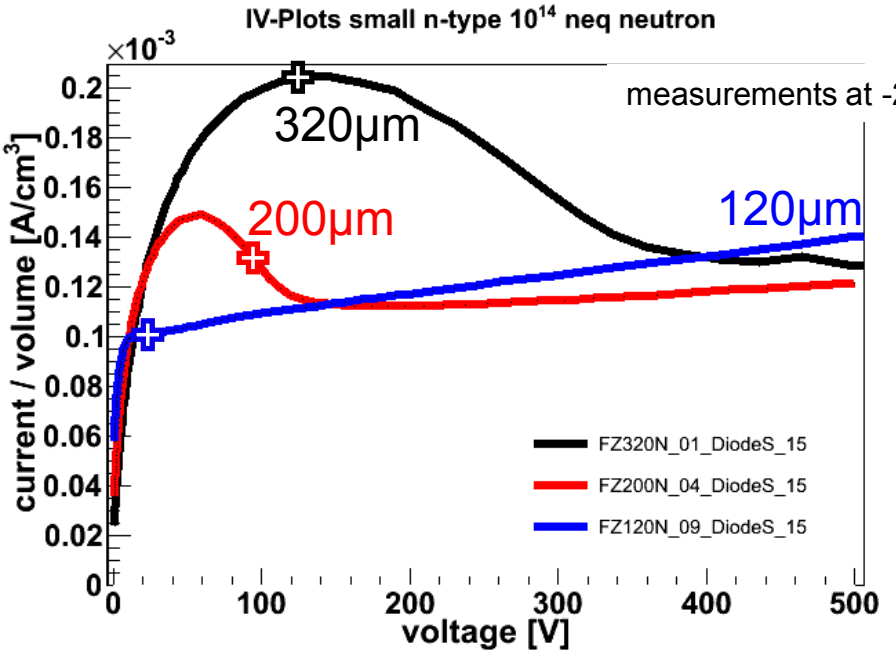


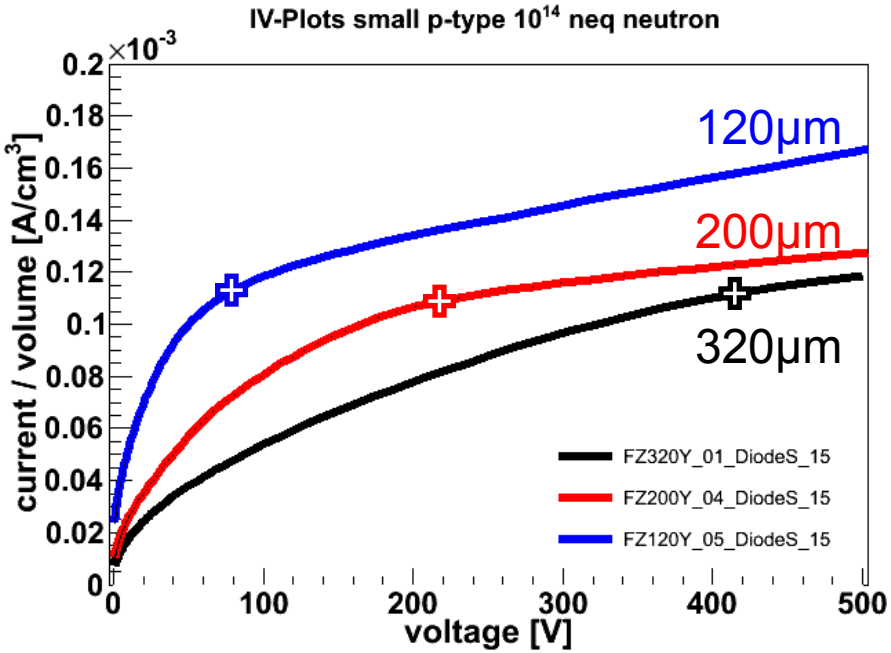
Underdepletion after type-inversion

Overdepletion after type-inversion
Guard-ring collects outer current



Neutron irradiated – small Diodes - IV

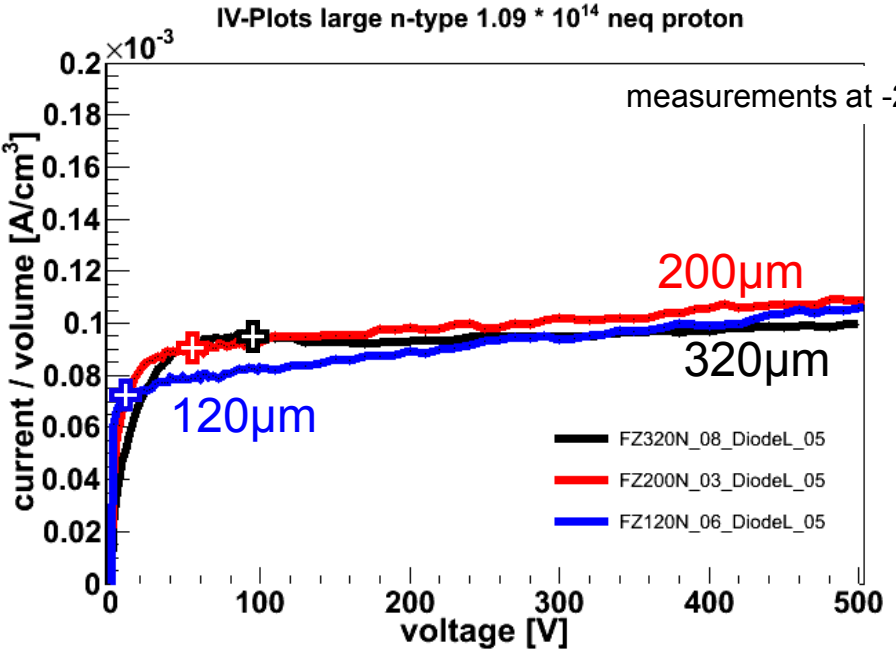


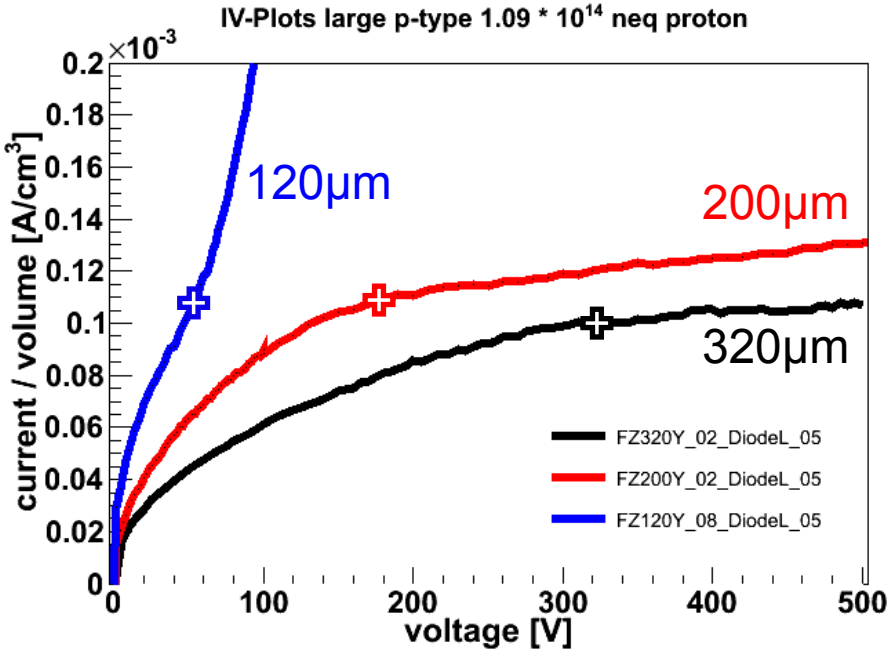


Bumps in the front of all 3 diodes

- Volume-currents are all in same range
- Slope of current above depletion is stronger for thinner diodes

Proton irradiated - IV

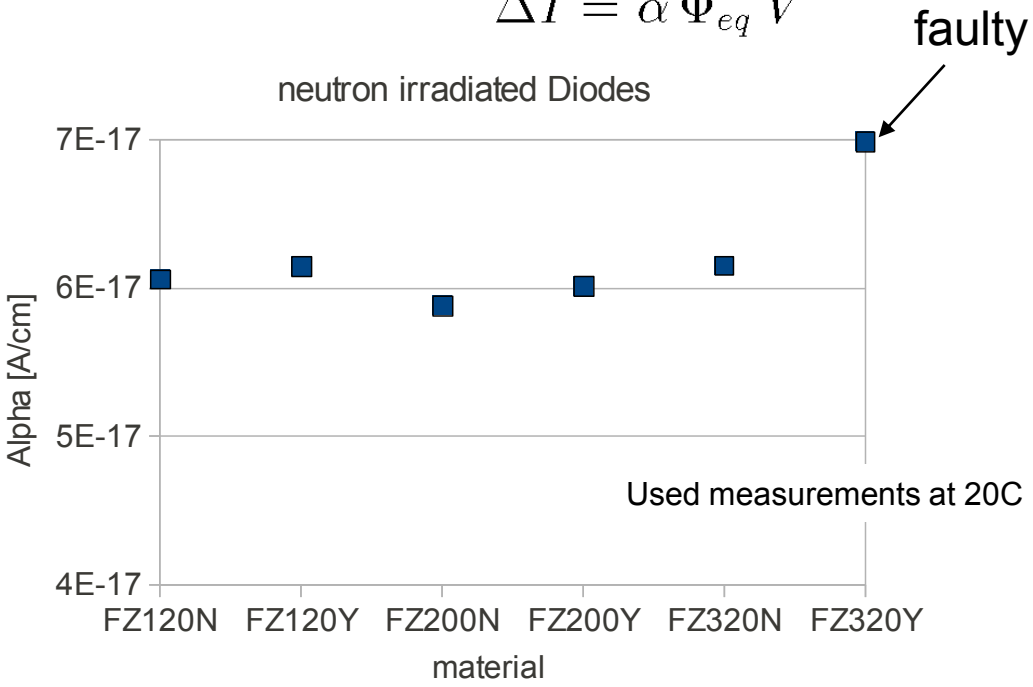


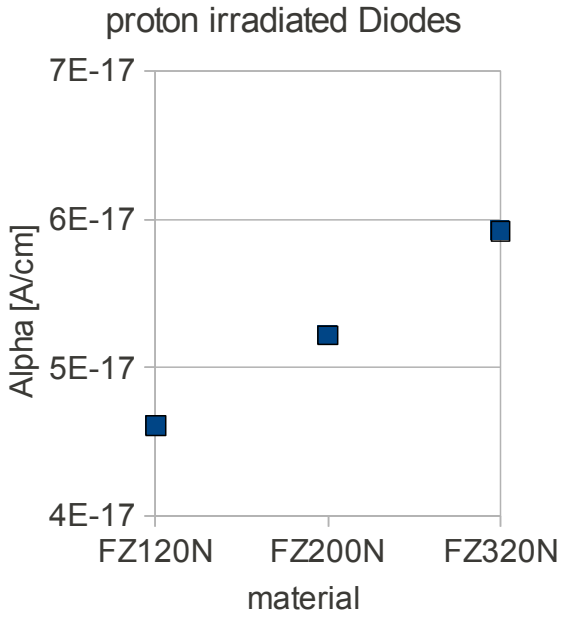


- Volume-currents are all in same range
- Slope of current above depletion is stronger for thinner diodes

Alpha

$$\Delta I = \alpha \, \Phi_{eq} \, V$$





Careful, no annealing done!
(but nevertheless in the right order)

Short annealing done (10min@60C, approx. 5.2 E-17 expected)

Conclusions and Outlook

- All n-type materials show a decrease of the depletion-voltage (and signs of type-inversion)
- All p-type materials show an increase of the depletion-voltage
- IV- and CV-curves still have the slope due to deep-diffusion
- Volume-normalization is difficult (volume changes with voltage)

Still a lot of structures wait for treatment → big irradiation campaign to be started

The deep-diffusion doesn't look like a show-stopper!