Total Dose Dependence of Oxide Charge, Interstrip Capacitance and Breakdown Behavior of sLHC Prototype Silicon Strip Detectors and Test Structures of the SMART Collaboration

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Structures Investigated

Type	Dimension	Measurements	Frequency
MOS Capacitor	Circular Area $=3.14mm^2$	C-V	10 kHz
Capacitance TS	Length = 1.15 cm Pitch = 50, 100 um Implant = 15, 25 um Poly width = 10 um Metal = 23, 33 um	Cint-V C-V i-V	~ 1 MHz 10 kHz n.a.
SSD	Length = 4.46 cm Pitch = 50, 100 um Implant = various	Cint-V C-V i-V	~ 1 MHz 10 kHz n.a.

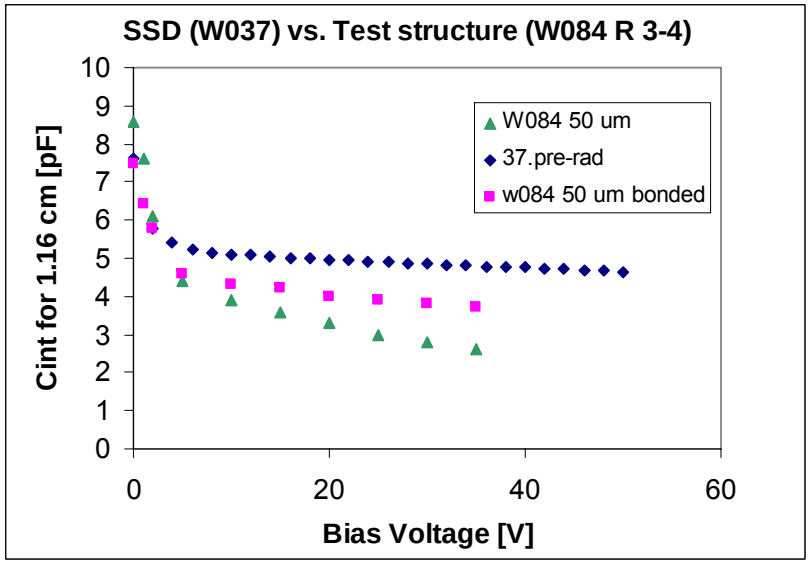
Wafers Investigated

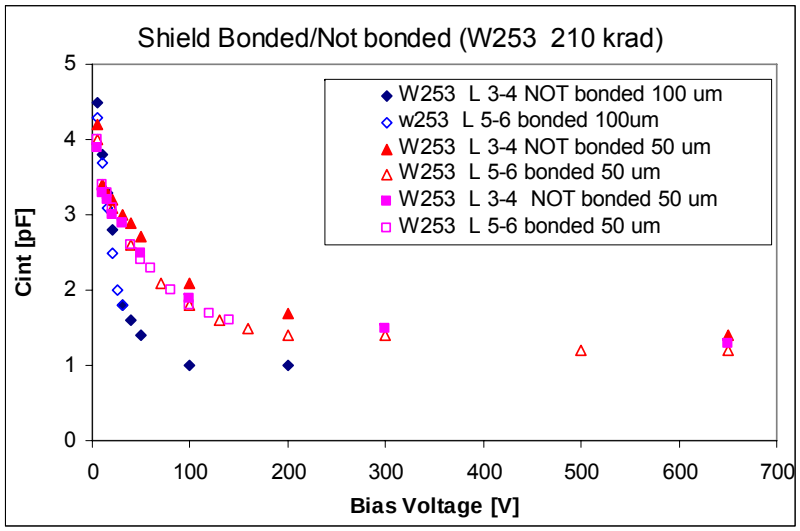
Wafer Type	Wafer #	Thickness [um]	P-spray Dose [cm^{-2}]	SSD / TS / MOS
n FZ	W1254		n.a.	TS, MOS
p FZ	W084	200	$5*10^{12}$	TS, MOS
p FZ	W014	200	$3*10^{12}$	SSD
p FZ	W037	200	$5*10^{12}$	SSD
p MCz	W044	300	$3*10^{12}$, no passivation	TS, MOS
p MCz	W253	300	$5*10^{12}$, no passivation	TS, MOS
p MCz	W066	300	$3*10^{12}$, no passivation	SSD
p MCz	W182	300	$5*10^{12}$, no passivation	SSD

SSD Investigated

SSD	Substrate	P-spray Dose **[cm^{-2}]**.	Pitch (µm)	# strips	Implant Width (µm)	Poly Width (µm)	Metal Width (µm)
14-5	FZ 200	$3*10^{12}$	50	64	15	10	27
14-8	FZ 200	$3*10^{12}$	100	32	35	30	43
37-5	FZ 200	$5*10^{12}$	50	64	15	10	27
37-8	FZ 200	$5*10^{12}$	100	32	35	30	43
66-8	MCz	$3*10^{12}$	100	32	35	30	43
182-5	MCz	$5*10^{12}$	50	64	15	10	27
182-8	MCz	$5*10^{12}$	100	32	35	30	43

Device Preparation and Irradiation





UCSC ^{60}Co source 3.15 kRad/hr

TS Un-bonded and unbiased
except to shield
Mini-SSD bonded to shield.

Ratio between
mini-SSD and T.S. =1.2
(3 pairs vs. 1 pair)

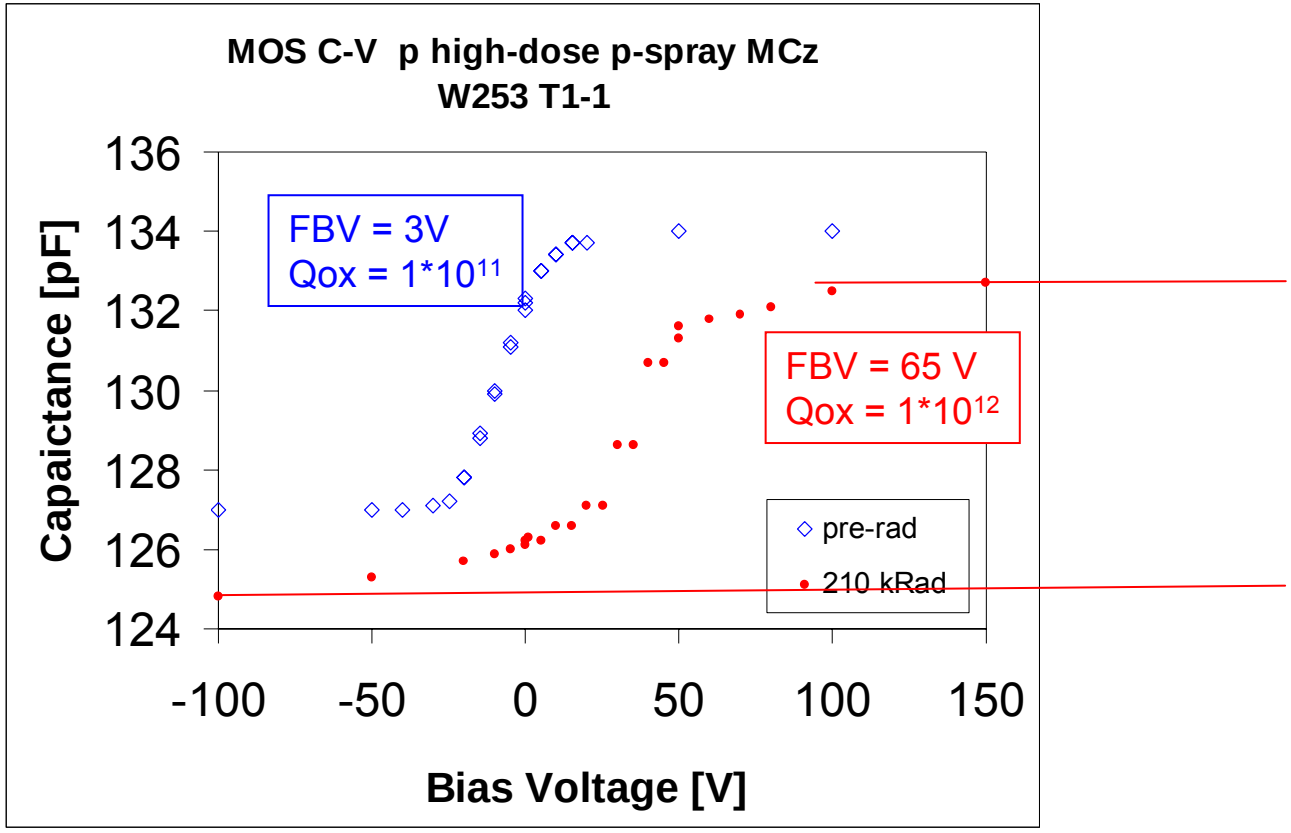
T.S. Pre-rad:
Large difference between
shield bonded and un-bonded

T.S. Post-rad:
No difference between
shield bonded and un-bonded

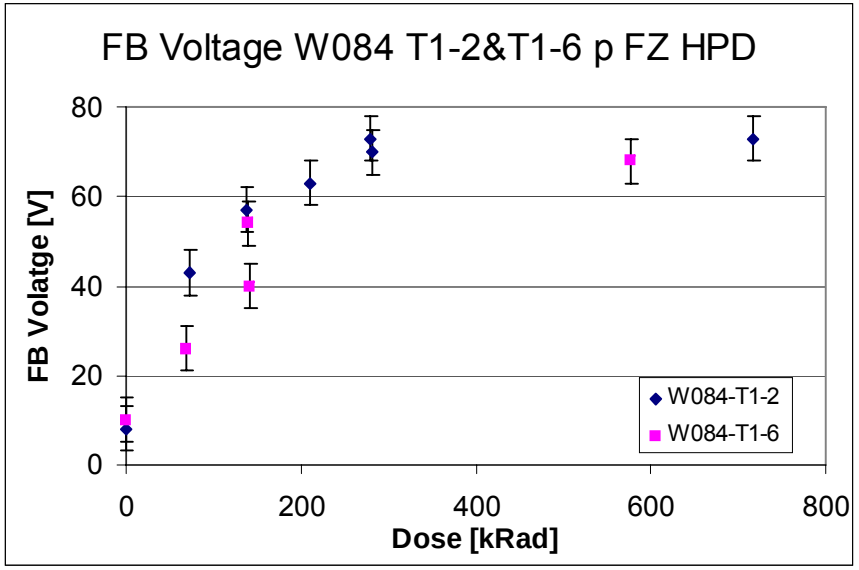
Expect substantial annealing
with unbiased devices.

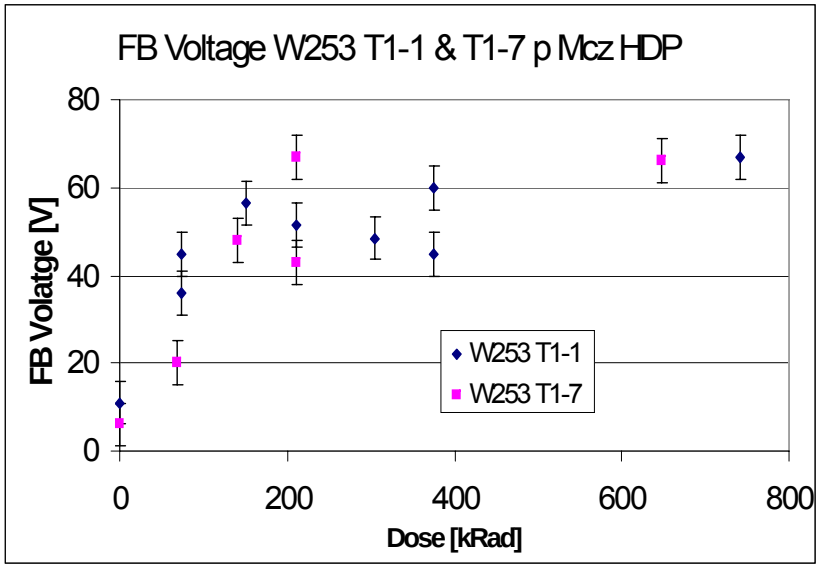
MOS Cap →

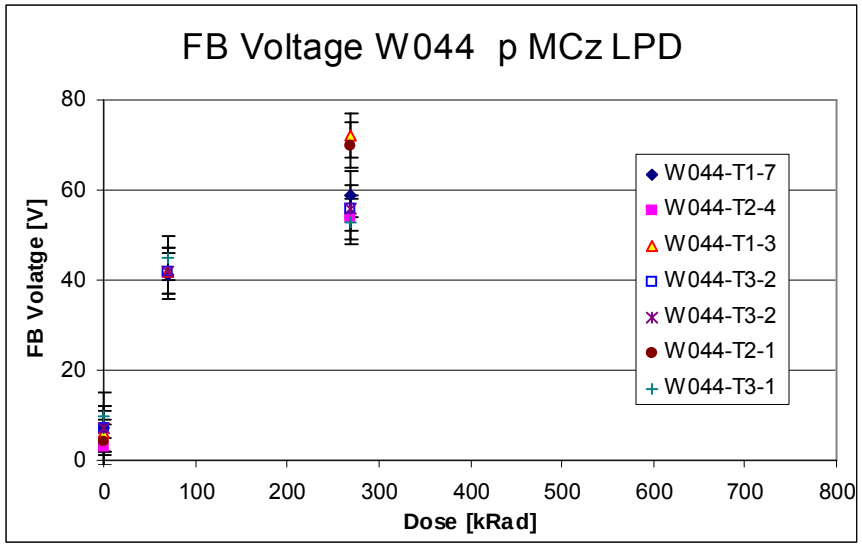
Doping Density Nd, Flatband Voltage FBV, Oxide Charge Qox

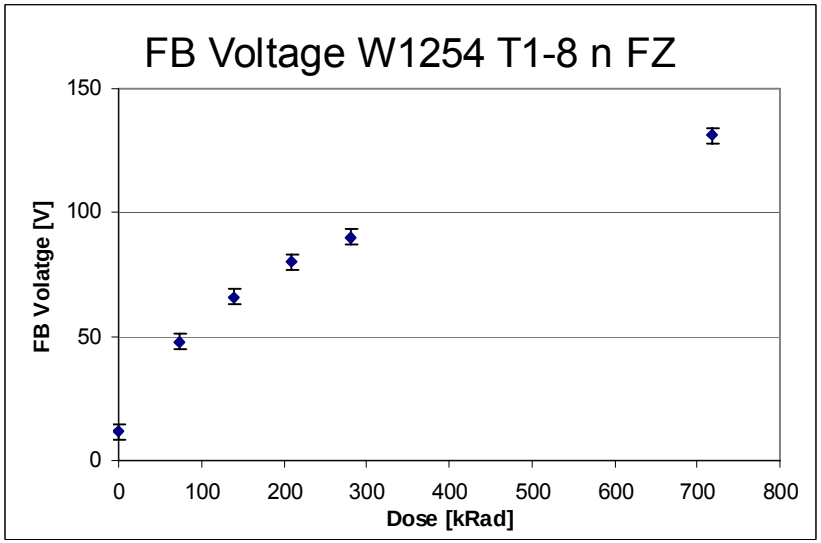


Flatband Voltage FBV vs. Dose

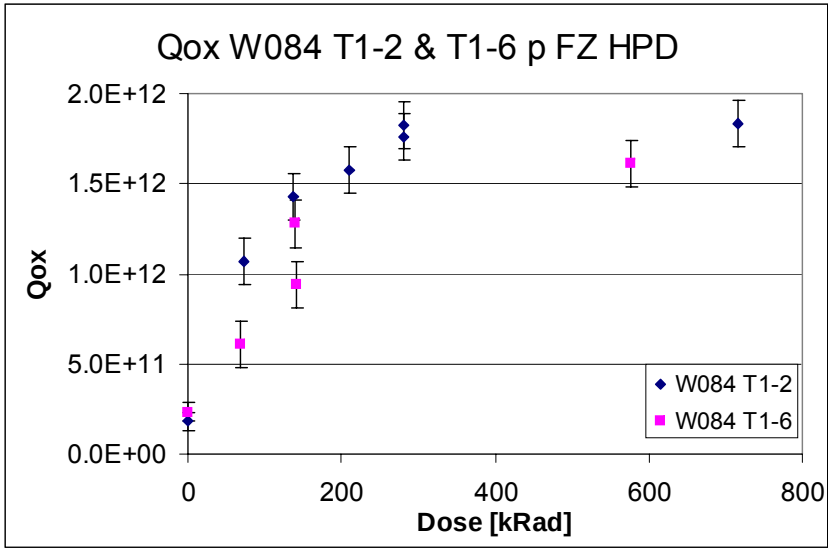


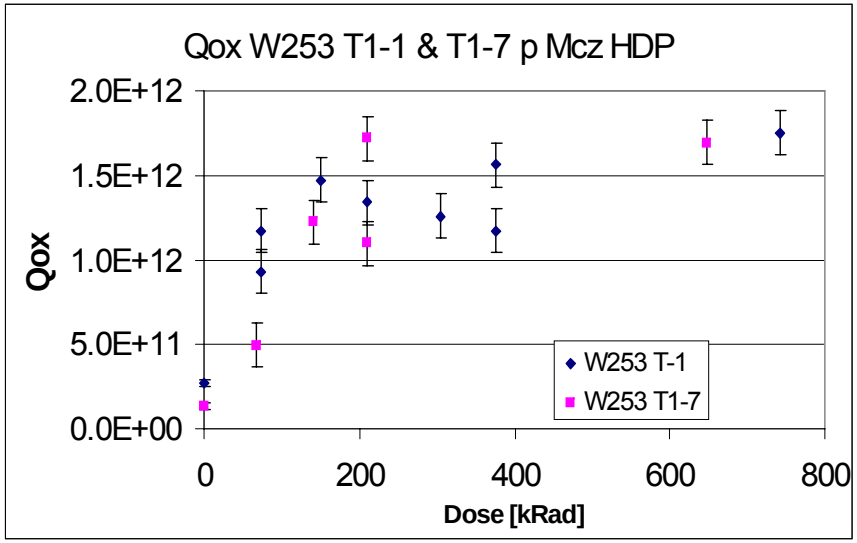


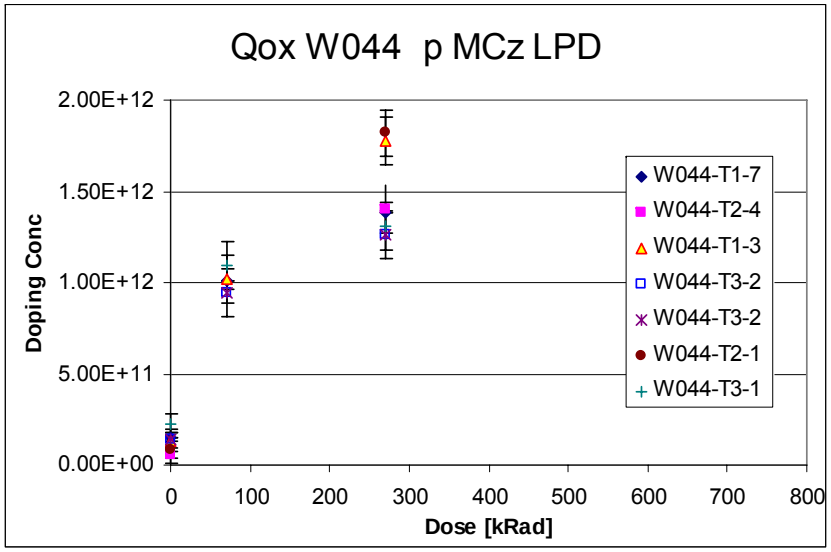


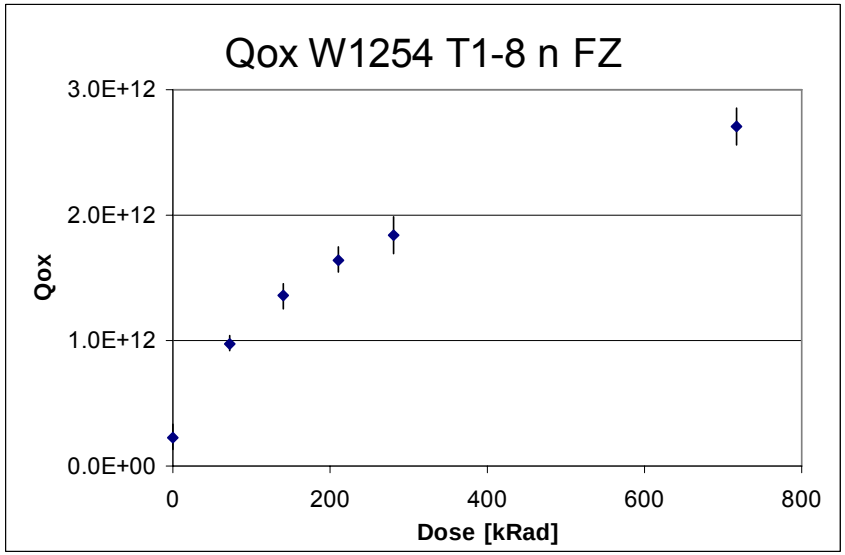


Oxide Charge Qox vs. Dose



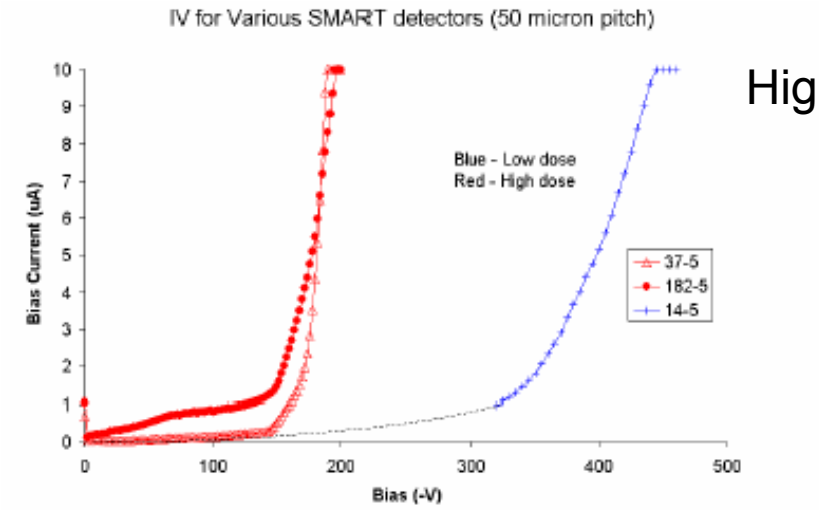






Mini-SSD and Cap T.S.:

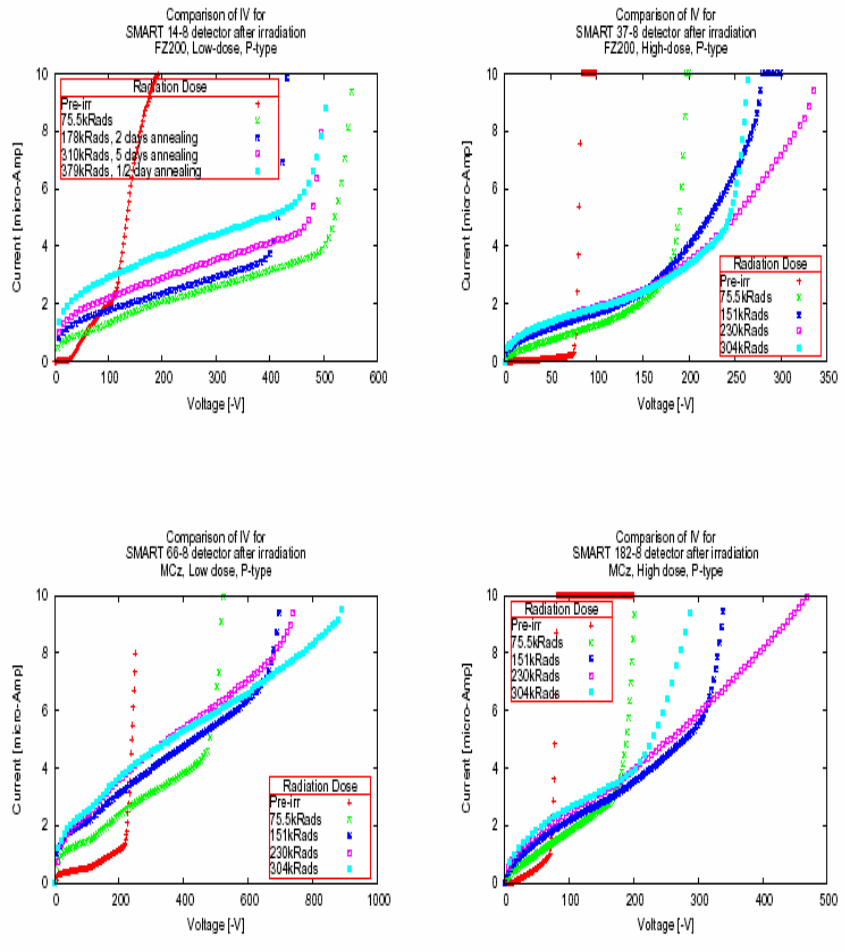
Breakdown Voltage, Leakage current, Cint vs. Dose



High dose p-spray breaks down much easier

Mini-SSD and Cap T.S.:

Breakdown Voltage, Leakage current, Cint vs. Dose



Voltage Range 1:
region between col.
is not fully depleted
⇒ large capacitance

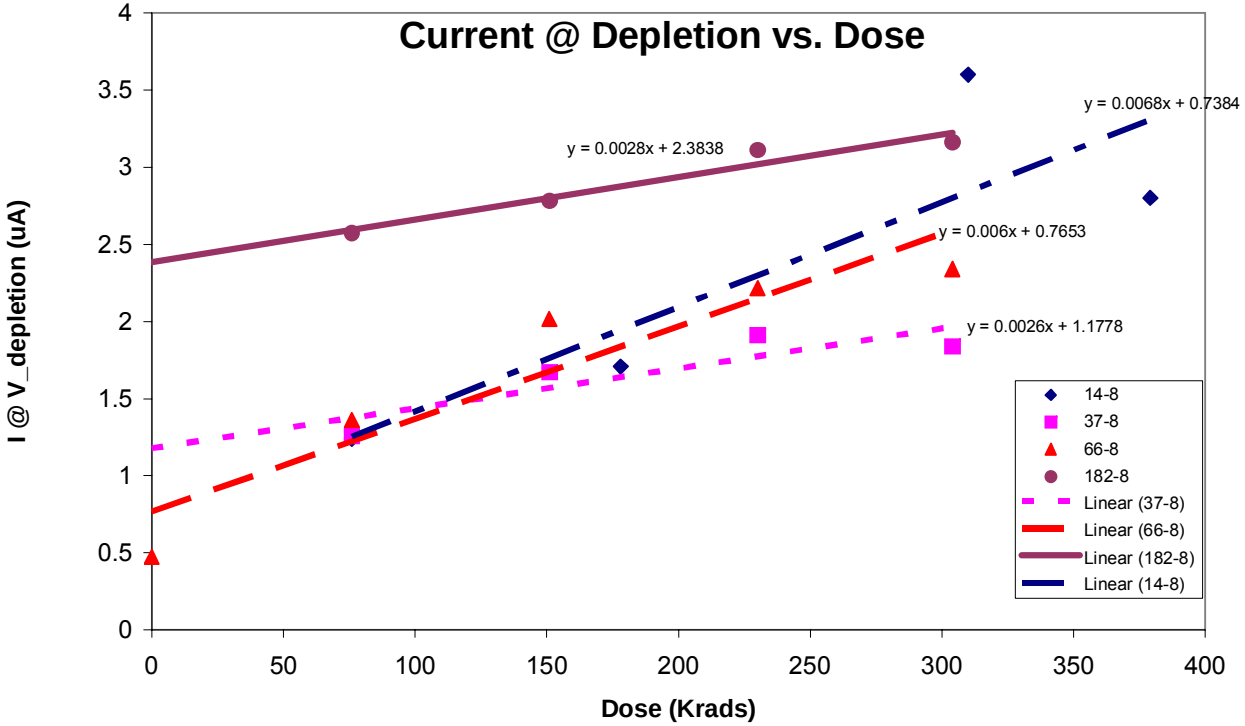
full dep. between columns
~ 7V

Voltage Range 2:
region between col.
is fully depleted
⇒ depletion proceeds
only towards the back
(almost like a planar diode)

full depletion ~200V
depletion width of ~350μm

Mini-SSD and Cap T.S.:

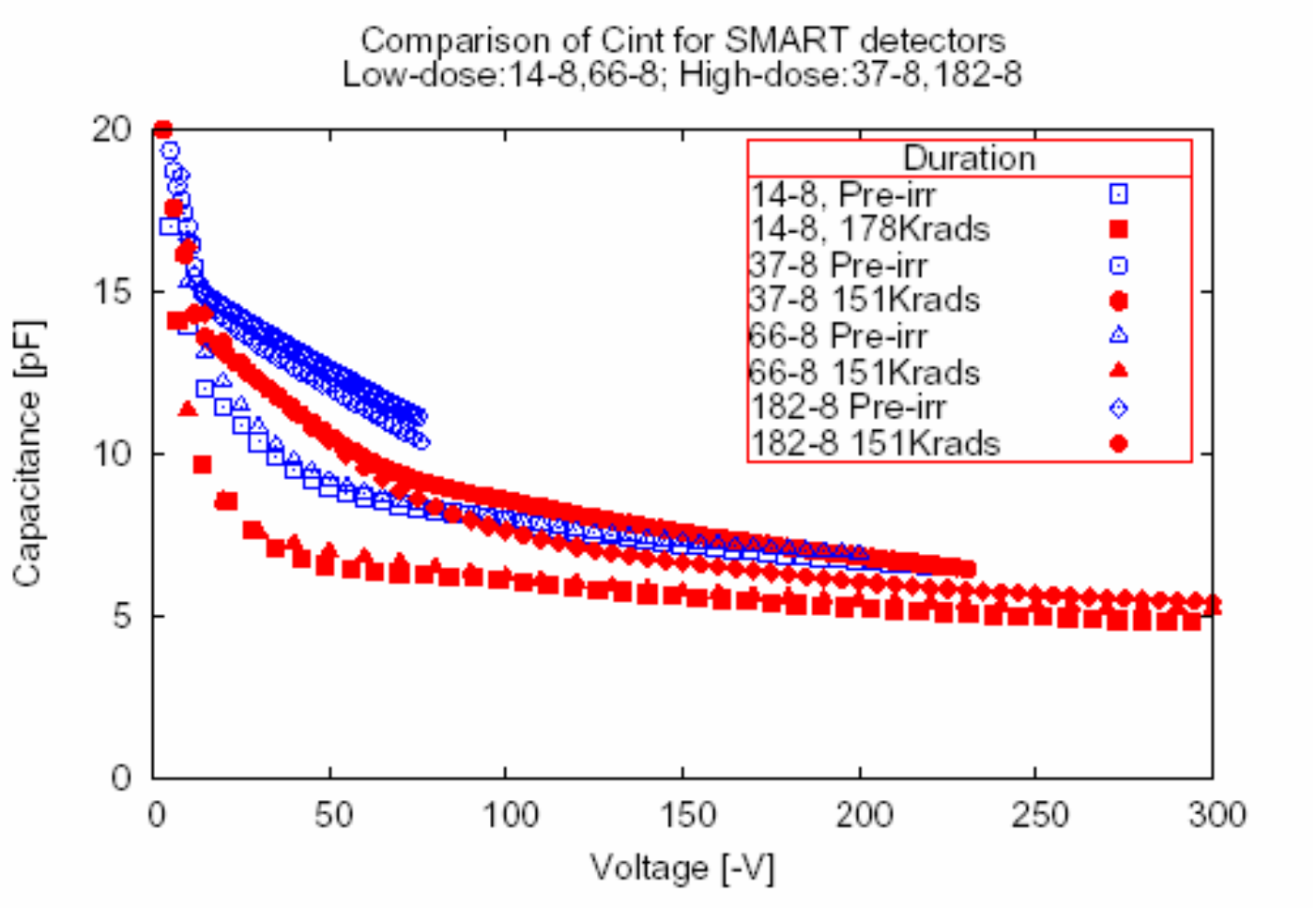
Breakdown Voltage, Leakage current, Cint vs. Dose



The current damage constant is independent of the wafer type,

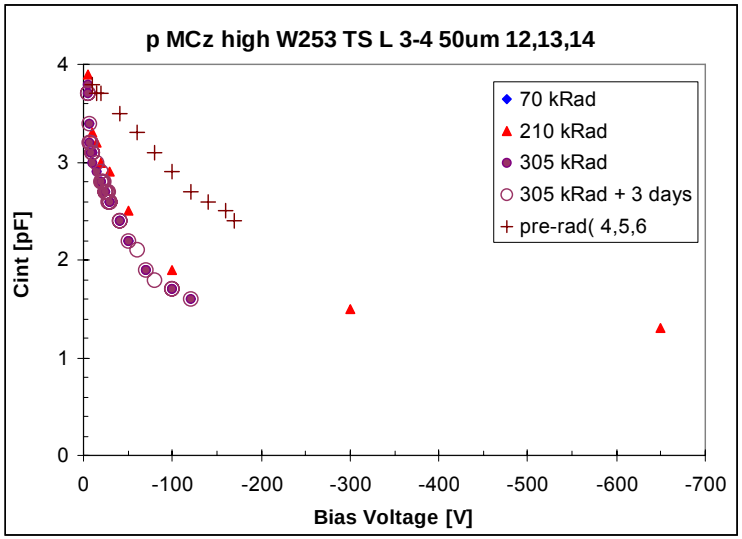
but is a factor two larger for low spray dose (wafer 14 and 66) than for high spray-dose (wafer 37 and 182).

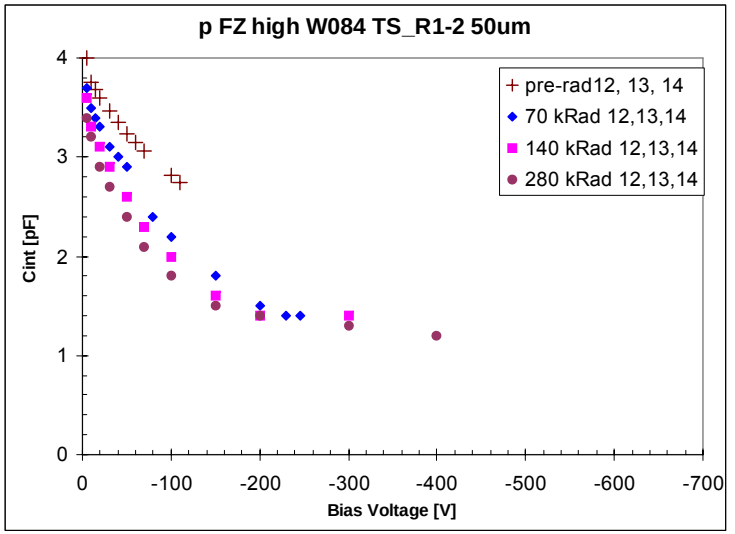
Cint pre-rad and after saturation (4.45 cm mini-SSD, 100 μm pitch)

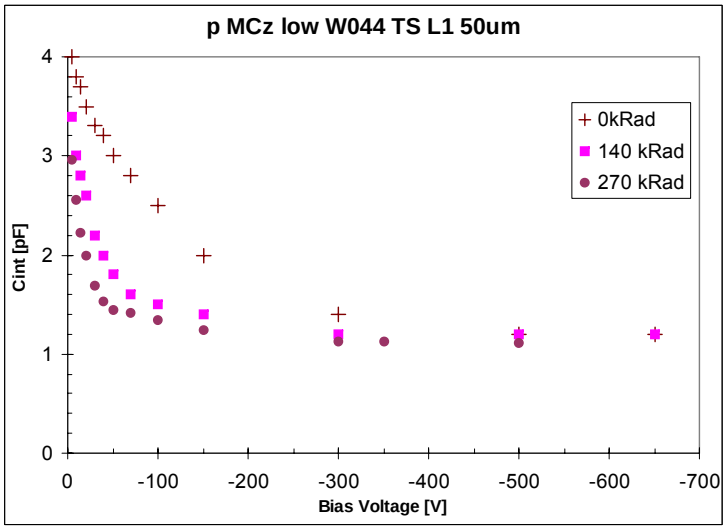


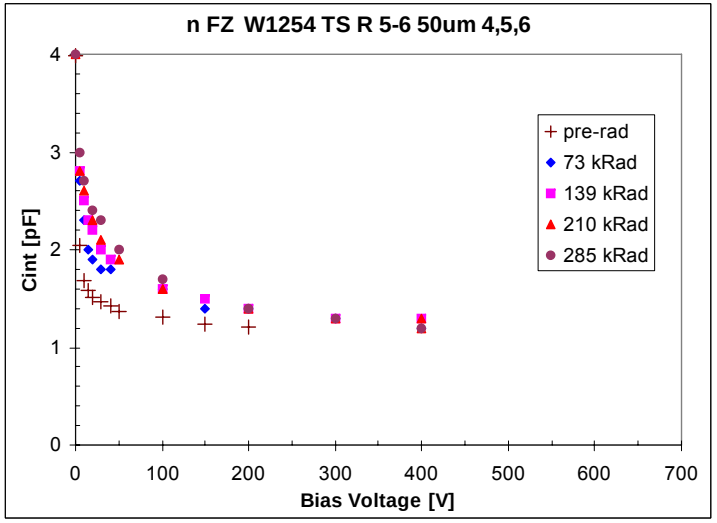
Wafers 14 and 37 are FZ, wafers 66 and 182 MCz.
Little difference between different wafers,
large dependence on the p-spray.

Cint vs. Dose(1.16 cm T.S.)









Little dependence of wafer type, i.e. MCz and FZ behave the same, but dependence on p-spray dose. Ntype increases with dose.

Conclusion

MCz and FZ behave similar,
Large dependence on p-spray dose.