



Dose Rate Effect on Bipolar Circuits Degradation

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r e t u r n o n i n n o v a t i o n

ELDRS: introduction

- ELDRS is a true dose rate effect (not a time dependent effect) giving rise to a degradation level at a given TiD increasing when the dose rate decreases (at least until 10 mrad/s)
- Many bipolar circuits present ELDRS
- ELDRS remain a difficult hardness assurance problem as there is no universal convenient method to bound the degradation

The TiD deposited in orbit can constitute the worst case of degradation

Objectives and test plan

Evaluate/verify the capability of low laboratory dose rate evaluation to bound very low dose rate degradation of popular device types

Three dose rates:

- ✓ Moderated Dose Rate (MDR): 100 krad(Si) at 360 rad/h
- ✓ Recommended Low Dose Rate (LDR): 100 krad(Si) at 36 rad/h
- ✓ Extreme Laboratory Low Dose Rate (ELDR): 45 krad(Si) at 10 rad/h

Two bias conditions:

- ✓ Static ON
- ✓ All pins grounded

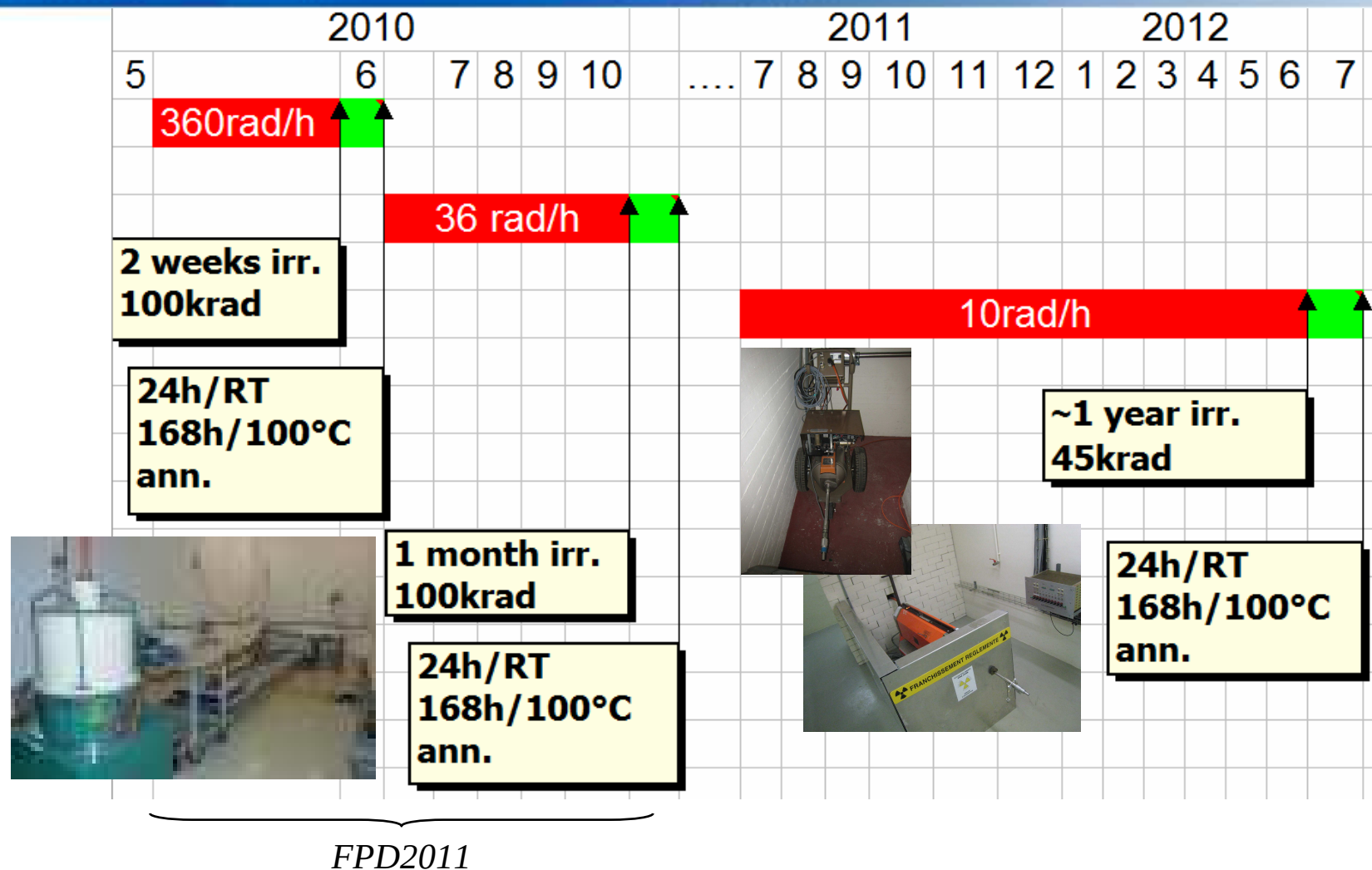
5 parts in each irradiation condition
9 device types

Devices

Device reference	Man.	Function	Technology	Qual. level	Packaging
AD574ATD	ADI	Complete 12-Bit A/D Converter		883B	DIL28
AD584SH	ADI	Precision Voltage Reference		883B	CAN8
OP15AZ	ADI	Precision J-FET Input Op. Amp.		QMLV	DIL8
UC1834J (diffusion lot)	TI	High Efficiency Linear Regulator		883B	DIL16
JL117BXA	NSC	Voltage Regulator	Bipolar	883B	TO39
LM111	TI	Precision voltage comparator	Bipolar	883B	DIL8
UCC1806J (diffusion lot)	TI	Low-Power, Dual-Out., Current-Mode PWM Controller	BiCMOS	883B	DIL16
RH 1021CMH	LTC	Precision 5V Reference	Bipolar	Rad-Hard	TO5
RH 1013MJ8	LTC	Dual Precision Op. Amp.	Bipolar	Rad-Hard	DIP8

For a device type, all parts come from the same dtc or diffusion lot

Test scheduled & facilities



Electrical characterization at ESTEC

Results overview

Dose rate sensitivity	Features	Device types
Large ELDRS	Bias effect: parameter dependent, biased lightly worst case	LM111
Moderate ELDRS	Bias effect: parameter dependent	OP15 (Vos) AD574 (Iil)
	Biased worst case	UCC1806 ($V_{th_Startup}$, Icc)
	Unbiased worst case	AD584 (Vout) UC1834 (Vout, Vth, Ib)
Almost no effect	Biased worst case	RH 1013 (Ib)
	Unbiased worst case	RH 1021 (Vout)
Time-dependent effect	Unbiased worst case	JL 117
	MDR worst case, total recovery	

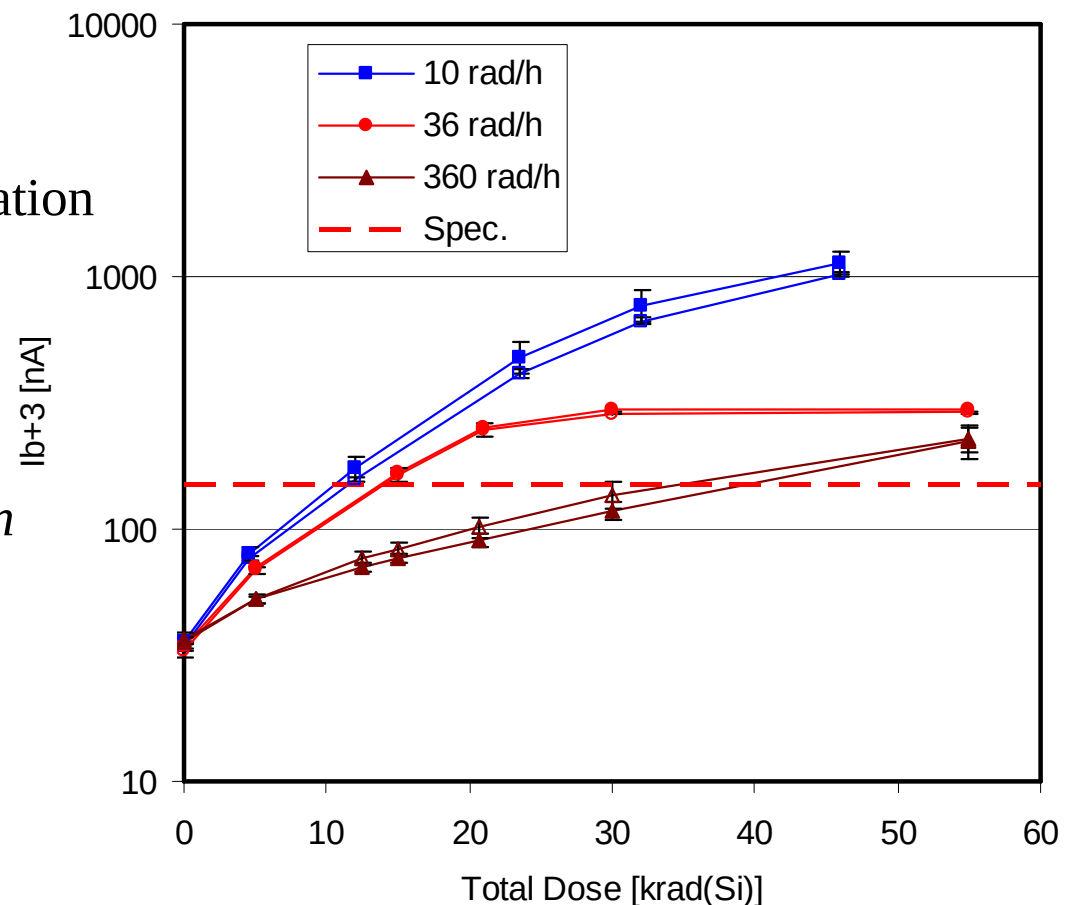
ELDRS without bias dependence

LM 111: Input bias current degradation

Solid: biased

Open: unbiased

® "error bar" = standard deviation

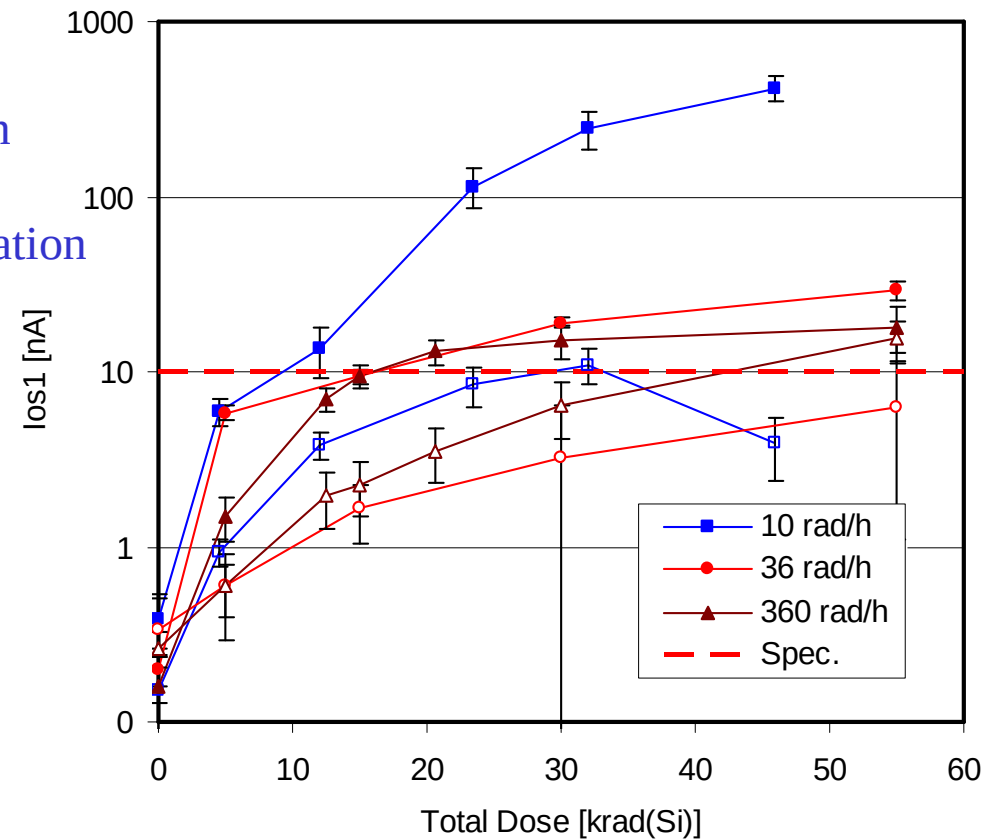


ELDRS with bias dependence

LM 111: Output short circuit current degradation

(Ios1) Vic=0V, Vcc=+/-15V, large degradation
(Ios2) Vic=13V, Vcc=+/-15V, no degradation
(Ios3) Vic=-14.5V, Vcc=+/-15V, large degradation

Solid: biased
Open: unbiased

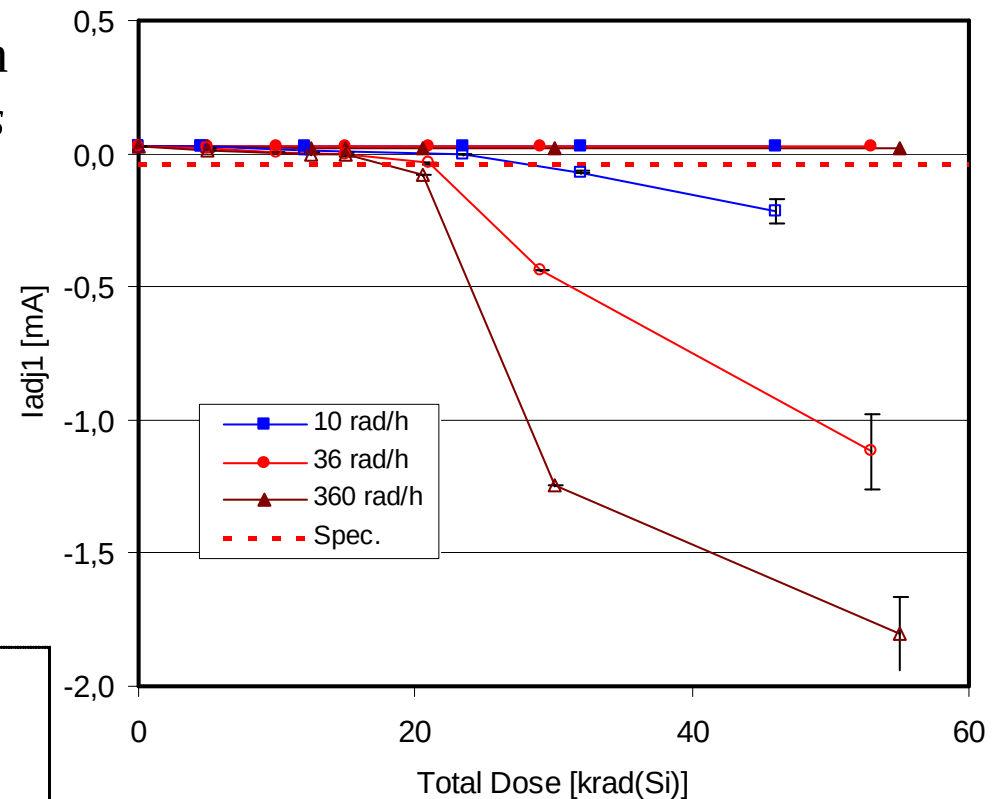
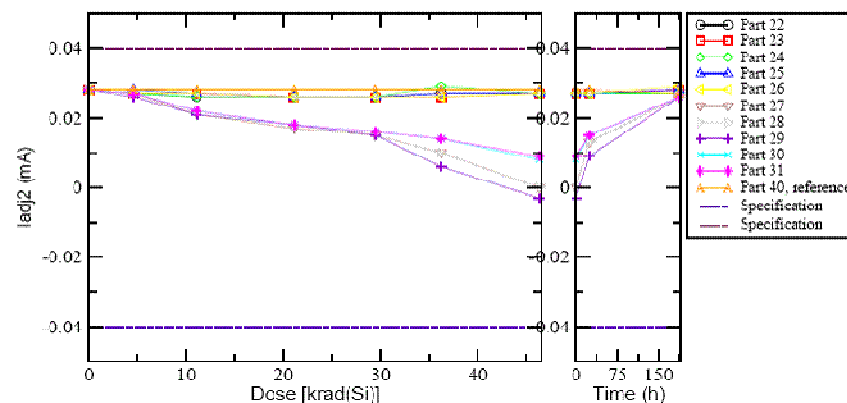


(CMOS-like) Time-dependence effect

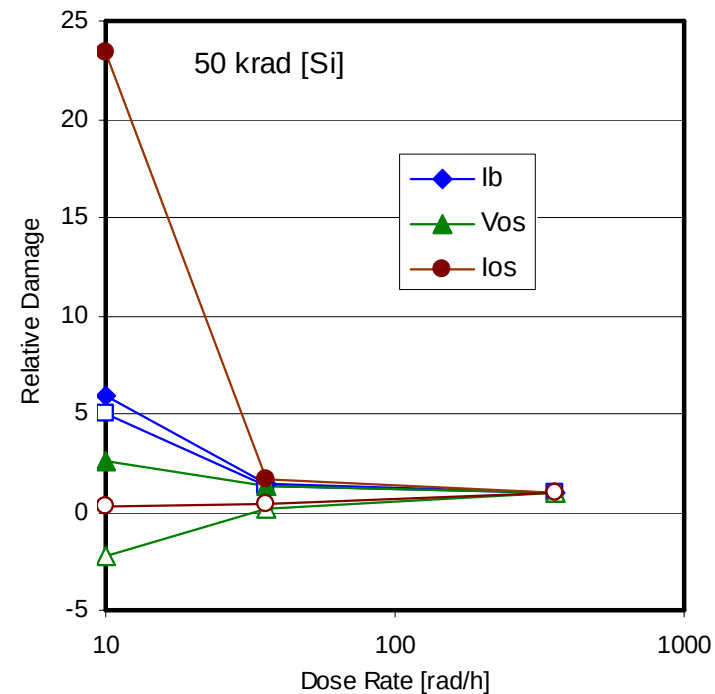
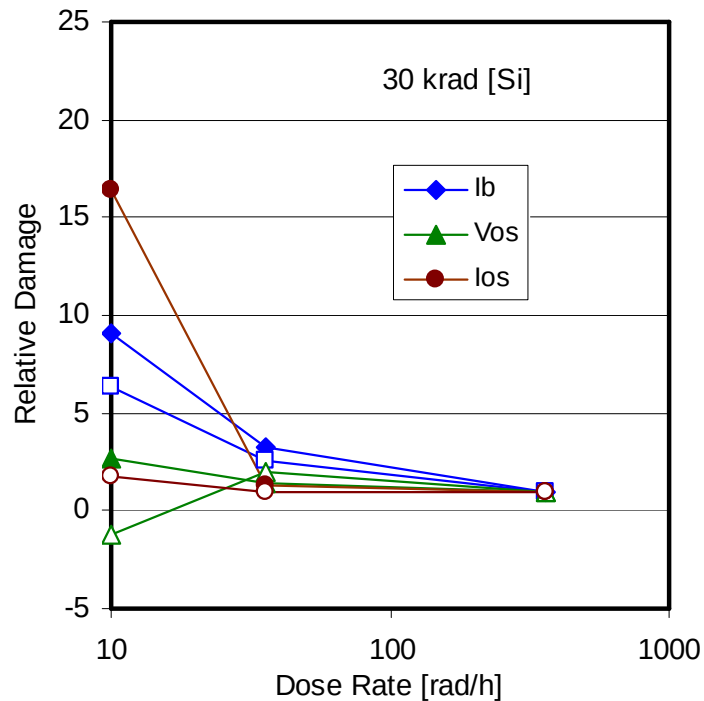
JL 117: Adjust current degradation
® "CMOS-like" but degradation is greater for unbiased devices

Solid: biased
Open: unbiased

® *total recovery*



ELDRS versus Total Dose level (1)

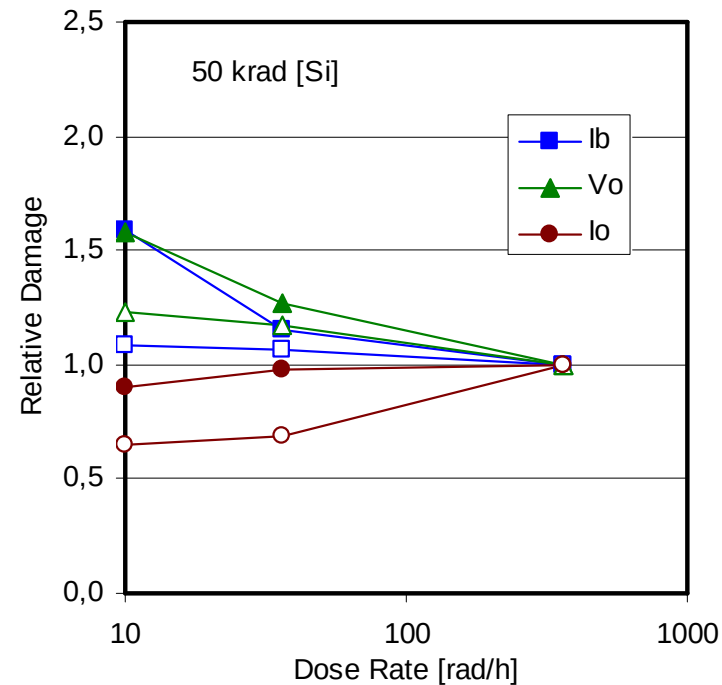
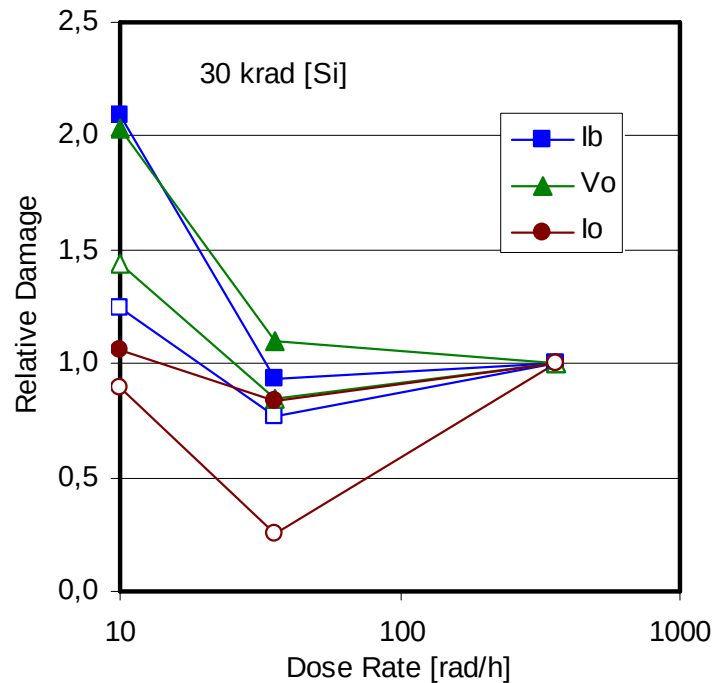


LM 111: Degradation normalized to high dose rate for 3 parameters

Solid: biased

Open: unbiased

ELDRS versus Total Dose level (2)

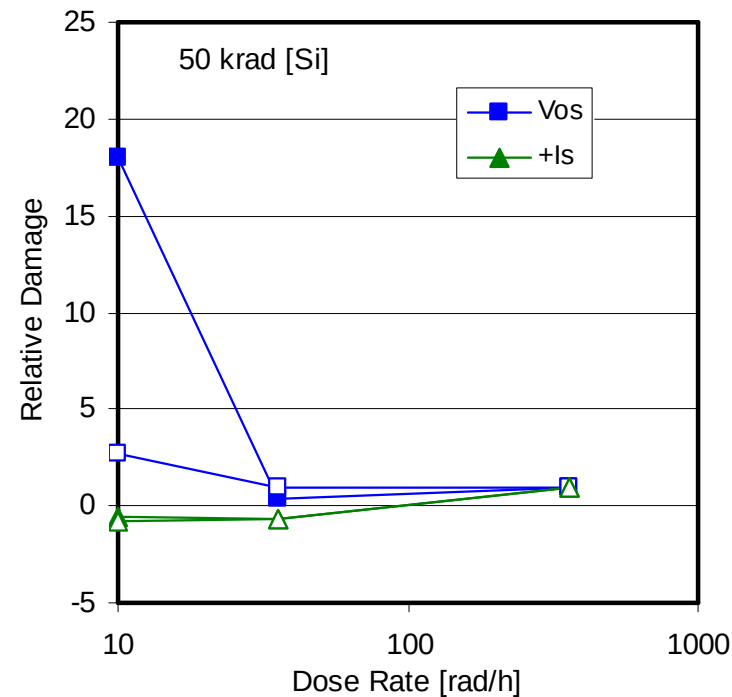
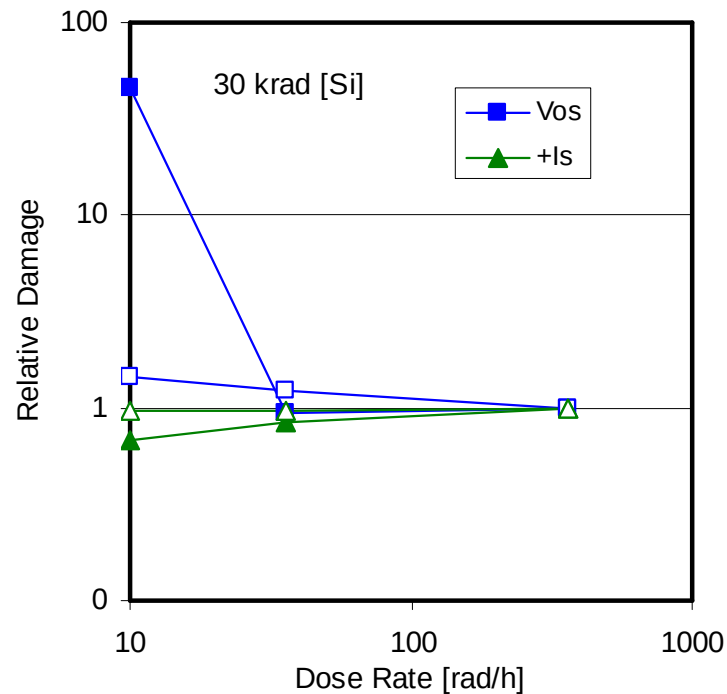


UC 1834: Degradation normalized to high dose rate for 3 parameters

Solid: biased

Open: unbiased

ELDRS versus Total Dose level (3)



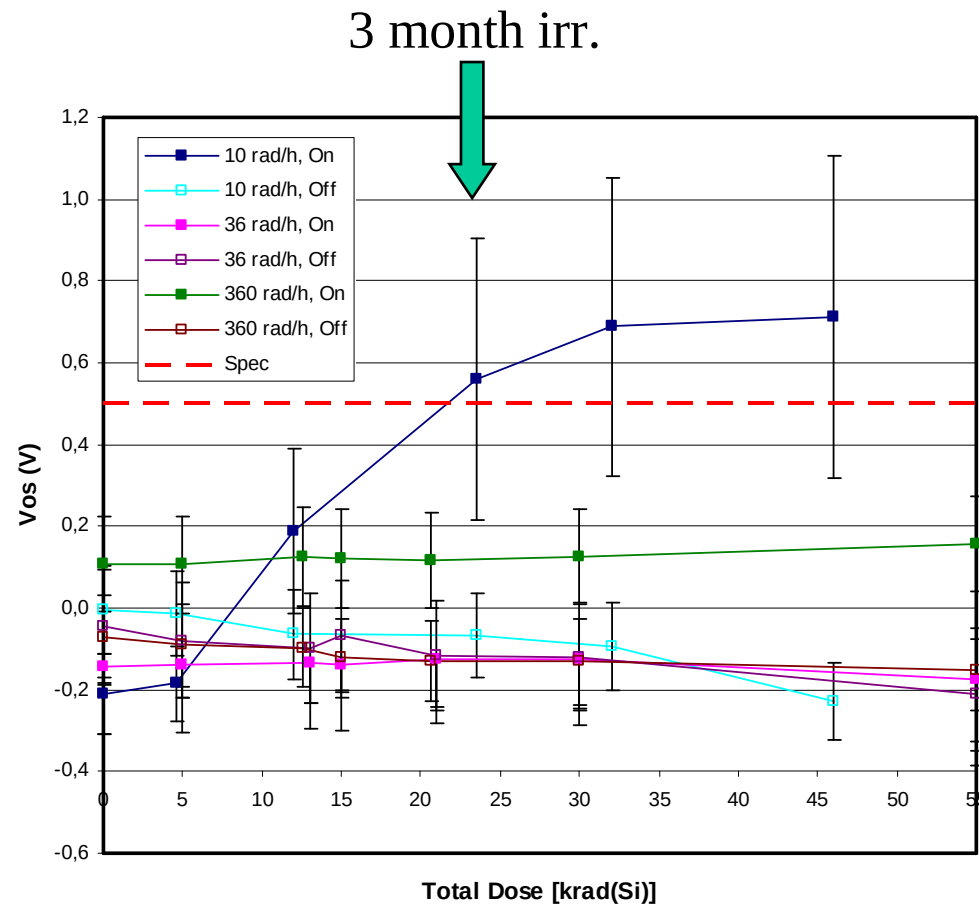
OP 15: Degradation normalized to high dose rate for 3 parameters

Solid: biased

Open: unbiased

ELDRS versus Total Dose level (4)

Solid: biased
Open: unbiased



OP 15: Vos degradation for 3 dose rates and 2 biases

Part to part dispersion

	10 rad/h		36 rad/h		360 rad/h	
Parameter	ON parts	OFF parts	ON parts	OFF parts	ON parts	OFF parts
LM111, I_{B+3}	209 / 1100	37 / 976	2.8 / 265	1.1 / 256	63 / 185	57 / 194
LM111, I_{OS1}	129 / 418	3.4 / 3.4	0.16 / 29	10 / 11	10 / 18	8.4 / 15
JL117, I_{adj1}	5.5e-4 / -1.6e-3	0.09 / -0.24	4.5e-4 / -1.2e-3	0.28 / -0.46	4.5e-4 / -4e-3	0.27 / -1.27
OP15, V_{OS}	0.79 / 0.71	0.19 / -0.23	0.31 / -0.17	0.27 / -0.21	0.23 / 0.16	0.20 / -0.15

Standard deviation / mean variation

Conclusions

- In many cases, the degradation at 10rad/h is larger than at 36rad/h
- For some devices, different conclusions are drawn with or w/o 10rad/h testing
 - OP15 Vos shows a large underestimate of the degradation with 36 rad/h testing
 - UCC1806 cmos-like => moderated eldrs
- ELDRS response of devices varies with bias,
tested temperature and TID level