SINGLE EVENT EFFECTS
TEST REPORT

Test Type:	Heavy ion
Test facility:	REF, TAMU, College station, Tx, USA
Test Date:	August 2013, June 2014,
Part Type:	STP6N52
Part Description:	NN-channel 525 V, 1 Ω, 5 A, TO-220 SuperMESH3™ Power MOSFET
Part Manufacturer:	STMicroelectronics

ESA contract n° 4000105495/12/NL/SFe dated 27/2/2012

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DOCUMENTATION CHANGE NOTICE

Issue	Date	Page	Change Item	
01	03/06/2016	All	Original issue	
02	09/08/2016		Addition of Table 3 and Figure 9 on SEB Vds thresholds as a function of ion species and deposited charge.	

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SEE TEST REPORT

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1 Glossary

DUT: Device under test.

Fluence (of particle radiation incident on a surface): The total amount of particle radiant energy incident on a surface in a given period of time, divided by the area of the surface.
In this document, Fluence is expressed in ions per cm2.

Flux: The time rate of flow of particle radiant energy incident on a surface, divided by the area of that surface.
In this document, Flux is expressed in ions per cm2*s.

Single-Event Effect (SEE): Any measurable or observable change in state or performance of a microelectronic device, component, subsystem, or system (digital or analog) resulting from a single energetic particle strike.
Single-event effects include single-event upset (SEU), multiple-bit upset (MBU), multiple-cell upset (MCU), single-event functional interrupt (SEFI), single-event latch-up (SEL), single-event gate rupture (SEGR), single-event burnout (SEB).

Single-Event Gate rupture (power mosfet) (SEGR): An event in which a single energetic-particle strike results in a breakdown and subsequent conducting path through the gate oxide of a MOSFET.

Sijngle-Event Burnout (SEB): An event in which a single energetic-particle strike induces a localized high-current state in a device, resulting in a catastrophic failure. SEB can be destructive and the use ofa protection limiting current resistor in serie with the drain supply allows for getting non destructive SEB during testing.

Error cross-section: the number of errors per unit fluence. For device error cross-section, the dimensions are cm2 per device. For bit error cross-section, the dimensions are cm2 per bit.

Tilt angle: tilt angle, rotation axis of the DUT board is perpendicular to the beam axis; roll angle, board rotation axis is parallel to the beam axis
Weibull fit: $F(x) = A\,(1-\exp\{-[(x-x_0)/W]^s\})$ with:

x = effective LET in MeV/(mg/cm^2);
$F(x)$ = SEE cross-section in cm^2;
A = limiting or plateau cross-section;
x_0 = onset parameter, such that $F(x) = 0$ for $x < x_0$;
W = width parameter;
s = a dimensionless exponent.

Error bars: error bars are computed using a confidence level of 95% and a beam flux uncertainty of +/-10% as recommended by Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100.

2 Introduction

This report presents the results of Heavy Ions test program carried out on STP6N52 part type from STMicroelectronics. STP6N52 samples were used for heavy ions testing at REF, TAMU, College station, Tx, USA.
This work was performed for ESA under ESA contract n° 4000105495/12/NL/SFe dated 27/2/2012.

3 Applicable and Reference Documents

3.1 Applicable Documents

AD-1. Hirex proposal « Test Methods, Requirements, and Guidelines for Evaluation of Radiation Sensitivity of Analog to Digital Converters (ADC), Digital to Analog Converters (DAC) and Vertical Power MOSFETs» HRX/PRO/3624 Issue 01 /2011/10/12.
AD-2. STP6N52, STMicroelectronics datasheet, March 2011 Doc ID 14994 Rev 2.

3.2 Reference Documents

RD-1. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100.

4 DEVICE INFORMATION

4.1 Device description

STP6N52 is an NN-channel 525 V, 1 Ω, 5 A, TO-220
SuperMESH3™ Power MOSFET.

Part type:	STP6N52
Manufacturer:	STMicroelectronics
Manufacturer lot number:	-
Datecode:	-
Package:	TO-220
Top marking:	6N52K3 G42C7 V6 CHN 029 ST e3
Die dimensions:	2598µ x 3305µ

4.2 Sample identification

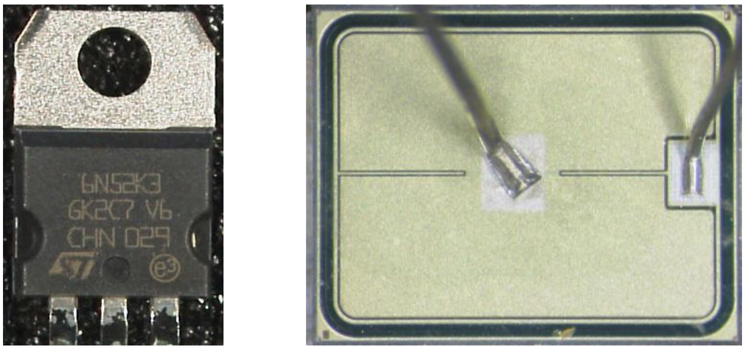


Photo 1 – Device top view Photo 2 – Die full view

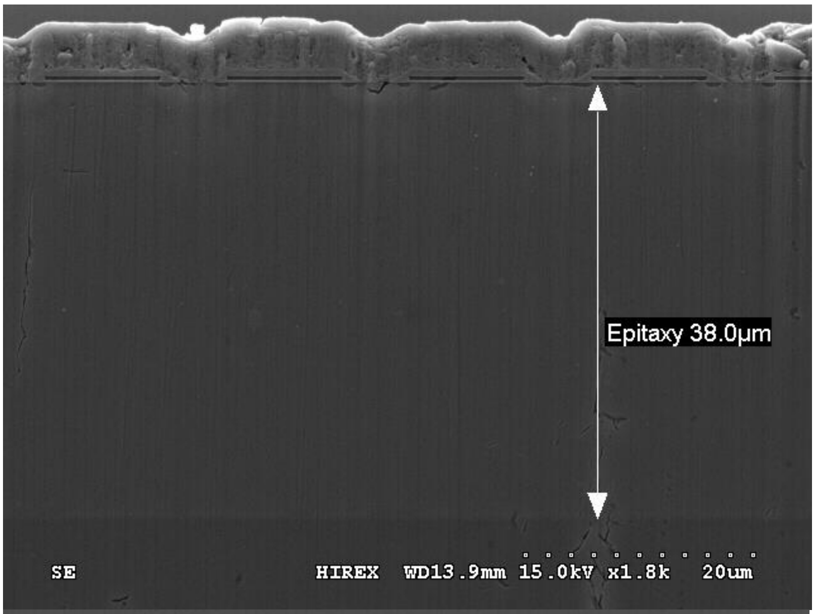
Figure 1: STP6N52 device identification

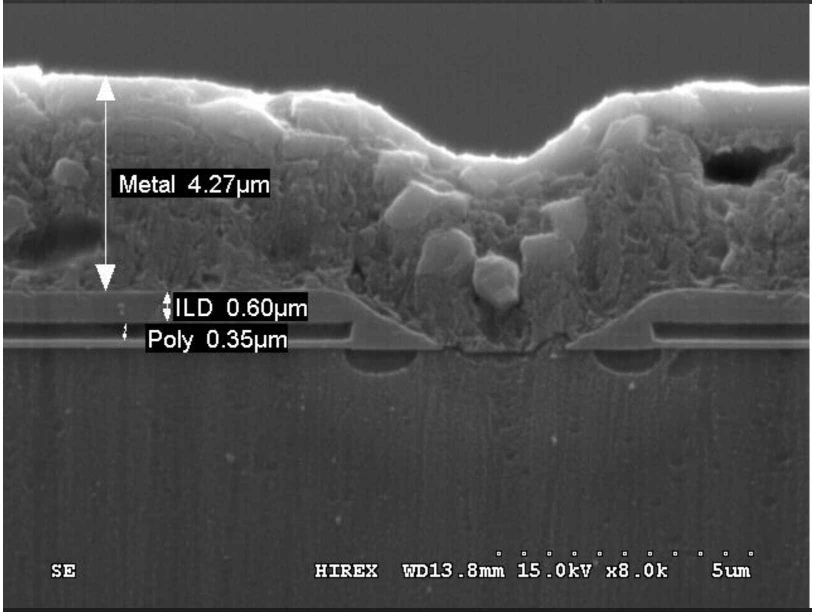
Figure 2 -STP6N52 die microsection

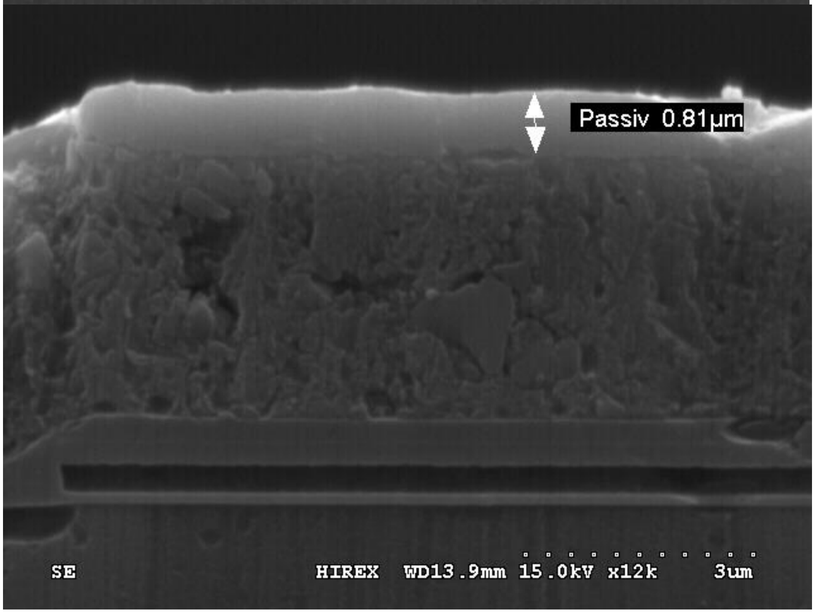
4.3 Sample preparation

Samples are opened by chemical etching.

4.4 Die microsection







5 TAMU Facility (REF)

Test at the cyclotron accelerator was performed at Texas A & M in College Station - TX- USA.
This facility includes a special beam line dedicated to irradiation studies of semiconductor components and devices. Testing may be conducted in either 30" diameter vacuum chamber or with in-air positioning system . Both provide precise positioning in x, y, and z as well as rotations up to 60 degrees. Positioning and dosimetry are carried out by custom-made SEUSS software.

In Air Station

The in-air station is located at the end of dedicated beam-line. The station consists of a rotating platform and a removable target mounting fixture. The target positioning assembly allows the motion of the target in four directions: X, Y, Z and Theta. X and Y are the horizontal and the vertical axis in the target plane, respectively. The Z-axis is in the direction of the beam-line, with theta being the clockwise and counter-clockwise rotation about the y-axis. Target position verification is provided by the means of a CCD camera aligned with the beam path and a narrow laser beam that crosses the beam path at the center of the target chamber. The size of the exposed area is controlled by the aperture defined by a pair of remotely adjustable horizontal and vertical slits.

Vacuum Station

Vacuum station has an inside diameter of 30inch and a height 30inch.Pumping time to an operating pressure in the low 10 -4 Torr range is approximately ten minutes and the chamber vents to gaseous nitrogen in two and half minutes. Target positioning system allows X, Y, Z and Theta moving. Like for in air station, the position is checked with the means of a CCD camera.

Ion Beam

Various ion beams are available for the Radiation Effects Facility. These beams provide for a wide scope of LET with high energies for deep part penetration. Time for beam species changes will vary, but with species that have the same energy per nucleon change times is about one half hour.
Beams can be delivered with a high degree of uniformity over a 1.8" x 1.8" cross sectional area for measurements inside the vacuum chamber and 1" diameter circular cross sectional area for the in-air station. Uniformity is achieved by means of magnetic defocusing.
A degrader foil system makes it possible to set the desired beam LET value at a particular depth inside the target without changing the beam or rotating the target. The beam energy is reduced by means of a degrader system with foils having a suitable thickness and orientation with respect to the incident beam. Each foil can be inserted, withdrawn, and rotated remotely through use of computer controls.
The intensity of any beam is easily regulated over a broad range spanning several orders of magnitude in a matter of seconds. This can be done by the operator on duty at the users request.
The target exposure system is fully automated. Exposure can be set for a certain time, total accumulated fluence, or can be manually stopped at any time.

Beam Quality control

The beam uniformity and flux are determined using an array of five detectors. Each detector is made up with a plastic scintillator coupled to photo-multiplier tubes. Four of the detectors are fixed in position and set up to measure beam particle counting rates continuously at four characteristic points 1.64 inches (4.71 mm) away from the beam axis. The fifth scintillator can be optionally put in to measure the beam particle counting rate right at the beam axis. The sensitive area of each detector is defined by a 0.1 cm^2 aperture, while the intrinsic efficiency is 100% for all practical purposes. The beam uniformity parameter (ranging from 0 to 100%), the axial gain (%), and the beam flux (in particles/cm^2/s) are determined by the control software based on the detector counting rates. The results are displayed and updated once every second.

Dosimetry

The current TAMU Cyclotron dosimetry system and procedures were used.

Figure 3 shows the TAMU facility different beam lines. K500 (88”) cyclotron is used to inject beam in Radiation Effects Facility (REF) cave.

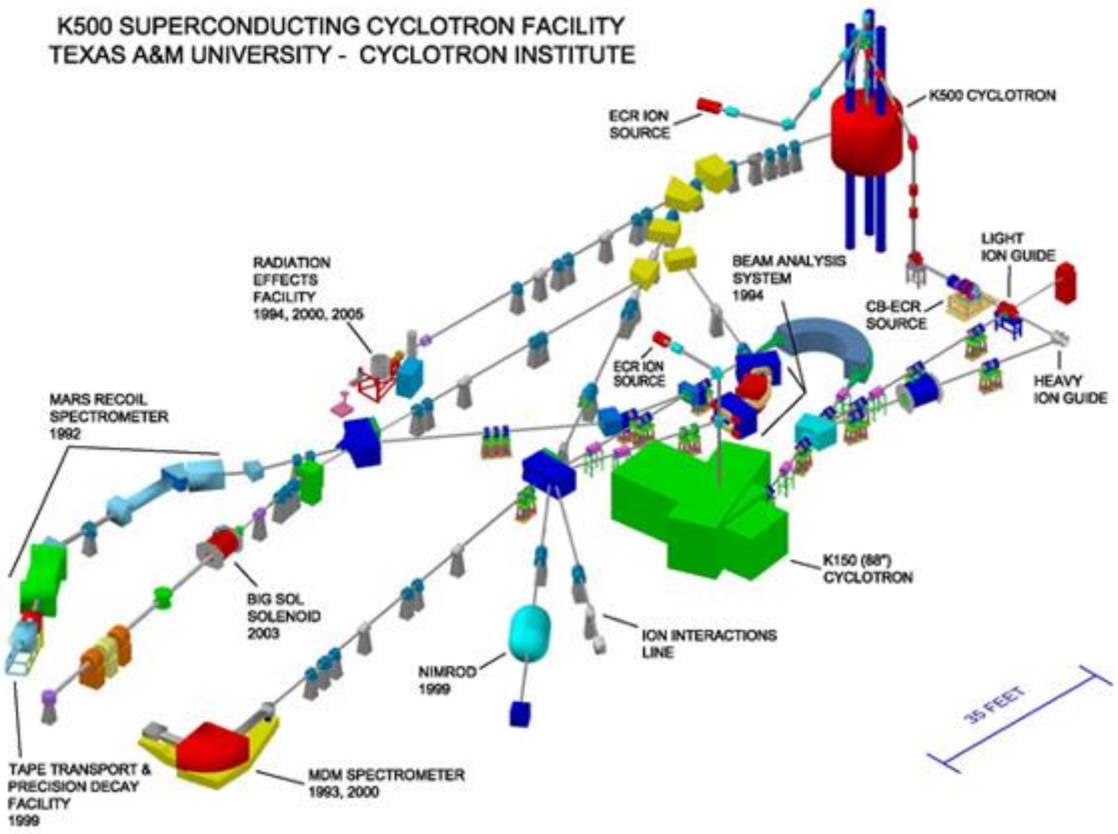


Figure 3 – TAMU facility beam lines (http://cyclotron.tamu.edu/facilities.html)

6 Test Set-up

The test set-up is composed of 4 main parts as shown in the following Figure 4 :

- DUTs board
- Set of Agilent Source Monitor Units (HP4142)
- V5 ASERT test board mounted with a 400 Msps digitizer
- A laptop running a Graphical User Interface

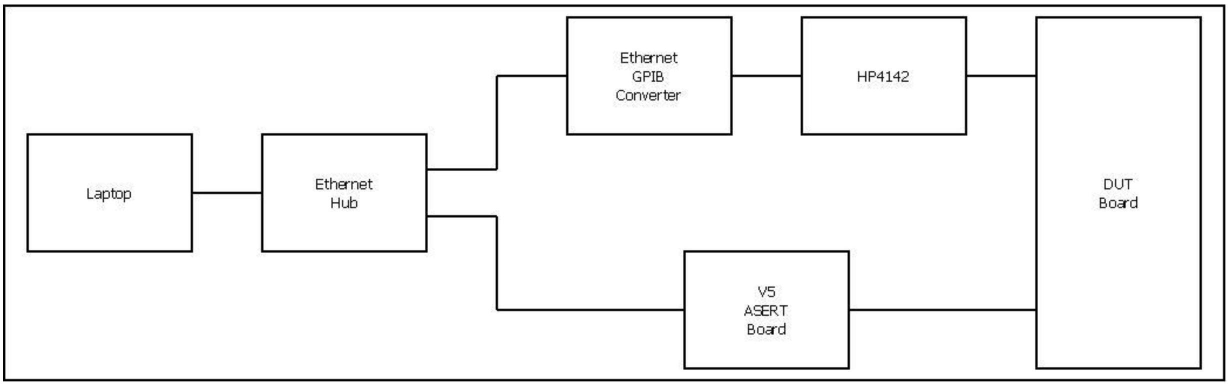


Figure 4 - Test set-up block diagram

6.1 DUTs board:

The DUTs board can hold up to 16 DUTs (2 rows by 8 columns). Each row (or line) as detailed on the Figure 5 is supplied by a set of 2 SMUs (Source Monitor Units) supplying drain and gate supplies. A drain sense is outputted from each line. A relay system allows the dynamic selection of:

- The DUT
- The bias included on the input and output conditioning systems

Input and output conditioning systems as well as DUTs are integrated on daughter boards plugged on the DUTs board.

The 2 lines are fully independent allowing the irradiation of 2 DUTs close by at the same time.

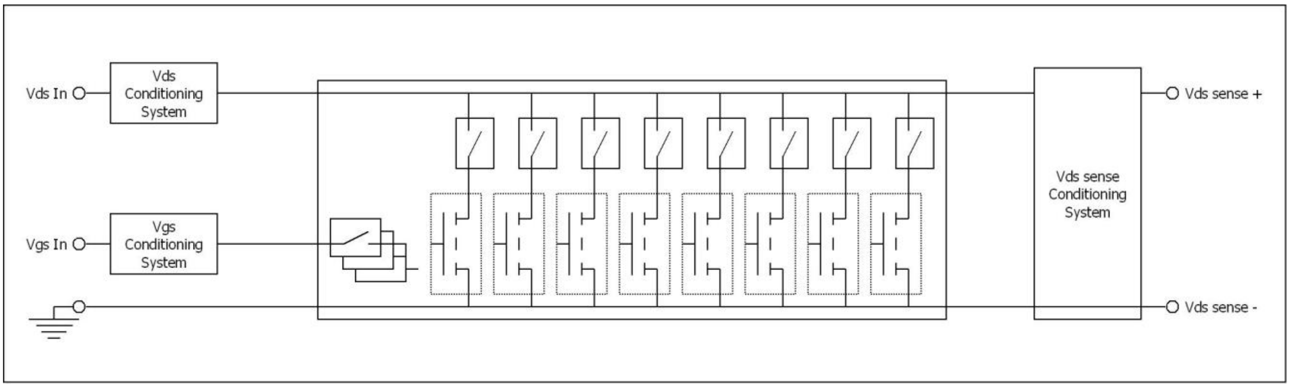


Figure 5 - DUTs board - One line schematic

The used bias is detailed on the following Figure 6.

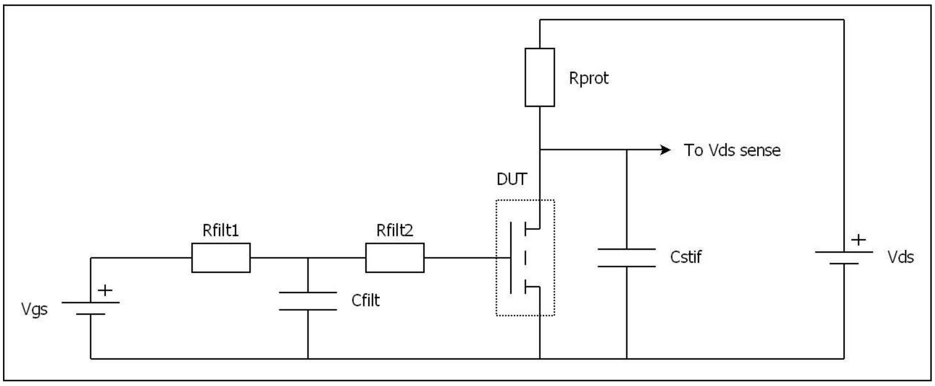


Figure 6 - Bias schematic

6.2 Agilent set of Source Monitor Units

The sourcing and monitoring of the DUT’s drain and gate supplies (voltages and currents) are performed using a set of Agilent SMUs (Source Monitor Units) HP4142 featuring the following ranges:

- For the gate: HP41421B: 40µV - 100 V / 20 fA - 100 mA
- For the drain: HP41423A: 2 mV - 1000 V / 2 pA - 2 mA

This set of SMUs is controlled remotely by the Graphical User Interface through an Ethernet/GPIB converter.

6.3 V5 ASERT test board

The V5 ASERT test board is used to:

- Monitor the bias through the relay system.
- Digitize (using a 400Msps digitizer) the drain sense signal. The digitizer is configured to trig on level voltage of both channels (lines). For each test conditions, high and low thresholds are set. All events higher than the high threshold or lower than the low threshold trig the digitizer and data are plotted and recorded on the computer.

6.4 Graphical User Interface

The GUI running on the computer mainly allows the:

- Selection of the DUT
- Control of the bias
- Choice of test conditions
- Monitoring of the SMUs
- Display of currents graphs
- Management of the test sequence

6.5 Test sequence

The basic sequence used to test was the following:

- Pre run test:	Initial gate stress
- Pre run test:	On / Off test
- Run test:	Start off test
- Run test::	exposition
Run test:	Stop off test
- Post run test:	Post gate stress (PIGS)

The On / Off test is performed at the beginning of each run before the irradiation. This test is used to verify the functionality of the device.

The Off test is the test achieved during the irradiation.

Gate Stress test is carried out at the beginning and at the end of the each run. This test is used to verify the integrity of the gate. For a selected drain voltage, a voltage cycle (between the upper and lower absolute maximum ratings) is applied on the gate.

7 SEE Test Results

7.1 Ions selection

The selection of the different ions and energies was performed in compliance with the following requirements:

> Each device type shall be tested with at least four ion types. Two of the ion types shall have an atomic number 25 < Z < 37 (group 1). The two other ion types shall have an atomic number 45 < Z < 55 (group 2). One of the ion type belonging of each group shall be tested for at least three energies: worst-case energy (corresponding to maximum deposited charge in sensitive volume), one energy that satisfies ion range requirements of Table 2, and a high-energy (≥40 MeV/u). The calculation of the worst case energy shall be detailed in the test plan. The second ion type of each group shall be tested at one energy such as the mean LET in EPI layer is similar to mean LET in EPI corresponding to one of the selected energies with the first ion.

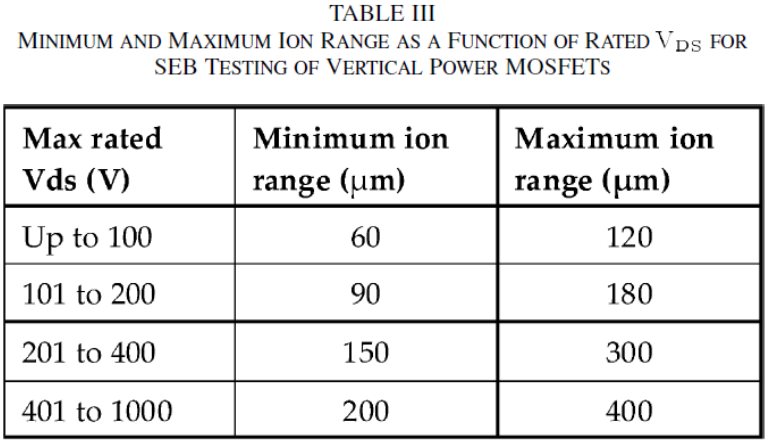


TABLE III
MINIMUM AND MAXIMUM ION RANGE AS A FUNCTION OF RATED V_{DS} FOR SEB TESTING OF VERTICAL POWER MOSFETS

Max rated Vds (V)	Minimum ion range (μm)	Maximum ion range (μm)
Up to 100	60	120
101 to 200	90	180
201 to 400	150	300
401 to 1000	200	400

(Table III Charge Collection in Power MOSFETs for SEB Characterisation—Evidence of Energy Effects, V. Ferlet-Cavrois *et al., IEEE TNS, VOL. 57, NO. 6, DECEMBER 2010)*

Table 1 – Ion range requirements

Copper and Kryptons ions, Cu (Z=29), Kr (Z=36), have been selected for the group 1 while Silver and Xenon, Ag(Z=47), Xe (Z=54) have been selected for the group 2.

SRIM 2013 was used to compute the critical charge deposited,energy deposited, the average LET value.

A dead layer equivalent to 6 µm of Aluminum (noted 4(1) in detailed run results in Table 4) was used during the first test campaign (y13w35), a sandwich of 4.3 µm of Aluminum, 0.6 µm of inter layer dielectric (ILD), 0.35 µm of gate polysilicon and 0.8 µm of passivation noted 6(2) in detailed run results in Table 4. Epitaxy depth was set to 38 µm according to the die microsection results (see § 4.4).

The different ion beams selected are detailed in Table 2 where R correspond to the silicon surface level below the dead layer. TAMU interface is based on SRIM 2005 computations and then some minor differences have been observed with SRIM 2013 computations. Table 2 identifies also the beam selected during the two different test slots.

SRIM 2013 computation						TAMU beam selectiion					
Ion	Q	R	LET at R	E at R	Mean_LET	Cocktail	Energy	degrader	Eff. LET	y13w35	y14w26
	pC	µm	MeV/ (mg/cm²)	MeV	MeV/ (mg/cm²)		MeV		MeV/ (mg/cm²)		
Kr_wc	15.4846	60	37.12	493.5	39.53	**15MeV**	**494**	**yes**	35.5		y
Kr high	5.9702	567	15.01	2996.2	15.24	**40MeV**	**2996**	**no**	14.6	y	y
Kr	9.391	214	23.03	1519.1	23.97	**25MeV**	**1674**	**yes**	21.9		y
Kr	11.0004	155	26.53	1181.4	28.08	**25MeV**	**1183**	**yes**	26.2		y
Cu	9.3875	97	21.89	600.8	23.96	**15MeV**	**601**	**yes**	22		y
Xe_wc	26.6121	64	65.6	853.9	67.93	**15MeV**	**854**	**yes**	58.6		y
Xe	18.4867	195	45.27	2492.2	47.19	**25MeV**	**2492**	**yes**	42.6		y
Xe	22.9317	116	55.17	1579,6	58.17	**25MeV**	**1581**	**yes**	50.8	y	
Ag	18.5635	113	44.2	1286.1	47.39	**15MeV**	**1286**	**no**	42.2		y

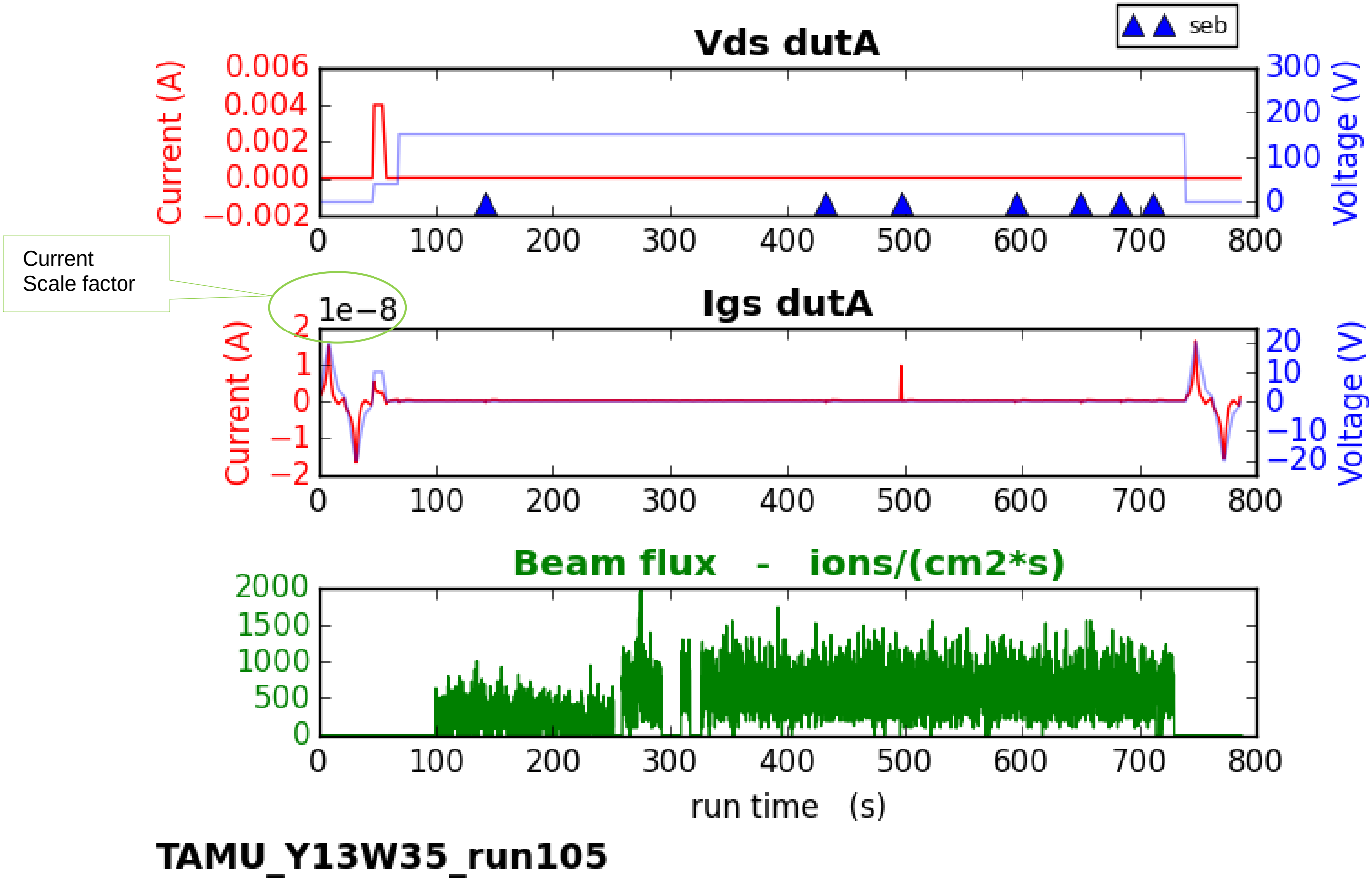
Table 2 – Ion beam setting

7.2 Run tests

All tests were performed in air and at room temperature.
Resistor protection was set to 10kOms.
The detailed list of runs performed at TAMU during the two test campains is provided in Table 4.
One or two samples can be tested at the same time with same or different test biasing conditions

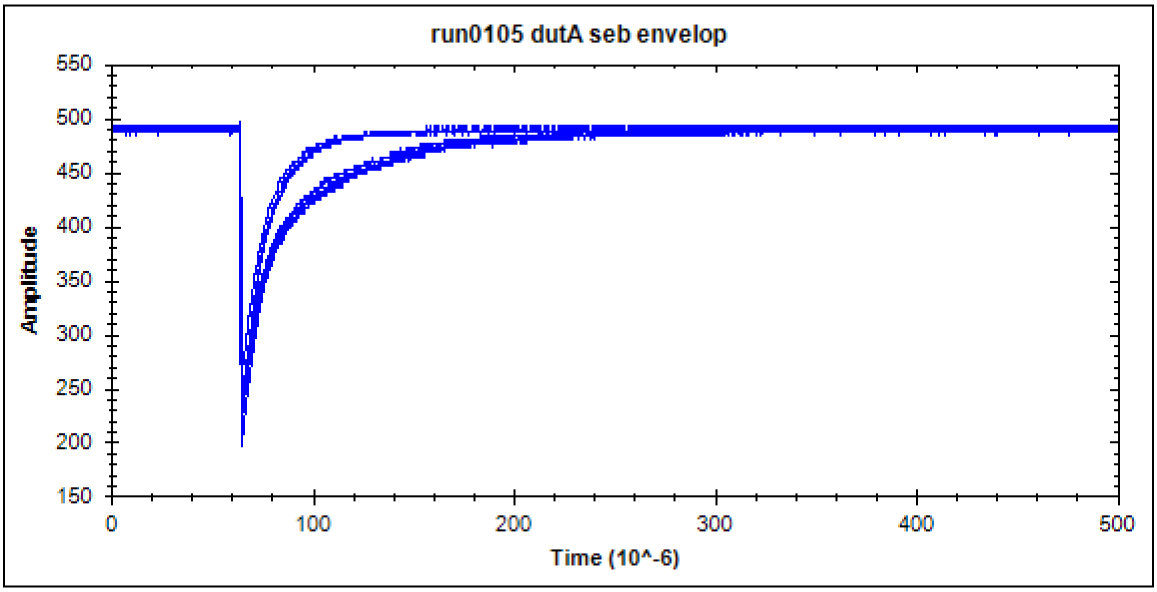
Figure 1 shows Example of the data recorded for each dut under test and each test run.
In this figure, one can observe the initial get stress followed by on/off condition then under off condition, beam is started until the desired fluence, then when run is stopped, a post gate stress is performed.
Actual final beam fluence value is listed in Table 4 while in this figure the computed flux is based on the recorded data from one scintillator only instead of the four scintillator detectors used by the accelerator interface.
Please note that Igs current plot can exhibit a scale factor (1e-8 in the present case)
The recorded sebs are identified by a blue triangle which are detected using 0.93 V threshold value (15 tester LSBs, 1 LSB=307 mV)
All data recorded for the different runs and duts are provided in a companion document ref. HRX/SEE/473-appendix issue1.

Figure 8 shows the envelop of the non destructive SEBs (same run as Figure 1).



Current
Scale factor

Figure 7 – Example of the data recorded for each dut under test and each test run.



Amplitude is measured in tester LSBs (1 LSB correspond to 307mV)

Figure 8 – SEBs recorded during y13w35 run0105 (see Figure 7)

7.3 Discussion

During first test campaign, samples delidding operation was not optimum (preopening subcontracted outside Hirex) and not all samples under test were under nominal conditions. For the second test campaign, all deliding tasks were performed at Hirex site with a better control.

First it has been observed that SEB threshold is not abrupt and it is difficult to define it precisely. Secondly, sensitivity to SEGR with the group 2 ions does not allow to perform very preciseley a comparison of the different SEB thresholds for the two groups. Table 3 and Figure 9 show this comparison using the observed SEBs.

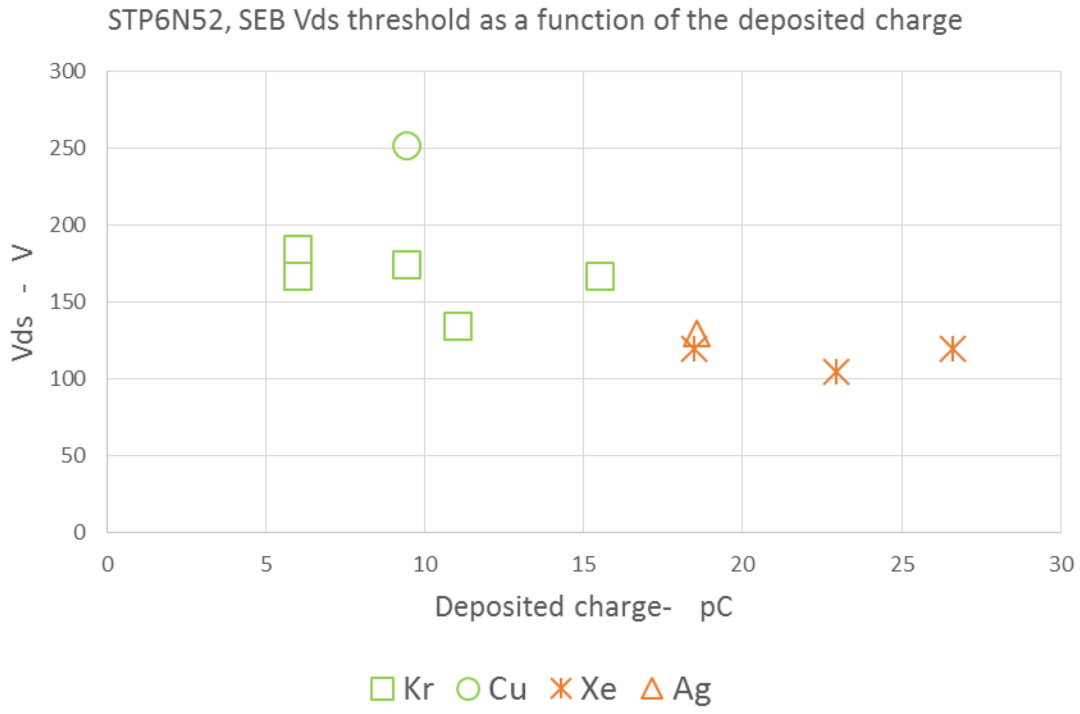


Figure 9 – SEB threshold for the 4 ions selected as a function of deposited charge

Ion group	Ion	Q (pC)	Ion, LET	Test slot	SEB threshold (V)
Group 1	Kr High energy	5.9702	Kr, 14.6	y13w35	few SEBs on a 150 to 185V range a SEGR at 164V on a third sample
		5.9702	Kr, 14.6	y14w26	few SEBs on a 170 to 200V range Ids degradation at 200V in coincidence with a SEB
	Kr_wc	15.4846	Kr, 35.5	y13w35	between 155 and 180V
	Kr	9.391	Kr, 21.9	y14w26	seb start at 175V, no abrupt threshold, no SEGR up to 210V
		11.004	Kr, 26.2	y14w26	few SEBs ar 135V, SEGR at post gate stress on both samples
	Cu	9.3875	Cu, 22	y14w26	very few SEB between 240 and 265V, no SEGR up to 270V
Group 2	Xe_wc	26.6121	Xe, 58.6	y14w26	SEGR start at 80 to 85V, without any SEB SEB obesrved at 120V before DUT degradation
	Xe	22.9317	Xe, 50.8	y13w35	small SEBs at 105V with Ids degradation on 1 sample followed by SEGR post gate stress
		18.4867	Xe, 42.6	y14w26	SEGR at or above 110V, SEB threhold between 110 and 130V
	Ag	18.5635	Ag, 42.2	y14w26	SEGR at or above 120V, SEB threhold between 120 and 140V few SEBs at 140V

Table 3 – SEB Vds thresholds as a function of ion species and deposited charges

test campaign	medium	run_number	Facility_run_number	board_id	dut_part_id	Selected_beam cocktail MeV/u	**Ion**	LET	roll	tilt	Al_thickness(mil)	Number_of_layers(file)	**Beam_energy(MeV)**	**Eff._LET(MeVcm2/mg)**	Eff._range(um)	Eff._fluence(ions/cm2)	Dose(rad)	run_duration live_time	Aver._flux(ions/(cm2s))	VgsA	vdsA	seb	VgsB	vdsB	seb	SEGR	comment
y13w35	air	96	114		12, 13	25	**Xe**		0	0	4.334	4(1)	**1581**	**50.8**	125.5	300000	244	526.35	569	0	105	188	0	105	0	1	small SEBs, Igs dutA degrades from 1 nA to 85 nA) at t= 463s, dutA fail post gate stress
y13w35	air	102	118		10, 11	40	**Kr**		0	0	0	4(1)	**2996**	**14.6**	584.6	52200	12.2	111.967	466	0	105	0	0	105	0	√	
y13w35	air	103	119		10, 11	40	**Kr**		0	0	0	4(1)	**2996**	**14.6**	584.6	300000	70.3	804.733	373	0	105	0	0	105	0	√	
y13w35	air	105	120		10, 11	40	**Kr**		0	0	0	4(1)	**2996**	**14.6**	584.6	300000	70.3	598.767	501	0	150	7	0	0	0	√	
y13w35	air	106	121		10, 11	40	**Kr**		0	0	0	4(1)	**2996**	**14.6**	584.6	300000	70.3	556.783	539	0	160	4	0	0	0	√	
y13w35	air	107	122		10, 11	40	**Kr**		0	0	0	4(1)	**2996**	**14.6**	584.6	300000	70.3	438.183	685	0	170	9	0	0	0	√	
y13w35	air	110	125		10, 11	40	**Kr**		0	0	0	4(1)	**2996**	**14.6**	584.6	129000	30.1	281.767	456	0	185	5	0	0	0	√	
y13w35	air	113	127		10, 11	40	**Kr**		0	0	0	4(1)	**2996**	**14.6**	584.6	300000	70.2	549.333	546	0	0	0	0	160	6	√	
y13w35	air	116	129		16	40	**Kr**		0	0	0	4(1)	**2996**	**14.6**	584.6	300000	70.3	639	470	0	164	4	0	0	0		dutA igs degradation down to 0.13µ
y14w26	air	2	1	A	A	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	121000	28.4	253.133	479	0	120	0	0	120	0	√	only dutA under exposure
y14w26	air	6	4	A	A	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	300000	70.2	513.167	584	0	140	0	0	140	0	√	only dutA under exposure
y14w26	air	7	5	A	A	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	299000	70.1	243.517	1230	0	150	0	0	150	0	√	only dutA under exposure
y14w26	air	9	6	A	A	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	300000	70.4	264.167	1140	0	160	0	0	160	0	√	only dutA under exposure
y14w26	air	10	7	A	A	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	300000	70.2	343.183	873	0	170	0	0	170	0	√	only dutA under exposure
y14w26	air	11	8	A	A	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	300000	70.3	391.367	767	0	180	1	0	180	0	√	only dutA under exposure
y14w26	air	12	9	A	A	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	328000	76.7	537.033	610	0	190	0	0	170	0	√	only dutA under exposure
y14w26	air	13	10	A	A	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	185000	43.2	332.55	555	0	200	2	0	170	0	√	only dutA under exposure, 2nd SEB with an IDS degradation
y14w26	air	15	12	B	A/B	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	308000	72	495.833	620	0	170	0	0	170	1	√	
y14w26	air	16	13	B	A/B	40	**Kr**		0	0	0	6(2)	**2997**	**14.6**	584.7	313000	73.2	305.883	1020	0	180	0	0	180	0	√	
y14w26	air	67	60	C	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	301000	171	175.417	1720	0	160	31	0	160	0	√	
y14w26	air	68	61	C	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	300000	171	173.183	1730	0	160	46	0	165	1	√	
y14w26	air	69	62	C	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	300000	171	174.167	1720	0	160	37	0	170	23	√	
y14w26	air	70	63	C	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	300000	171	166.7	1800	0	155	3	0	165	3	√	

test campaign	medium	run_number	Facility_run_number	board_id	dut_part_id	Selected_beam cocktail MeV/u	**Ion**	LET	roll	tilt	Al_thickness(mil)	Number_of_layers(file)	**Beam_energy(MeV)**	**Eff._LET(MeVcm2/mg)**	Eff._range(um)	Eff._fluence(ions/cm2)	Dose(rad)	run_duration live_time	Aver._flux(ions/(cm2s))	VgsA	vdsA	seb	VgsB	vdsB	seb	SEGR	comment
y14w26	air	71	64	D	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	300000	171	165.483	1810	0	160	11	0	160	0	√	
y14w26	air	72	65	D	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	300000	171	167.1	1790	0	160	6	0	165	0	√	
y14w26	air	73	66	D	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	301000	171	239.183	1260	0	160	10	0	170	0	√	
y14w26	air	74	67	D	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	300000	171	158.017	1900	0	160	11	0	175	0	√	
y14w26	air	75	68	D	A&B	15	**Kr**		0	0	2.576	6(2)	**494**	**35.5**	59.8	299000	170	145.233	2060	0	160	9	0	180	4	√	
y14w26	air	93	85	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	73.7833	4070	0	160	0	0	165	0	√	
y14w26	air	94	86	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	104.6	2860	0	165	0	0	175	0	√	
y14w26	air	95	87	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	301000	106	112.75	2670	0	170	0	0	180	0	√	
y14w26	air	96	88	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	301000	106	114	2640	0	180	0	0	190	0	√	
y14w26	air	97	89	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	301000	106	120.067	2510	0	190	0	0	200	0	√	
y14w26	air	98	90	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	149.883	2000	0	200	0	0	210	0	√	
y14w26	air	99	91	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	299000	106	144.35	2070	0	210	0	0	220	0	√	
y14w26	air	100	92	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	301000	106	151.017	1990	0	220	0	0	230	1	√	
y14w26	air	101	93	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	299000	106	157.283	1900	0	225	0	0	235	0	√	
y14w26	air	102	94	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	301000	106	162.383	1850	0	230	0	0	240	1	√	
y14w26	air	103	95	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	301000	106	123.817	2430	0	235	0	0	245	0	√	
y14w26	air	104	96	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	146	2050	0	240	1	0	250	0	√	
y14w26	air	105	97	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	180.867	1660	0	245	0	0	255	0	√	
y14w26	air	106	98	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	301000	106	191.733	1570	0	250	3	0	260	0	√	
y14w26	air	107	99	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	203.033	1480	0	255	4	0	265	2	√	
y14w26	air	108	100	c	A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	219.9	1360	0	260	6	0	270	2	√	
y14w26	air	110	101		A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	222.167	1350	0	245	1	0	245	0	√	
y14w26	air	111	102		A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	233.567	1290	0	250	0	0	250	0	√	
y14w26	air	112	103		A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	242.35	1240	0	255	5	0	255	1	√	
y14w26	air	113	104		A&B	15	**Cu**		0	0	1.315	6(2)	**601**	**22**	97.4	300000	106	231.433	1300	0	260	7	0	260	1	√	
y14w26	air	130	120	E	A&B	15	**Xe**		0	0	1.785	6(2)	**854**	**58.6**	68.1	49600	46.6	24.0667	2060	0	120	9	0	120	39		both Ids dutA and dutB increase, dut dead (PIGS); small events
y14w26	air	131	121	F	A&B	15	**Xe**		0	0	1.785	6(2)	**854**	**58.6**	68.1	301000	283	147.183	2040	0	70	0	0	70	0	√	
y14w26	air	132	122	F	A&B	15	**Xe**		0	0	1.785	6(2)	**854**	**58.6**	68.1	299000	281	174.367	1720	0	80	0	0	80	0	√	

test campaign	medium	run_number	Facility_run_number	board_id	dut_part_id	Selected_beam cocktail MeV/u	**Ion**	LET	roll	tilt	Al_thickness(mil)	Number_of_layers(file)	**Beam_energy(MeV)**	**Eff._LET(MeVcm2/mg)**	Eff._range(um)	Eff._fluence(ions/cm2)	Dose(rad)	run_duration live_time	Aver._flux(ions/(cm2s))	VgsA	vdsA	seb	VgsB	vdsB	seb	SEGR	comment
y14w26	air	133	123	F	A&B	15	**Xe**		0	0	1.785	6(2)	**854**	**58.6**	68.1	300000	281	207.083	1450	0	85	0	0	85	0		dutA (post gate stress) and dut B(initial gate stress)
y14w26	air	175	164	B	A&B	15	**Ag**		0	0	0	6(2)	**1283**	**42.2**	118.6	287000	194	219.333	1310	0	100	0	0	100	0	√	
y14w26	air	176	165	B	A&B	15	**Ag**		0	0	0	6(2)	**1283**	**42.2**	118.6	300000	203	242.65	1240	0	120	0	0	120	0		dutA √, dutB(post gate stress)
y14w26	air	177	166	B	A&B	15	**Ag**		0	0	0	6(2)	**1283**	**42.2**	118.6	87100	59	70.4167	1240	0	140	8	0	140	6		dutA √, see run176: segr sur B
y14w26	air	178	167	B	A&B	15	**Ag**		0	0	0	6(2)	**1283**	**42.2**	118.6	300000	203	247.567	1210	0	150	40	0	-	-		dutA (post gate stress)
y14w26	air	180	169	C	A&B	24.8	**Kr**		0	0	4.798	6_(hrx40)	**1183**	**26.2**	158.1	300000	126	291.367	1030	0	135	6	0	135	1		wrong dead layer dutA (post gate stress) and dut B(post gate stress)
y14w26	air	189	177	D	A&B	24.8	**Kr**		0	0	1.704	6(2)	**1674**	**21.9**	247	299000	105	198.55	1510	0	130	0	0	130	0	√	
y14w26	air	190	178	D	A&B	24.8	**Kr**		0	0	1.704	6(2)	**1674**	**21.9**	247	300000	105	269.15	1120	0	140	0	0	140	0	√	
y14w26	air	191	179	D	A&B	24.8	**Kr**		0	0	1.704	6(2)	**1674**	**21.9**	247	300000	105	360.45	831	0	150	0	0	150	0	√	
y14w26	air	192	180	D	A&B	24.8	**Kr**		0	0	1.704	6(2)	**1674**	**21.9**	247	300000	105	451.883	663	0	175	4	0	175	0	√	
y14w26	air	193	181	D	A&B	24.8	**Kr**		0	0	1.704	6(2)	**1674**	**21.9**	247	300000	105	426.483	703	0	180	8	0	180	1	√	
y14w26	air	194	182	D	A&B	24.8	**Kr**		0	0	1.704	6(2)	**1674**	**21.9**	247	300000	105	316	948	0	190	20	0	190	1	√	
y14w26	air	195	183	D	A&B	24.8	**Kr**		0	0	1.704	6(2)	**1674**	**21.9**	247	300000	105	409.933	731	0	200	39	0	210	19	√	
y14w26	air	196	184	I	A&B	24.8	**Xe**		0	0	1.357	6(2)	**2492**	**42.6**	210.2	301000	205	257.85	1170	0	130	45	0	130	57		Ids dutA & duB degradation, dutA (post gate stress) and dut B(post gate stress)
y14w26	air	197	185	J	A&B	24.8	**Xe**		0	0	1.357	6(2)	**2492**	**42.6**	210.2	299000	204	253.983	1180	0	110	0	0	110	0		Ids dutA, high initial Ids dutb,dutA (post gate stress) and dut B(post gate stress)

Table 4 – REF, August 2013 (y13w35), June 2014 (y14w26), STP6N52, run table