HEAVY IONS TEST REPORT

Single Event Effects
RHFLVDS31K1
(30539)
from
STMicroelectronics

Ref: TRAD/TI/RHFLVDS31K1/30539/STM/WF/0510	***Labège, December 19th, 2005***
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Observations:

Rev 0 Creation of document

TO: STMicroelectronics **Mr. Hervé DUPERRAY**	**Ref:** **Project/program:**

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1 Introduction

This report presents the results of a heavy ions **S**ingle **E**vent **E**ffects (SEEs) test program carried on **high speed differential line drivers RHFLVDS31K1** from **STMicroelectronics**.
The main scopes of these tests were to evaluate if **RHFLVDS31K1** would be affected by **S**ingle **E**vent **T**ransients (SET) and **S**ingel **E**vent **L**atchup (SEL).

2 Documents

2.1 APPLICABLE DOCUMENTS

TRAD/P/ST/LVDS/CC/171005.

2.2 REFERENCE DOCUMENTS

STMicroelectronics STLVDS31 datasheet.
EIA JESD57

3 Organization of Activities

The relevant company has conducted the following tasks during this evaluation:

1	Procurement of Test Samples	STMicroelectronics
2	Preparation of test Samples (delidding)	TRAD
3	Preparation of Test Hardware and Test Program	TRAD
4	Samples Check out	TRAD
5	Accelerator Test	TRAD
6	Heavy Ion Test report	TRAD

Table 1: Organization of activities.

4 Device Description

The RHFLVDS31K1 is a differential line driver which implements **L**ow **V**oltage **D**ifferential **S**ignaling (LVDS). It works with a 3.3V single supply and allows operations up to 400Mbps.

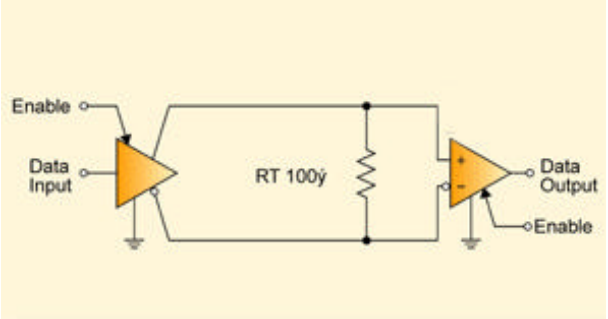

Figure 1: Typical Application Schematic.

5 Parts References

REFERENCES	
Type:	**RHFLVDS31K1**
Manufacturer:	**STMicroelectronics**
Packaging	16 pins Flat Package
PROCESS / TECHNOLOGY	
/	
PARTS PROCUREMENT	
Lot number:	30539
Number of PARTS	4

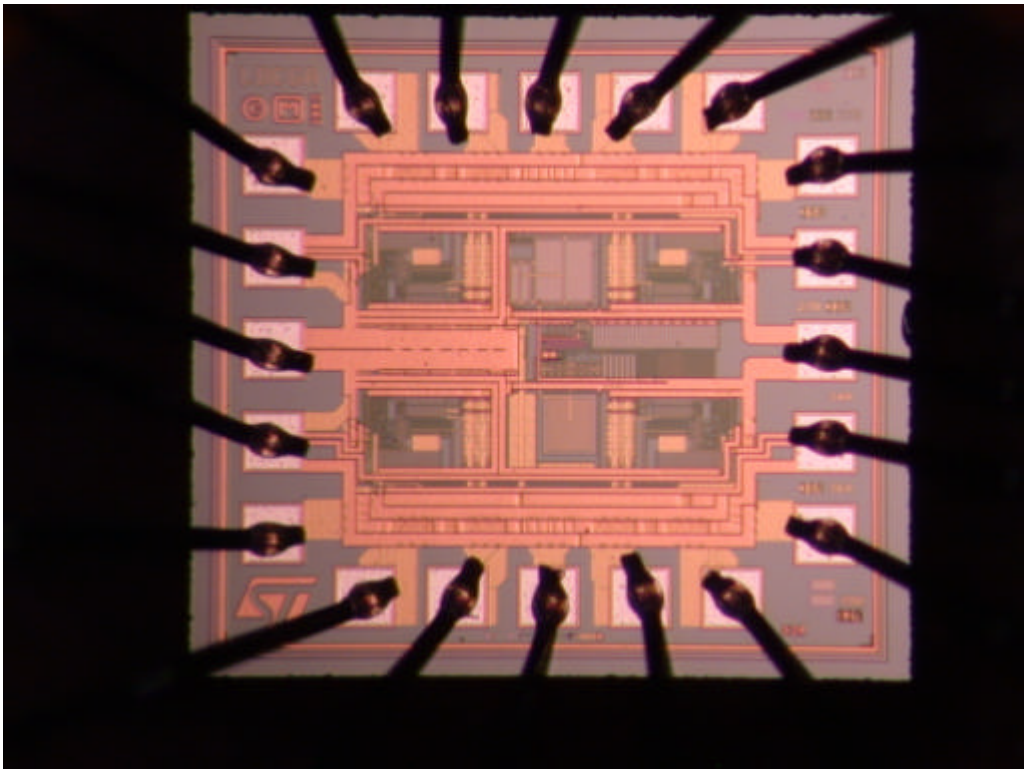

Figure 2: Delidded sample, view1

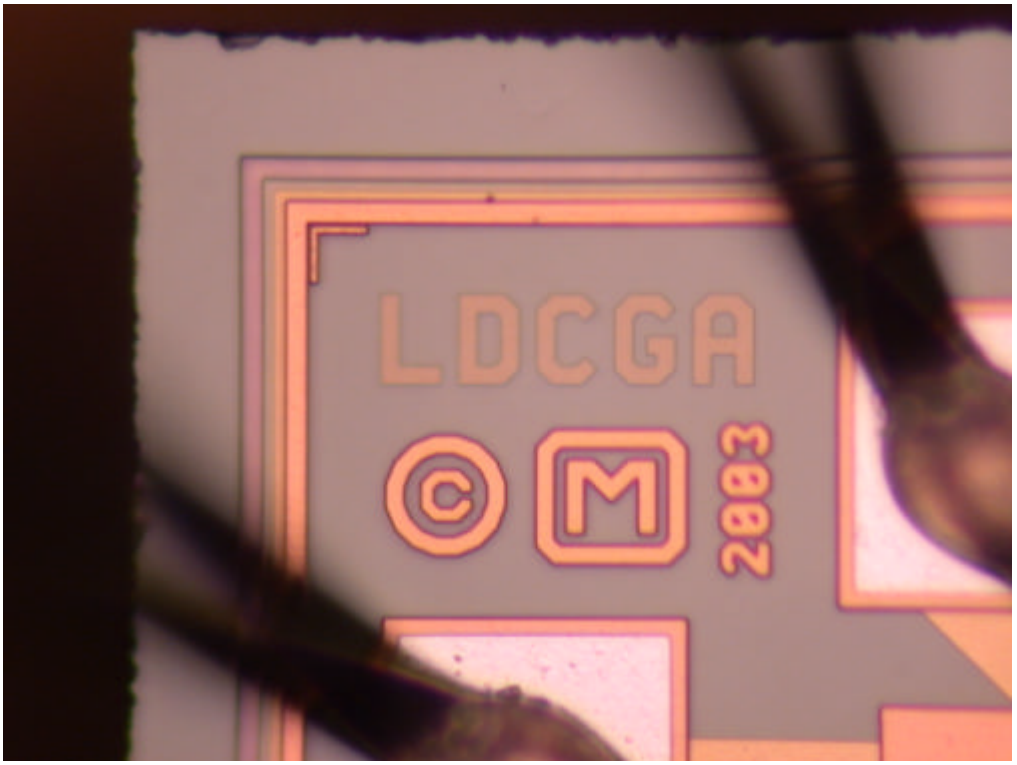

Figure 3: Delidded sample, view 2

6 Test Description

6.1 Procurement of test samples

7 parts were provided by STMicroelectronics.

6.2 Preparation of samples

4 devices were delidded by TRAD.
No sample was damaged during this operation.

6.3 Preparation of test board and program

TRAD has developed a specific test program called **APPLI_PRINCIPALE.VI** which performs the event counting and the curve acquisition.

The test board was specifically designed following the typical application schematic.The board includes 2 RHFLVDS31K1 (8 Emitters) and 2 RHFLVDS32K1 (8Receivers).

- A RHFLVDS31K1, as emmiter. The input signal of the line, a 50Mhz square waveform, is connected to the RHFLVDS31K1.
- A RHFLVDS32K1, as receiver.It is connected to the RH-LVDS31 with the typical differential connection, including a 100Ù resistor between the 2 differential lines of the signal. The scope is connected to the outputs of the RHFLVDS32K1.

This board allows us to test both the RHFLVDS31K1 and the RHFLVDS32K1. We select the device to test by moving the board into the radiation chamber to place it be in front of the beam. The 4 devices mounted on the board are placed in accordance with the beam focus. The beam cannot hit two devices, so if an SET is detected, it can only come from the device hit by the ion beam. We use a latchup monitoring device (GUARD SYSTEM) on the component's power supply to detect SEL and prevent the destruction of the device under test.

This testing system is connected to a compatible Personal Computer through a standard IEE488 communication interface. The PC and the interface control and monitor the test. They receive the output signal and store it in the PC memory.

At the end of each test run, the data are transferred to a floppy disk for storage. An overall description of the test system is given in part 9 (see figure 4).

6.4 Samples Check

A functional test sequence was performed on delidded samples to check that the devices had not been degraded during the delidding operation.

6.5 Accelerator facility

The test was performed at Brookhaven National Laboratory under TRAD's responsability, the 30th of November 2005. Three delidded samples were irradiated.

Ion	Energy (MeV)	LET (MeV/mg.cm²)	RANGE (µM)
Gold (Au-197)	332	81.31	27.40
Iodine (I-127)	322	59.73	31.10
Bromine (Br-81)	279	37.45	36.10
Nickel (Ni-58)	265	26.58	42.20
Chlorine (Cl-36)	210	11.44	63.50

Table 2: 5 ions cocktail

We have performed the tilt operation with Gold ion. A tilt operation increase the LET of an ion by a variation of the ion beam incidency angle. We used the following tilt settings:

Ion	Energy(MeV)	Tilt Angle(°)	Effective Range (µm)	Effective LET(MeV/mg.cm²)
Gold (Au-197)	332	47	18.69	119.20
Chlorine (Cl-36)	210	55	36.42	19.95

Table 3: Tilted ion

7 Dosimetry and Irradiation Facilities

The characteristics of the ion beam used for the test are described hereunder.

IRRADIATION FACILITIES	
Heavy Ions used:	Au, I, Br,Ni,Cl
Vacuum:	6.10^{-5} torr
Flux range :	$4.5.10^{3}$ to $6.1.10^{4}$ ions/cm²/s
Fluency range :	1.10^{6} to 10^{7} ions/cm²
Particle angle :	0°, 47° and 55°
Uniformity beam :	Diameter 3 cm ±10%
Dosimetry:	Scintillation detector, Faraday cups

8 Device set up

Power Supplies	Module	Voltage (V)
ME-30	RHFLVDS31K1	+3.3V

9 Test Procedure

9.1 Description of the test method

During the test, we have irradiated 3 components.

We divided the test in two parts, under respect of reference or applicable documents:

- We performed runs up to a fluency of 10^6 ions/cm^2 for the SET detection. A latchup monitoring was used during these tests. This configuration allowed us to verify both the SET and the SEL sensitivity of the device.

- We performed runs up to a fluency of 10^7 ions/cm^2 with only a latchup monitoring. This configuration allowed us to verify the latchup sensitivity of the device for a high fluency.

The test was terminated if the maximum fluency was reached or if more than 100 events occurred.

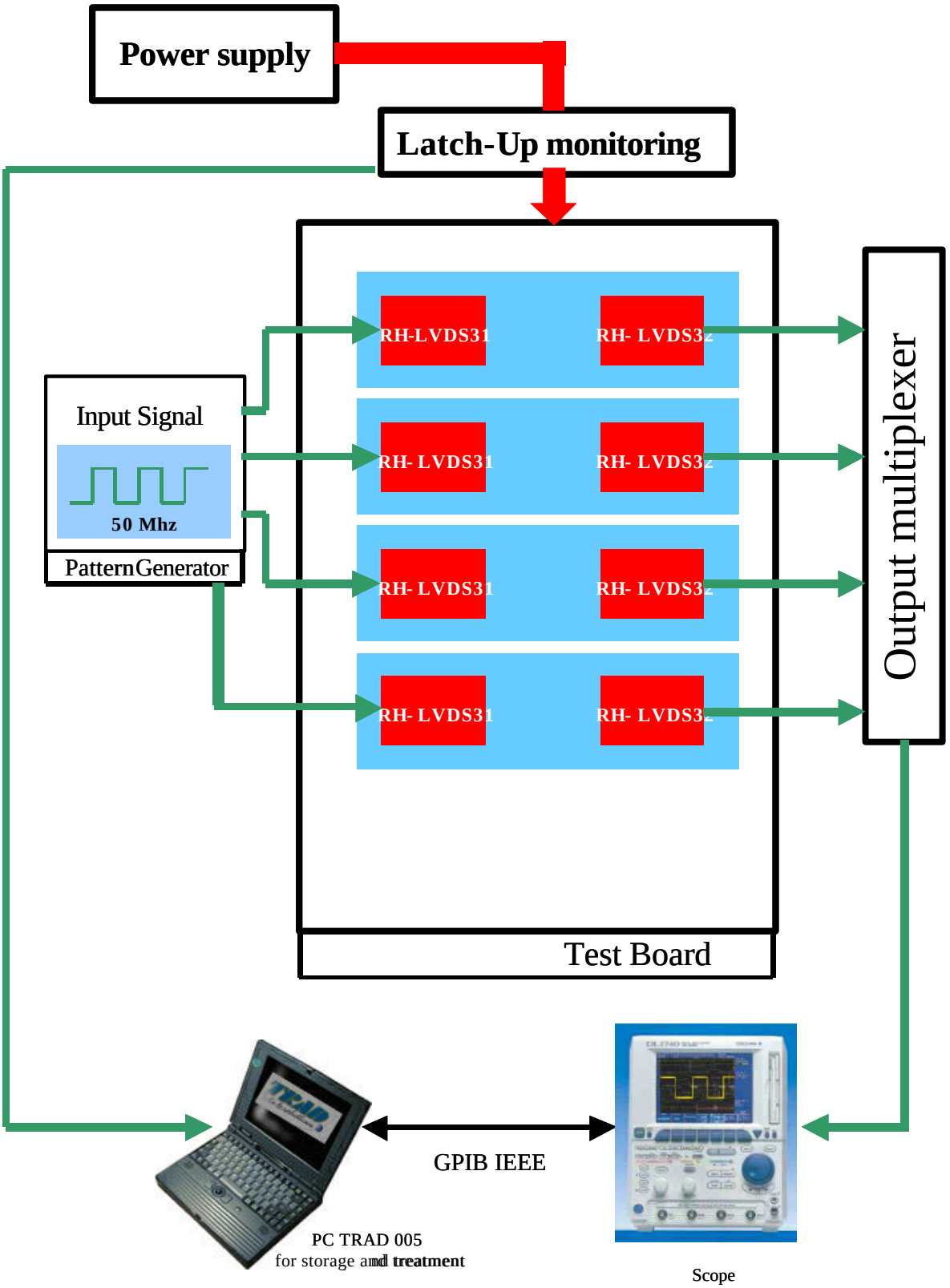

Figure 4: Description of test system.

The line activation switcher selects which line will be supplied power through the latchup monitoring device. There are two power lines, one for the RHFLVDS31K1 and one for the RHFLVDS32K1. The latchup monitor is effective only for one of these lines, the one for the device under test. For the latchup configuration (fluency up to 10^7), the inputs signals are not connected to the test board, so the scope counts the SEL.

9.2 Description of a measured signal

The output signal got the following shape:

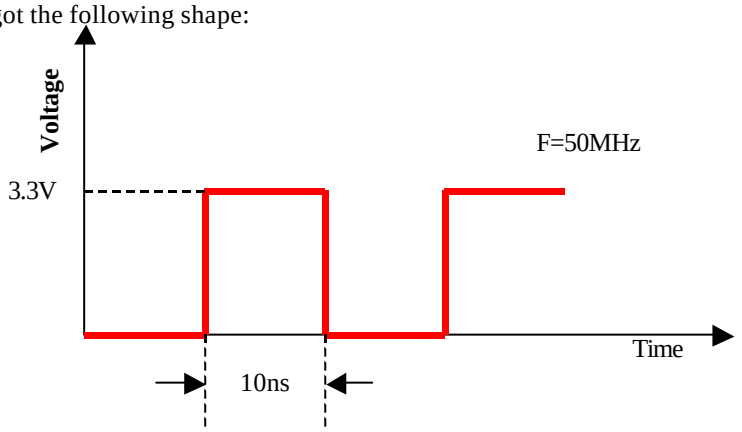

Figure 5: output signal

We have to detect pulse width modification of this signal. Such modification will be due to SET.

9.3 Test Configurations

There are two different configurations. For the SET detection, the outputs signals are connected to the scope channel (Four outputs of the receiver). This channel is configured to detect all pulse widths different than 10ns.If such an event is detected, an increment of the scope internal counter occurs and the scope trace is store into the PC memory. The latchup monitoring is active during the SET detection but we cannot store the latchup characteristic.
We use a second configuration to store latchup traces. In this configuration the output of the latchup monitor is linked to the scope channel (50mV/div and 500µs/div). When a latchup occurs, the scope counter increases and the scope screen is stored into the PC memory. In this SEL configuration, the tested line is still active, but the output signal is not used for events detection. The latchup threshold is defined as twice as the regular power consumption of the RHFLVDS31K1. The consumption measured on our test board was approximatively 18 mA. According to this, we defined our latchup detection threshold to 35mA (range 4 of GUARD System).

10 Test Equipment

The tests were carried out with test cards developed by TRAD.

Computer	Laptop TRAD MI-OP10
Test Equipment	MO-30,Guard System,ME-16
Program Test	Appli_principale.vi
Board Test	TRAD/CT1/I/RHFLVDS32K1/FPACK/MV/0511

The pattern generator is carried with a Quartz 50 MHz.

11 RESULTS

11.1 SET characterisation:

Scope trigger 10 ns
Scope input impedance 50Ω

The SET sensitivity was measured for a fluency of 10^7 ions/cm^2 throught divider by 10 (500Ω/50Ω) on all outputs. The number of events of SET, is the sum of SET on 4 outputs. We observed the 2 types of SET:

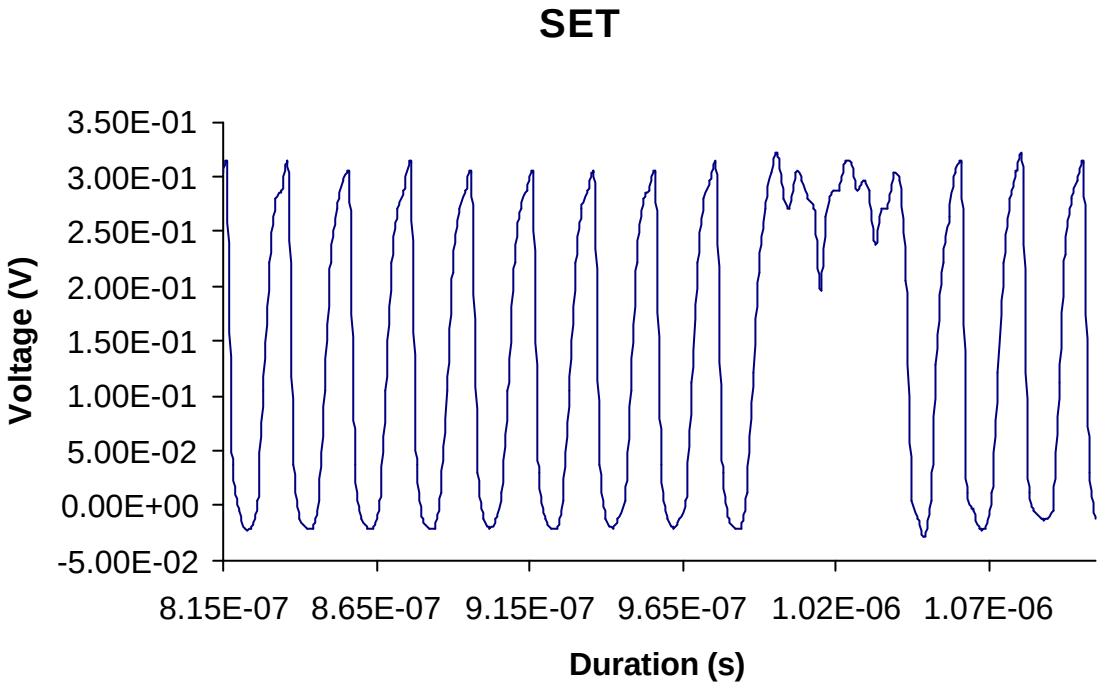

Figure 6: SET worst case of type 1, wider pulse

Obtained on device RHFLVDS31K1 n°2, run 55, ion Gold.

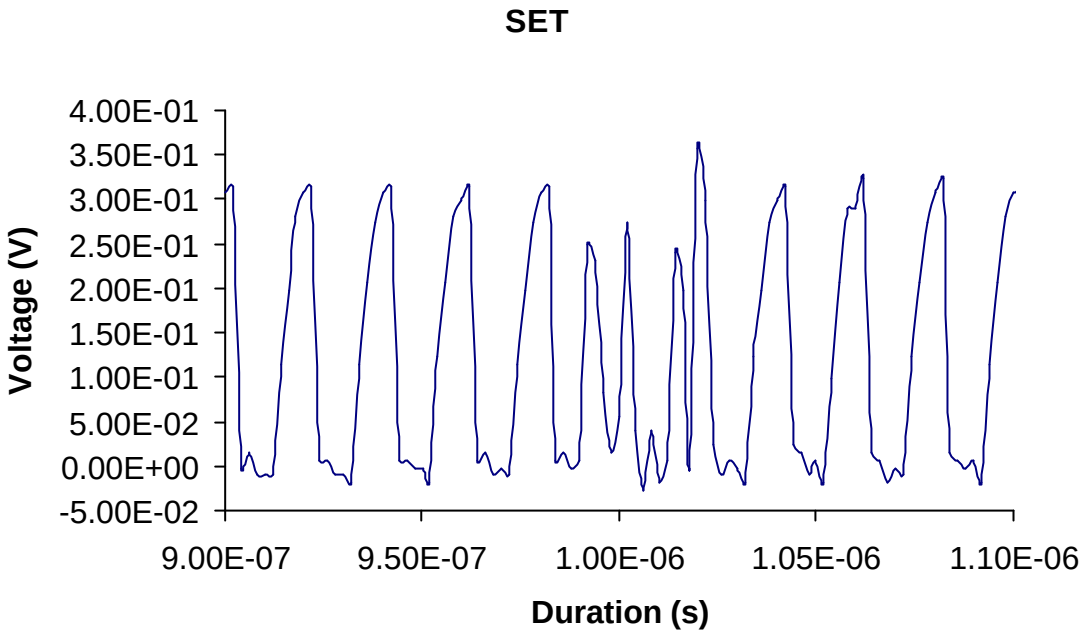

Figure 7: SET worst case type2, thinner pulse

Obtained on device RHFLVDS31K1 n°4, run 40, ion Chlorine.

Of all type of SET observed, we obtains the following cross section versus LET curve:

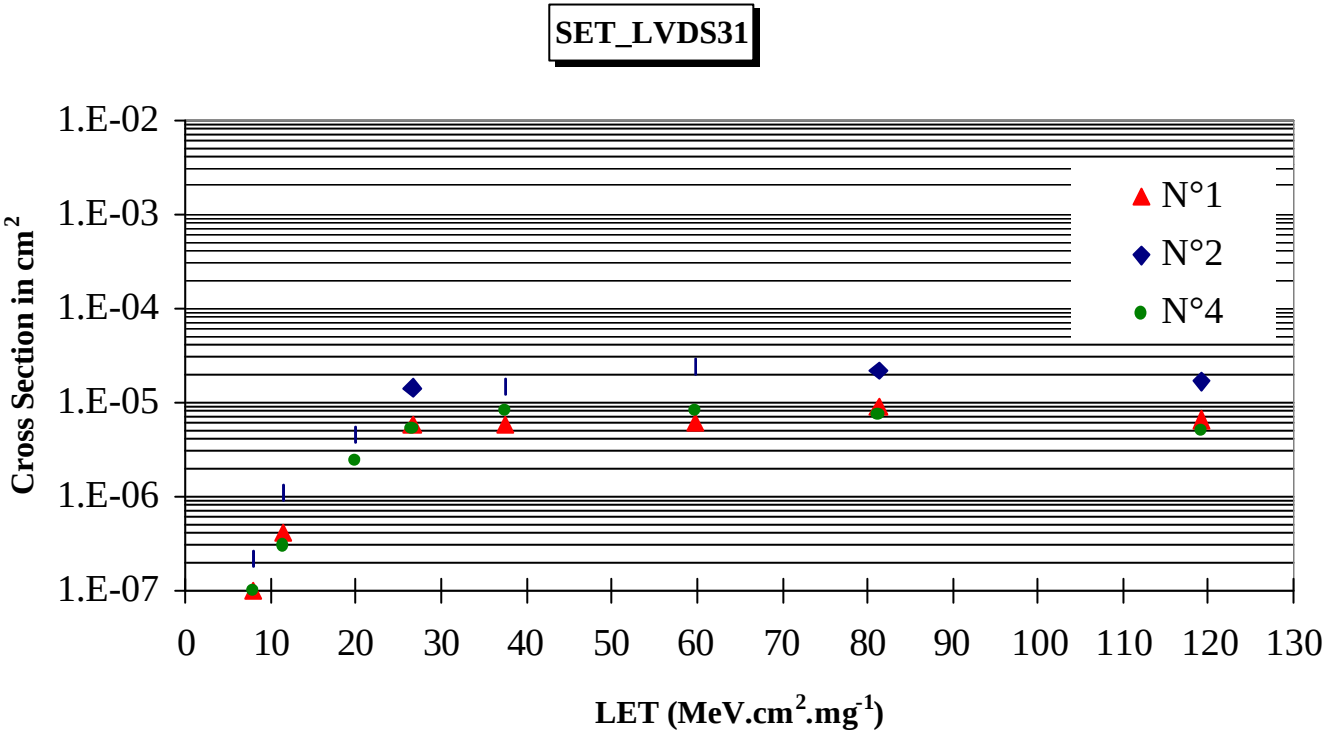

Figure 8: RHFLVDS31 Cross section vs LET, SET characterization

SET_31			
LET	**Cross Section**		
	N°1	**N°2**	**N°4**
119.20	6.50E-06	1.65E-05	5.00E-06
81.31	8.80E-06	2.20E-05	7.40E-06
59.73	6.00E-06	2.40E-05	8.00E-06
37.45	5.80E-06	1.48E-05	8.00E-06
26.58	5.80E-06	1.41E-05	5.30E-06
19.95		4.50E-06	2.40E-06
11.44	4.00E-07	1.10E-06	3.00E-07
7.88	1.00E-07	2.20E-07	1.00E-07

Table 4: Cross Section of SET.

11.2 SEL Characterisation :

Latchup threshold 35mA
The SEL characterisation was performed with a fluency of 10^7 ions/cm^2. The typical SEL waveform was the following:

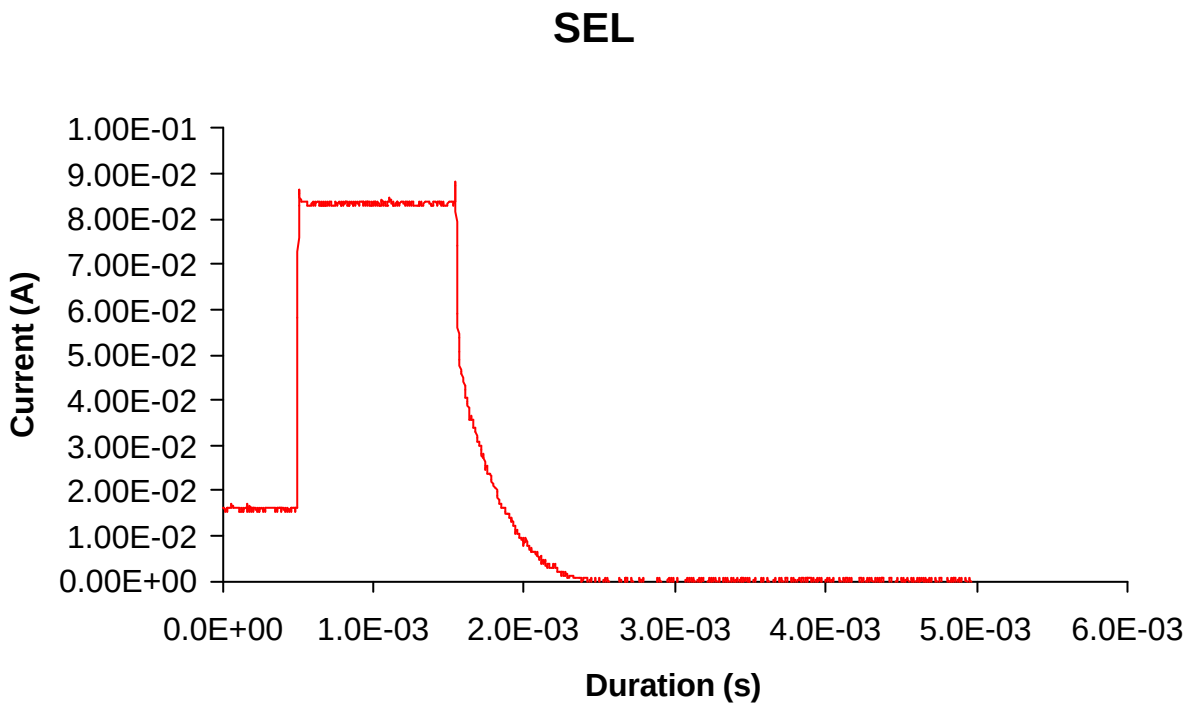

Figure 9: Typical SEL curve

Of all type of SEL observed, we obtains the following cross section versus LET curve:

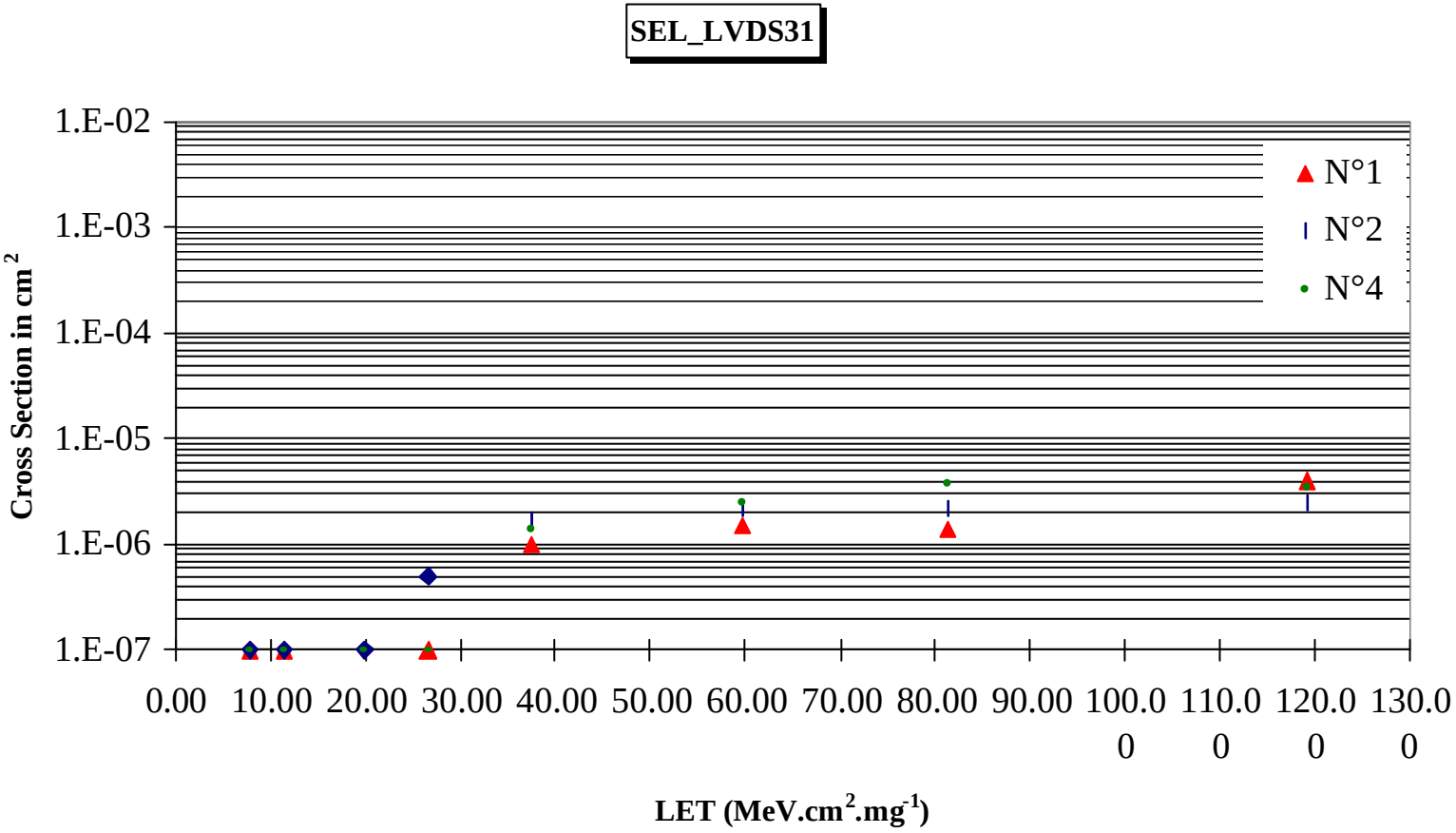

Figure 10: RHFLVDS31 Cross section vs LET, SEL characterization

SEL_31			
LET	**Cross Section**		
	N°1	**N°2**	**N°4**
119.20	4.00E-06	2.50E-06	3.50E-06
81.31	1.40E-06	2.20E-06	3.80E-06
59.73	1.50E-06	2.20E-06	2.50E-06
37.45	1.00E-06	1.70E-06	1.40E-06
26.58	1.00E-07	5.00E-07	<1.00E-07
19.95	-	<1.00E-07	<1.00E-07
11.44	<1.00E-07	<1.00E-07	<1.00E-07
7.88	<1.00E-07	<1.00E-07	<1.00E-07

Table 5: Cross Section of SEL.

12 Appendix

All runs are listed below.

Run	Part	N°	Ion	Energy (MeV)	Range (µm)	LET (MeV./mg/cm²)	Tilt (°)	Range eff (µm)	LETeff (MeV/mg/cm²)	Flux (#/cm².sec)	Fluency (#/cm²)	Dose Totale (krad)	Events SEL	Events SET	Cross Section SEL	Cross Section SET	Remarks
1	LVDS31	1	I	322	31.10	59.73	0	31.10	59.73	1.16E+04	1.00E+07	9.557	15		1.50E-06	-	Run SEL only
3	LVDS31	1	I	322	31.10	59.73	0	31.10	59.73	4.50E+03	1.00E+06	10.512	1	0	1.00E-06	-	
4	LVDS31	1	I	322	31.10	59.73	0	31.10	59.73	1.52E+04	1.00E+06	11.468	1	0	1.00E-06	-	
6	LVDS31	4	I	322	31.10	59.73	0	31.10	59.73	1.43E+04	1.00E+06	0.956	0	0	-	-	
10	LVDS31	4	I	322	31.10	59.73	0	31.10	59.73	4.61E+04	1.00E+07	10.512	25		2.50E-06	-	
11	LVDS31	2	I	322	31.10	59.73	0	31.10	59.73	4.63E+04	1.00E+07	9.557	22		2.20E-06	-	
14	LVDS31	2	I	322	31.10	59.73	0	31.10	59.73	1.00E+04	1.00E+06	10.512	6	24	6.00E-06	2.40E-05	
15	LVDS31	4	I	322	31.10	59.73	0	31.10	59.73	1.00E+04	1.00E+06	11.468	3	8	3.00E-06	8.00E-06	
17	LVDS31	1	I	322	31.10	59.73	0	31.10	59.73	9.87E+03	3.06E+05	11.761			-	-	Run canceled, mistake operator
18	LVDS31	1	I	322	31.10	59.73	0	31.10	59.73	1.00E+04	1.00E+06	12.716	1	6	1.00E-06	6.00E-06	
21	LVDS31	1	Br	279	36.10	37.45	0	36.10	37.45	6.10E+04	1.00E+07	18.708	10	58	1.00E-06	5.80E-06	
22	LVDS31	4	Br	279	36.10	37.45	0	36.10	37.45	5.56E+04	1.00E+07	17.460	14	80	1.40E-06	8.00E-06	
24	LVDS31	2	Br	279	36.10	37.45	0	36.10	37.45	5.41E+04	1.00E+07	16.504	17	148	1.70E-06	1.48E-05	
27	LVDS31	2	Ni	265	42.20	26.58	0	42.20	26.58	5.65E+04	1.00E+07	20.757	5	141	5.00E-07	1.41E-05	
28	LVDS31	4	Ni	265	42.20	26.58	0	42.20	26.58	5.65E+04	1.00E+07	21.713	0	53	-	5.30E-06	
30	LVDS31	1	Ni	265	42.20	26.58	0	42.20	26.58	5.71E+04	1.00E+07	22.961	1	58	1.00E-07	5.80E-06	
33	LVDS31	1	Cl	210	63.50	11.44	0	63.50	11.44	4.78E+04	1.00E+07	24.791	0	4	-	4.00E-07	
34	LVDS31	4	Cl	210	63.50	11.44	0	63.50	11.44	1.63E+04	1.00E+07	23.543	0	3	-	3.00E-07	
36	LVDS31	2	Cl	210	63.50	11.44	0	63.50	11.44	4.48E+04	1.00E+07	22.588	0	11	-	1.10E-06	
39	LVDS31	2	Cl	210	63.50	11.44	55	36.42	19.95	3.61E+04	1.00E+07	25.779	0	45	-	4.50E-06	
40	LVDS31	4	Cl	210	63.50	11.44	55	36.42	19.95	3.85E+04	1.00E+07	26.735	0	24	-	2.40E-06	
42	LVDS31	4	Si	186	76.30	7.88	0	76.30	7.88	5.85E+04	1.00E+07	27.995	0	0	-	-	

Run	Part	N°	Ion	Energy (MeV)	Range (µm)	LET (MeV./mg/cm²)	Tilt (°)	Range eff (µm)	LETeff (MeV/mg/cm²)	Flux (#/cm².sec)	Fluency (#/cm²)	Dose Totale (krad)	Events SEL	Events SET	Cross Section SEL	Cross Section SET	Remarks
43	LVDS31	2	Si	186	76.30	7.88	0	76.30	7.88	5.88E+04	1.00E+07	27.040	0	2	-	2.00E-07	
44	LVDS31	1	Si	186	76.30	7.88	0	76.30	7.88	6.13E+04	1.00E+07	26.052	0	1	-	1.00E-07	
45	LVDS31	1	Au	330	27.40	81.31	0	27.40	81.31	1.43E+04	5.00E+06	30.048	7	44	1.40E-06	8.80E-06	
47	LVDS31	4	Au	330	27.40	81.31	0	27.40	81.31	1.71E+04	2.53E+06	31.287			-	-	Run canceled, cable disconnected
48	LVDS31	4	Au	330	27.40	81.31	0	27.40	81.31	1.79E+04	5.00E+06	34.500	18	37	3.60E-06	7.40E-06	
51	LVDS31	4	Au	330	27.40	81.31	47	18.69	119.22	1.06E+04	2.00E+06	38.315	7	10	3.50E-06	5.00E-06	
52	LVDS31	1	Au	330	27.40	81.31	47	18.69	119.22	1.24E+04	2.00E+06	33.863	8	13	4.00E-06	6.50E-06	
54	LVDS31	2	Au	330	27.40	81.31	0	27.40	81.31	1.68E+04	5.00E+06	33.544	11	110	2.20E-06	2.20E-05	
55	LVDS31	2	Au	330	27.40	81.31	47	18.69	119.22	1.37E+04	2.00E+06	37.360	5	33	2.50E-06	1.65E-05	
58	LVDS31	2	Au	330	27.40	81.31	0	27.40	81.31	2.08E+04	2.00E+06	39.962			-	-	Test on destrutive SEL
59	LVDS31	4	Au	330	27.40	81.31	0	27.40	81.31	2.21E+04	5.00E+06	68.553			-	-	Test on destrutive SEL

Table 6: complete table of the runs SEL and SET

During the run 58, we have verified if the part n°2 is sensitive at the destructive latchup. We observed increase consumption current by step from 19mA, 50mA, 113mA. At the last value, the part is destroy. On run 59, we tried the same test with part n°4 and we observed the same comportment. The difference between the part n°2, if it's not destroy but loss of functionality.