Executive summary: MOSFET Commercial plastic components survey (Trenchfet,...) and its SEE characterization

ATN-TN-165

Written by	Reviewed by	Approved by
EEE Parts Engineer	EEE parts Engineer	

Release date: 13/02/2023

ALTER TECHNOLOGY TÜV NORD S.A.U. CIF: A41990490. c/ Tomas A. Edison, 4,
41092 Seville, ESPAÑA. T: 34-95-446 70 50, E-Mail: info@altertechnology.com

DOCUMENT CONTROL CARD

INTERNAL REFERENCE: ATN-TN-165 **CUSTOMER REFERENCE**: n/a

TITLE:

SECURITY CLEARANCE	**INTERNAL**		**CUSTOMER**	
	Restricted	X	**Restricted**	X
	Confidential		**Confidential**	

SUMMARY:

RESPONSIBLE FOR KEEPING:

FILE (Location and title):

DOCUMENT TYPE: Word **LETTER TYPE**: Arial 11, normal, justified

CONFIGURATION MANAGEMENT	**Not applicable**	
	Internal	X
	Customer	

CHANGE RECORD

Issue / Revision	Change date	Affected Issue / Revision	Affected chapter or page / Change description
ATN-TN-165 Ed. 1	Release date		

ALTER TECHNOLOGY TÜV NORD S.A.U. CIF: A41990490. c/ Tomas A. Edison, 4,
41092 Seville, ESPAÑA. T: 34-95-446 70 50, E-Mail: info@altertechnology.com

TABLE OF CONTENTS

1 OBJECTIVE AND INTRODUCTION

The aim of this document is to provide the Executive Summary in the frame of ESA contract 4000135250/21/NL/GLC/ov

2 MAIN FINDINGS

One of the main findings during the development of this task is current MOSFET trends in space applications, based on three pillars: search data in DoEEEt platform, data from orders and direct answers from the customers. This preliminary study confirms the need to have radiation data on specific MOSFETs or MOSFETs technologies that allow users to make the designs more flexible in lower quality level projects, or when the performance needs of the system are not covered by the current space market. We need to highlight that the main applications are mainly power distribution and switching; key parameters are voltage, current capability and RDSon, along with some others that are more specific, mainly related to switching characteristics or capacitances. It is also remarkable the fact that some users stress out the fact that it is difficult to find MOSFETs for New Space or lower quality level projects (such as Class 3 projects)
We would like to highlight that during this study, Alter Technology has been able to find out that several companies are working in the development of COTS rad hard MOSFET solution. Some of them are still in a very preliminary design phase and thus information can not be revealed.

Another important aspect, that was faced during the contract is the semiconductor industry lead times. For example, due to their nature of the components and the latest updates in ECSS-Q-ST-60-13 automotive MOSFETs were considered. This is due to the fact that automotive components could be easily used in some Class 3 project with a low cost, and if radiation data was available, it would be easier for space users to select non space qualified MOSFETs. However, due the very long lead times it was not possible to use automotive components as much as it was desired.

In terms of the radiation testing, the de-capsulation process needs to be performed with and extremely careful process. One of the selected components had a weak remarkable weak construction and the de-capsulation process damaged the component. The other three components were successfully de-capsulated

In terms of schedule it is also important to remark the availability of the irradiation facilities. In the frame of this contract no problem has been encountered because a thorough scheduling of the testing activities has been performed. However, it is true that irradiation facilities are loaded and it is usual that several months of wait are needed.

Finally, in terms of irradiation results these are the main findings:

- **PMPB85ENEAX**: The MULTI-PURPOSE SILICON DMOS RF FET PMPB85ENEAX demonstrated no good SEE hardness under full conditions defined in test plan ATN-RP-490 Iss. 1. No SEB or SEGR were observed. No gate degradation was observed during irradiation or during PIGS test. However, increase of drain leakage current has been observed for all runs and all bias conditions:
  For SN5, two successive runs were performed with Krypton ion with increase drain voltage: 20 and 30V, Ids failure level was reached at a fluence of 1.76E+05 ions/cm2 (RUN009)

ALTER TECHNOLOGY TÜV NORD S.A.U. CIF: A41990490. c/ Tomas A. Edison, 4,
41092 Seville, ESPAÑA. T: 34-95-446 70 50, E-Mail: info@altertechnology.com

For SN7, three successive runs were performed with Krypton ion with increase drain voltage: 10, 20 and 30V, Ids failure level was reached at a fluence of 7.88E+04 ions/cm2 (RUN036) with Vds=20V
The same sequence of three Krypton irradiation runs with increasing drain voltage, was repeated on SN6 and failure level was reached during the third run (RUN038) with Vds=20V at a fluence of 7.92E+04 ions/cm2.
The degradation observed is gradual and for all drain voltages. However, higher drain voltages show more degradation. Degradation is attributed to localized dose deposition by ions in the trenches.
Successive runs were performed at lower LET with Chromium ion (Cr). On 3 parts three successive irradiations runs were performed with increasing drain voltages: 10, 20 and 30V. As with Krypton we observe a gradual increase of leakage current, but the current increases less. The Ids failure is only reached during the third irradiation run at the voltage of 30V at a fluence of 1.39E+04 ions/cm2 and at the beginning of run, for SN9 and SN4 respectively (irradiation runs 31 and 34)

- **FDD8896**: The 30V N-CHANNEL POWER TRENCH MOSFET FDD8896 demonstrated no good SEE hardness under full conditions defined in test plan ATN-RP-491 Iss. 1. No SEB or SEGR were observed. No gate degradation was observed during irradiation or during PIGS test. However, increase of drain leakage current has been observed for all runs and all bias conditions:
  For SN2, at Vds=15V and Krypton ion, Ids failure level was reached at a fluence of 8.62E+04 ions/cm2(RUN001).
  For SN3, three successive irradiation runs were performed with Krypton with increasing drain voltages: 5, 10, and 15V. Ids failure level was reached at the beginning of the third run (RUN005).
  The same sequence of three Krypton irradiation runs with increasing drain voltage, was repeated on SN5 and failure level was reached during the third run (RUN008) with Vds=15V at a fluence of 8.25E+04 ions/cm2. The degradation observed is gradual and for all drain voltages. However, higher drain voltages show more degradation. Degradation is attributed to localized dose deposition by ions in the trenches.
  Successive runs were performed at lower LET with Chromium ion (Cr). On 3 parts four successive irradiationsruns were performed with increasing drain voltages: 5, 10, 15, and 20V. As with Krypton we observe a gradual increase of leakage current, but the current increases less. The Ids failure is only reached during the fourth irradiation run at the voltage of 20V at a fluence of 1.09E+05 ions/cm2, 6.00E+03 ions/cm2, 2.97E+05 ions/cm2 for SN6, SN7, and SN8 respectively (irradiation runs 21, 25, and 29).
  Four additional runs were performed on SN10 with a low LET ion (Carbon, C), with increasing voltages: 5, 10, 20 and 30V. We can still see a gradual increase of drain leakage, but it is very small even for the highest applied drain voltage of 30V. At the end of the last irradiation (run 44), Ids is still lower than 1 uA.

- **FDC608PZ:** The 2.5V P-CHANNEL POWERTRENCH MOSFET FDC608PZ demonstrated good SEE hardness under full conditions defined in test plan ATN-RP-492 Iss.1. Additional tests were performed in order to apply other irradiation stress conditions. The behaviour during the irradiation test was the following: no SEB or SEGR were observed. No gate degradation was observed during irradiation or during PIGS test. However, increase of drain leakage current has been observed for all runs and all bias conditions:

For SN4, four successive runs were performed with Krypton ion with increase drain voltage: -5, -10, -15 and -20V. Ids failure level was not reached at any fluence. A slightly decreasing trend of I_D was observed during the runs just after a peak when the drain voltage was being changed.

For SN2, SN3, SN5, SN7 and SN8, one run was performed with Krypton ion with a drain voltage of -20V. Ids failure level was not reached at any fluence. No anomalies were detected. Successive runs at MAXIMUM FLUX were performed with Krypton ion with a drain voltage of -20V on SN4, SN2, SN3, SN5, SN7 and SN9. Only for the case of part with S/N R5, increasing I_D and I_G currents were observed beyond the first quarter of the run time, and the failure level for I_{ds} current was exceeded.

Additional runs at MAXIMUM LET were performed with Xenon ion with different drain voltages on SN4, SN2, SN3, SN7 and SN9, to obtain more irradiation data. Only for the cases of part with S/N R4 and SN9 with a drain voltage of -20V (RUN 22 and RUN29, respectively), increasing I_D and I_G currents were observed beyond the first quarter of the run time, and the failure level for I_{ds} current was exceeded at the end part of the run.