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A new Laser Source for SEE Test

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1. INTRODUCTION

Today Single Event Effect (SEE) characterization of electrical, electronic, and electromechanical (EEE) components is carried out at heavy ion and proton facilities. In recent years however, SEE laser test systems have become available to augment irradiation tests performed at particle accelerators. Laser SEE tests are useful for component screening purposes and also in conjunction with EEE component hardening efforts (e.g. by detection of sensitive nodes). It has been demonstrated that the pulsed laser technique can reproduce SEEs in most EEE components [1-9]. The test method is also less costly than irradiation tests carried out at particle accelerators.

A new laser source for SEE test has been implemented in Spain. In this paper the laser facility and some of the work performed there is presented. The Sensors and Instrumentation Group of the Complutense of Madrid University has developed a system to reproduce the damage on electronic devices with the LASER facility, as in space environment.

2. LÁSER FACILITY

The system is based on a femtosecond pulsed laser source. The laser system is flexible with the following parameters during laser SEE irradiation tests: wavelength, pulse width, spot size and pulse energy. Typically for SEE laser test facilities, the pulse width and wavelength are fixed parameters but, at the UCM-Spain, the wavelength is variable and can be chosen from ultraviolet (300 nm) to infrared (3000 nm) while keeping the same pulse width (80 fs). The facility is capable of performing tests both employing the SPA (Single Photon Absorption) and TPA (Two Photon Absorption) methods. There are advantages and disadvantages associated with both methods. The SPA beam spot size can be smaller but has a shallower penetration depth. In some cases, employing the SPA detection of sensitive nodes may be possible. Due to the physical mechanism of the TPA process the beam spot size is larger. However, the beam can penetrate deep into the device (usually back side illuminated) enabling detection of sensitive nodes at any depth in the device.

In addition to the opto – mechanical structures to accurately control the laser beam and spot location, a measurement system is implemented enabling synchronization of the device output signal measurement after each laser "shot" for every scan point (Fig. 1).

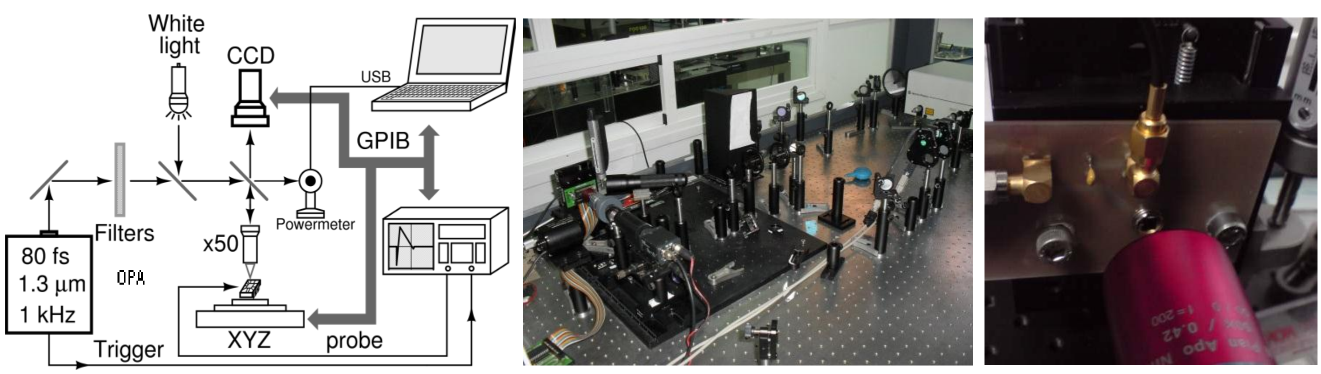

Fig. 1 Schematic and photography of the set-up implemented at the Centre of Femtosecond Multiphoton Spectroscopy (UCM).

The laser spot location may be observed with an infrared CCD camera to allow the correct placement of the laser (Fig. 2). A timing routine is programmed by LabView triggered by an external signal coming from the laser (Fig. 3). This timing routine is sometimes necessary to ensure you have time to read the device output signal (analog or digital) before the next pulse of energy arrives to the device (the pulsed laser has a frequency of 1 kHz). Sometimes it is necessary to block the laser source by means of shutters that are also synchronized with LabView, to ensure a non-stacked device response. After each laser "shot" the device is moved to the next scan point by means of a motorized xyz stage with 0.1 µm of resolution. Thus, we can perform a complete study of the device, both in two or three dimensions. Sample pictures of the laser typical output data are illustrated in Figs (4-6).

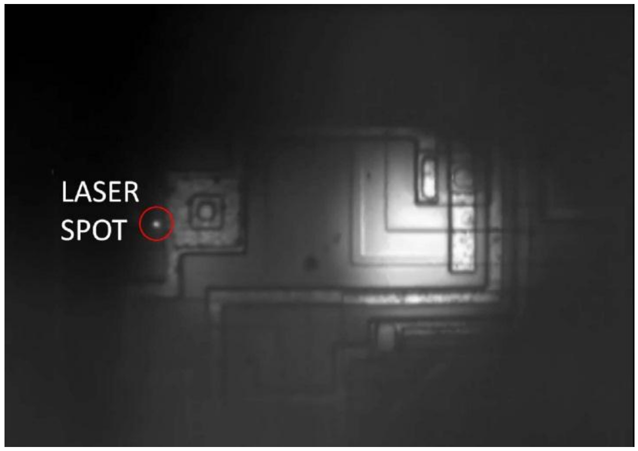

Fig. 2. Microphotography of the LM124 integrated circuit. LASER spot is located in one of the transistors at the input stage.

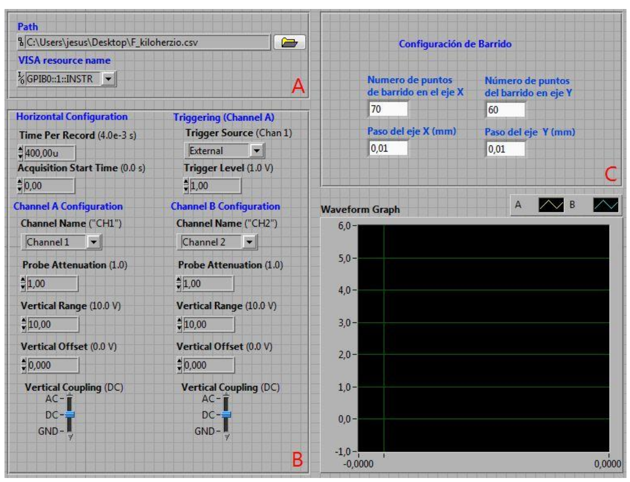

Fig. 3. GPIB protocol is synchronized with "Labview" (Fig. 1).

3. DATA COLLECTION AND REPRESSENTATIVENESS

The production of an electronic device failure is the initial step for the further study of the behaviour, error mitigation or protection of the device against these events of particles. The laser becomes a complementing tool to evaluate the radiation tolerance of the electronic devices. The advantages of the system are both, the availability to carry out the tests avoiding the inconvenience of a long wait and limited timeframe and the repeatability in a safe environment.

Once the laser configuration has been chosen the system is very useful to make comparisons between the parameters that can affect the device performance: the electronic configuration, the bias polarization, the design process, the mitigation techniques (hardware or software) and many other processes related to radiation hardness assurance. One of the important advantages of the laser test system is identification and sensitive nodes and generic device sensitivity while modifying device and laser parameters.

The data presented in Fig. 4 are showing the results of laser and heavy ion irradiation on the LM124 operational amplifier device. The results obtained by laser irradiation are equivalent to those obtained by heavy ions in a particle accelerator.

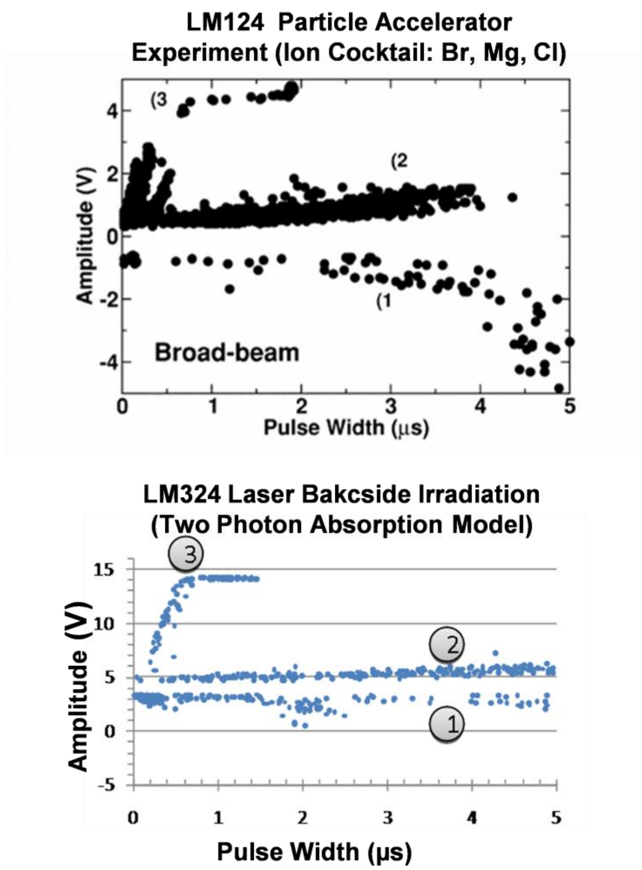

Fig. 4. Comparison between heavy ions in a particle accelerator [8] and laser irradiation in the UCM laser facility.

Fig. 5 shows TPA technique allows the injection of charge at any position depth of the device being able to discover all the sensitive nodes. A back-side irradiation of the LM111 voltage comparator plastic package device was done with 1300 nm laser wavelength. After the device entire scanning an output map shows the sensitive area where the laser shot has produced damage at the output of the device. Comparing both front-side and back-side TPA, employing the back-side approach there are no sensitive nodes masked by metallization layers even with very low energy. However, the same front-side irradiation of the LM111 ceramic package device is not able to detect the entire sensitive area because it is covered by a metal layer. These figures clearly show that employing backside irradiations with the focused position at the desired depth, there is not sensitive nodes masked by any metallization layer.

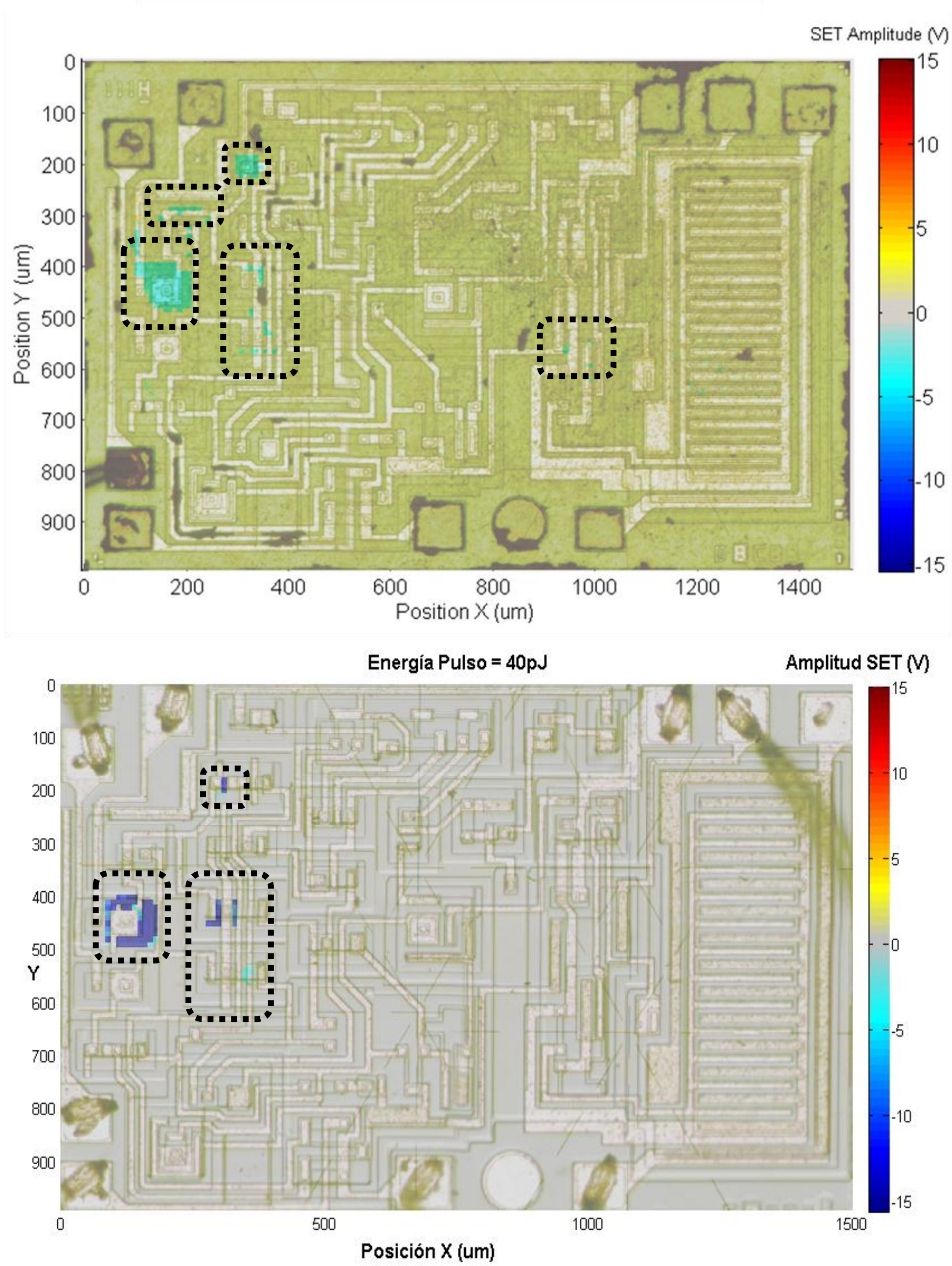

Fig. 5 . Comparison of back-side (up) and front-side (bottom) laser test of the LM111 with TPA.
Wavelength = 1300 nm, pulse energy = 50 pJ, pulse width= 80 fs, spot size = 1.5 μm^2.

A new form of data presentation allows comparing the sensitive nodes at a glance. The TPA method enables the generation of a 3D efficiency matrix for a device [8]. Fig. 6 is a sensitive map plotted after a complete LASER scan for the LM124

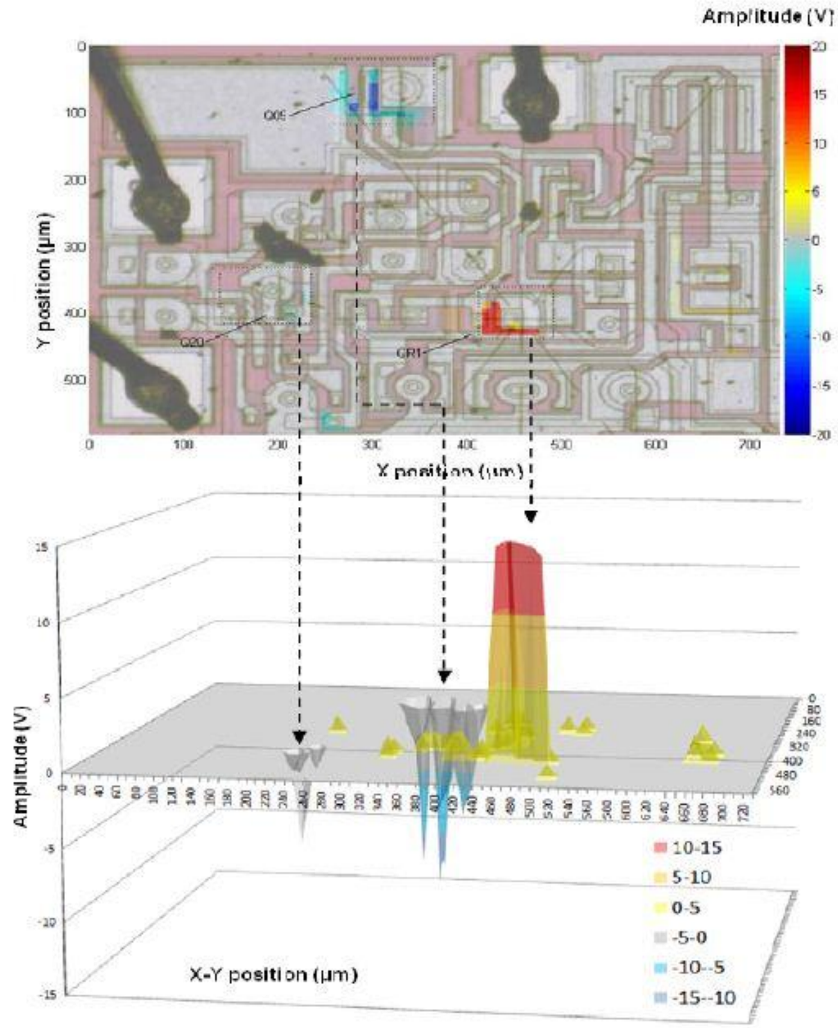

Fig. 6 Sensitive maps after a complete LASER scan over the LM124. 2D view (up) and 3D view (bottom) data representation.

The next fig. 7 shows the plot of the laser screening for a cost SRAM. The pulsed laser has pointed out the block cells in use, once again the sensitive nodes. The laser system is able to induce a latch-up in the device controlling the pulse energy, as the same that occurs with heavy ions. The number of single events upset occurring after each laser shot has been added in the representation.

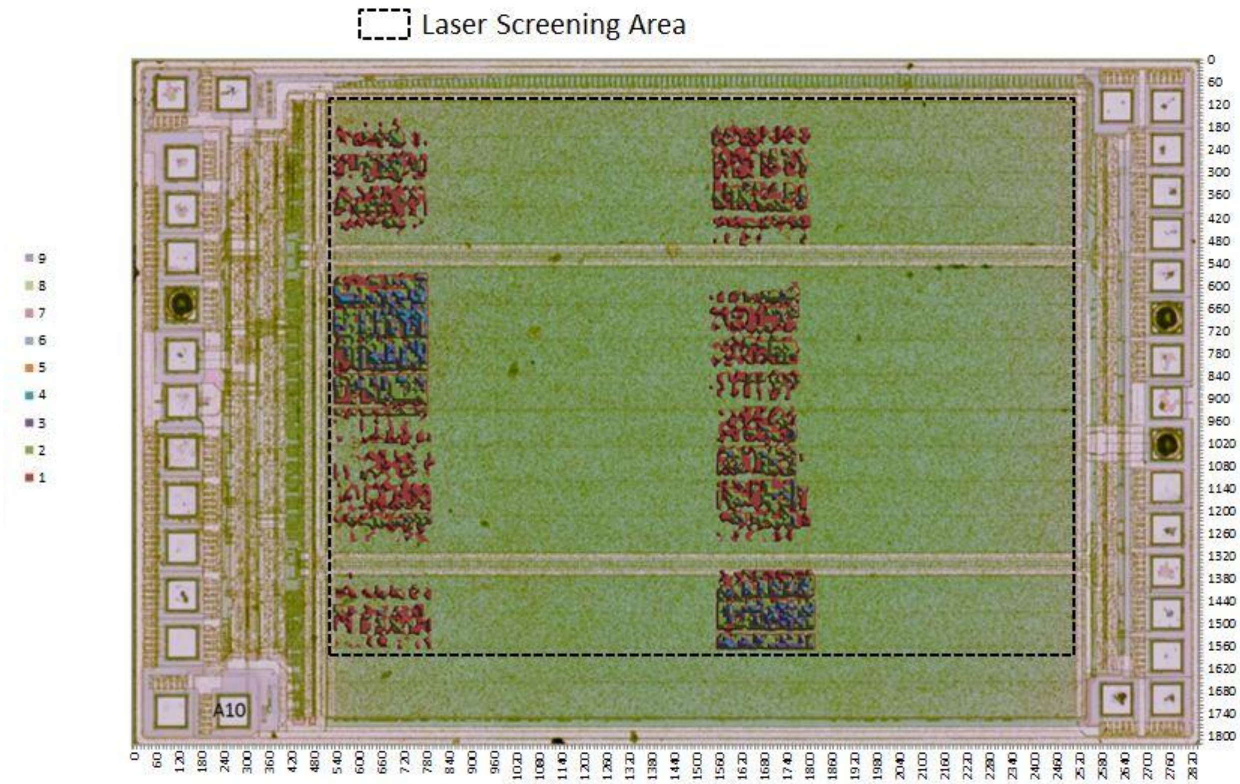

Fig. 7. Representation of the Alliance cost SRAM screening map. Sensitive memory cell blocks have been detected

4. CONCLUSION

The Sensors and Instrumentation Group of the Complutense University of Madrid has developed a system to reproduce the damage on electronic devices, as in space environment. The laser is a complementary evaluation tool compared to the particle accelerator that serves for evaluating devices under ionizing radiation. The results from this work indicate that the pulsed laser charge collection can be used as a reference point to establish when the laser parameters could ensure the same device response in a certain space environment.

Apparently could be an issue the fact that sometime there are metal layers that the laser can not to across. Take into account not all of the heavy ions are able to across an entire device, from a point of view of device designer could be an option if the device is designed without internal metal layers for ensuring a good characterization after applying a mitigation technique.

5. REFERENCES

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