Single Event Effect Studies on the 180 nm UMC process with the GSI Heavy Ion Microprobe

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Introduction

For the future experiments at the new FAIR accelerator facility radiation damages to electronic components are an important issue. In this regard, the ASIC design group of the GSI Experiment Electronics department has launched a research project for the characterisation of Single Event Effects (SEE) on the 180 nm UMC process, including the development of an ASIC called *GRISU*[1].

SEE is the term for effects in semiconductor devices triggered by a single ionising particle in contrast to effects triggered by a damage accumulated by many particles. A good choice to test these effects is the irradiation with heavy ions. Several irradiation tests with different heavy ions were performed at the X6 testing site. The beam was widened so that the entire *GRISU* chip has been irradiated at the same time[1].

First results showed that some digital storage cells were more sensitive to SEU than expected from simulation. To clarify and understand this unexpected high sensitivity the *GRISU* chip was irradiated with the sub-micron resolution beam of the heavy ion microprobe at the X0 testing site.

Single Event Effect Studies with a Single Heavy Ion Hit Microprobe

Briefly, the microbeam is situated at the end of the GSI heavy ion linear accelerator. The ions entering the microbeam line through object slits are focused down to a focal spot of about 500 nm in diameter by means of magnetic quadrupole lenses. Deflecting magnets, situated in front of the focusing lenses, are used to move the beam spot in the focal plane[2].

In May 2009 a *GRISU* chip was irradiated with a carbon microbeam with an energy of 4.8 MeV/u. This corresponds to a Linear Energy Transfer (LET) of approximately 2.25 MeV cm^2 mg^{-1}. In total five different test structure areas were irradiated. The ASIC has been scanned over $80 \times 80\,\mu\mathrm{m}^2$ for the first three SEE tests and $20 \times 20\,\mu\mathrm{m}^2$ for the last two tests.

As an example of these test results an inverter chain of different transistor sizes is depicted. The layout overlay picture of the irradiated area and the observed Single Event Transient (SET) events are shown in Fig. 1. Each red circle represents a SET event. The circle centre points to the measured origin by the microbeam DAQ system whereas the radius represents the 3σ position accuracy of 612 nm. For inverter chain no. 4 and 5 SET events were measured for NMOS transistors (lower layout part in each row) as well as for PMOS transistors (upper layout part). However for inverter chain no. 6 and 7 SET hits were only measured for NMOS transistors. The explanation for this is that the node capacitances of these PMOS transistors are larger compared to the smaller NMOS.

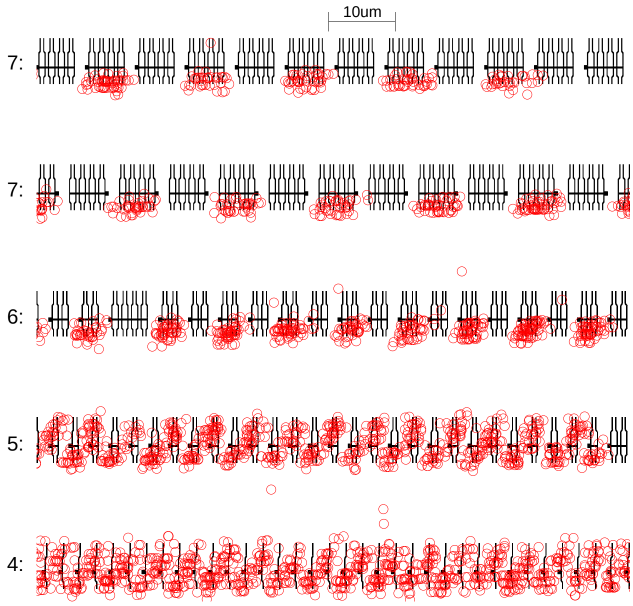

Figure 1: Overlay of inverter chain test structure layout and position of SET events. The radius of the circle is equivalent to 3σ position accuracy or approx. 600 nm.

Results

The first measurement showed that the microbeam setup is a powerful tool for spatially resolving SEE investigations. However the number of events for a closer statistical analysis as well as the resolution must be increased for closer investigations of the 180 nm process, especially for the study of some special memory structures on the *GRISU* chip.

References

[1] S. Löchner, "Radiation Studies on the UMC 180 nm CMOS Process", GSI Scientific Report 2009

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