



UMC 0.18 μm radiation hardness studies

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Reminder: GRISU project



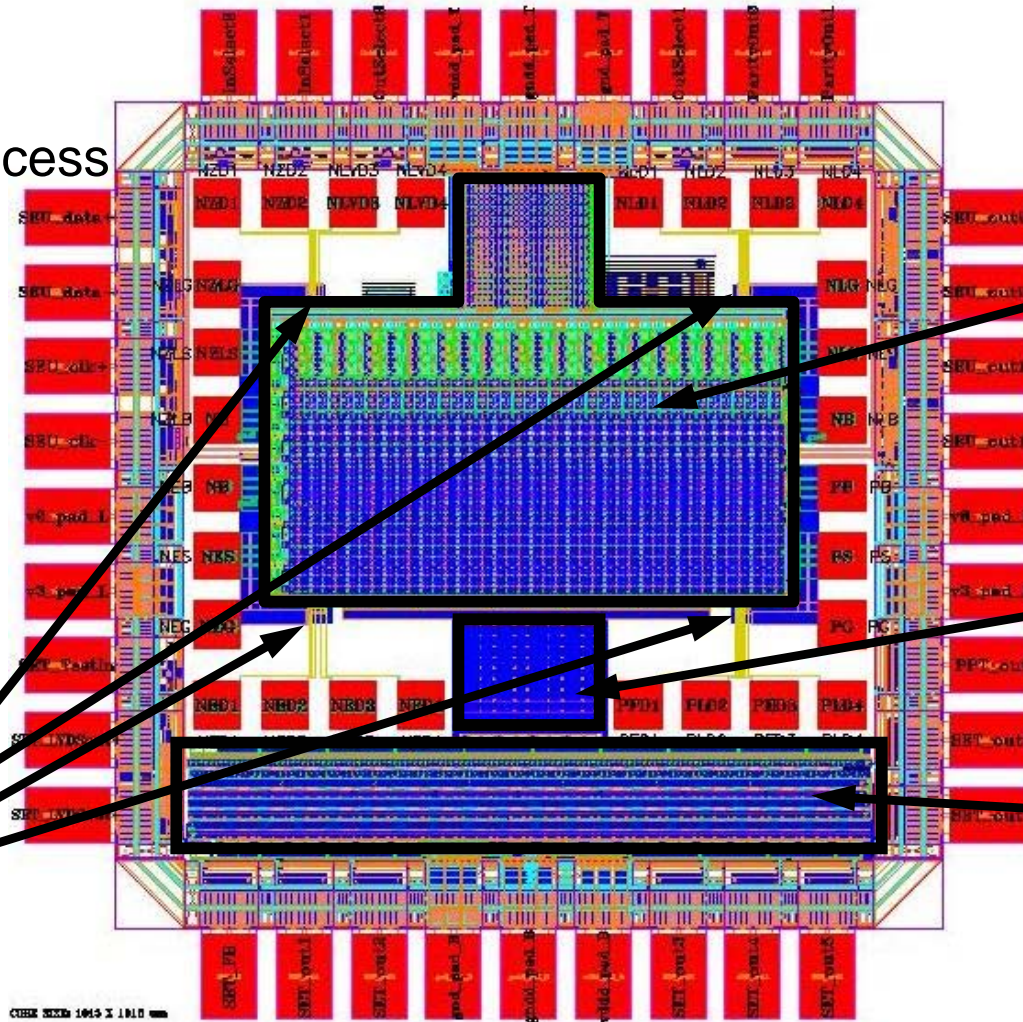
Project objectives: Characterisation of UMC 0.18 μ m CMOS process concerning :

- Vulnerability against Single Event Effects (SEE), especially Single Event Upsets (SEU) and Single Event Transients (SET)
 - SEU cross section for different Flip-Flop designs and layouts
 - SET sensitivity of the UMC 0.18 μ m process
 - Critical Linear Energy Transfer (LET_{crit})
- Single Transistor measurements
 - Comparison of transistor models by simulation
 - Total Ionising Dose (TID)
Characterisation of the UMC 0.18 μ m process under irradiation
 - leakage currents
 - threshold shifts,
 - annealing

GRISU test ASIC

GRISU chip

- UMC 0.18 μ m process
- 1.5 x 1.5 mm²
- 64 pads
 - 28 core pads
 - 36 pads



Test structures for SEU measurements

Ring oscillator for TID / SEU measurements

Test structures for SET measurements, Q_{crit}

Test structures for TID measurements

Low Energy testing site

- Installation of a test facility for ASIC irradiation with heavy ions at X6 cave at GSI (in cooperation with bio physics group)
- Beam monitoring via ionisation chamber
- Dosimetry setup available
- Irradiation of DUT in air
- Testing parameters:
 - 11.4 MeV/u
 - LET in the range of 1...62 MeV·cm²/mg (SiO₂)
 - 10³...10¹² ions / (cm² s)
 - 50mm beam size



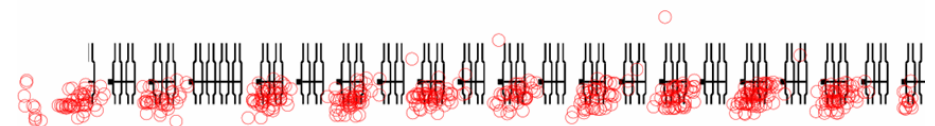
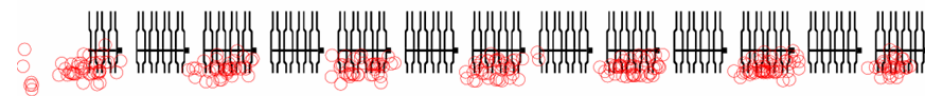
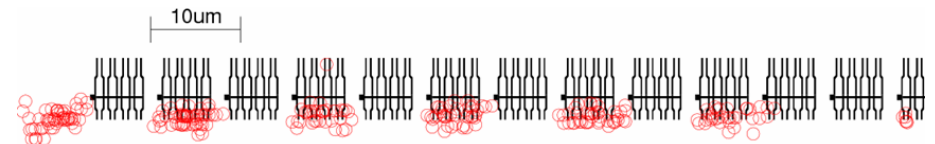
X6 cave at GSI

Micro beam testing site



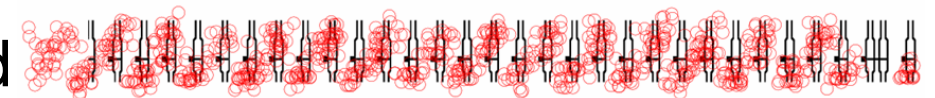
Setup of a single hit heavy ion test environment for ASIC irradiation (micro beam test line)

- possibility of a localised radiation of the DUT
- resolution: $\sim 700\text{nm}$
- scanning area:
 $30 \times 30 \mu\text{m}^2$ or $100 \times 100 \mu\text{m}^2$
- energy of ions: 4.8 MeV/u

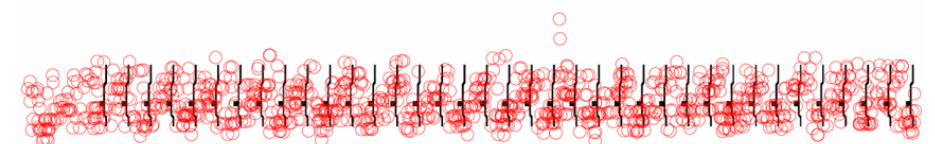


First results from Xe-132 test:

- plot shows overlay of detected ion positions (3σ) which triggered an SET and chip layout



➔ SET homogeneity map of ASIC



Total Ionizing Dose (TID) tests

- TID testing with X-rays
 - Irradiation facility at Institute for Experimental Nuclear Physics, University of Karlsruhe
 - 60keV X-ray, 100...600krad/h
 - GRISU chips tested
 - Total dose between 800krad and 2500krad(SiO_2)
 - Operating dose rate between 200krad/h and 580krad/h
 - Measurements: leakage current, threshold shift, transition times, total power consumption, annealing, ... of non-hardened digital library
- ➔ Leakage current of ESD protection diodes increased by factor of 100
- ➔ Average core current increased by factor 2 (after 1.5 Mrad)
- ➔ Transition times of ring oscillator inverters decrease (changing of NMOS / PMOS ratio)
- ➔ Good annealing performance

Work progress at GSI so far...

- ✓ Development of a UMC 0.18 μ m Test-ASIC (GRISU)
- ✓ Installation of testing site for SEE measurements
- ✓ Installation of a micro beam testing site for single ion hit measurements
- ✓ TID testing of the UMC 0.18 μ m process at Karlsruhe

Still to do:

- ✗ TID irradiation with low dose rates
- ✗ Long term test with gamma source (for example Co-60)
- ✗ Neutron test
- ✗ 3rd iteration of GRISU test ASIC:
 - Triple redundant test structures (for SEU / SET improvement)
 - Test circuits for SET suppression
 - Re-design of the DICE layout cells (decrease SEU cross-section)

➔ Right now nothing is contradicting against the UMC 0.18 μ m process

Additional Talks & Documents

Reference to further talks:

- EE-Gruppenmeeting (7.7.2008)
GRISU Statusreport
- CBM-XYTER Family Planning Workshop (5.12.2008)
UMC 0.18 μ m radiation hardness studies
- IT/EE-Palaver (20.1.09)
Untersuchung von Strahlungseffekten in anwendungsspezifischen integrierten Schaltungen (ASIC) Strahlungseffekte
- 13th CBM Collaboration Meeting (12.3.2009)
Radiation hardness studies - Update
- EE-Gruppenmeeting (29.6.2009)
GRISU Microbeam Irradiation

Link: <http://wiki.gsi.de/cgi-bin/view/EE/GRISU>



Thank you
Christian
for presenting the
status report