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"Single Event Transient"
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SET ground testing : an overview

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All the space you need

EADS astrium

Content

- Part traceability
- Application conditions
- Measurements
- Test facility
- Lessons learnt

Introduction

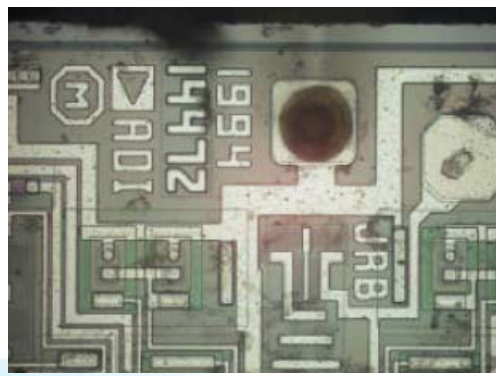
- For Single Event Transient (SET), the baseline of Radiation Hardness Assurance (RHA) approach shall be the analysis of the effect of a SET on equipment performance: it shall be demonstrated that a SET will not produce equipment out of specification.
- However, in some cases, countermeasure by design can be difficult and it can then necessary to perform SET ground testing
- Test data set shall be reliable & representative of the application(s) of concern
- Present work focuses on SET on analog integrated circuits

SET ground testing – part traceability

- Part traceability is mandatory: test what you are going to fly; Fly what you have tested

  – Same part-reference of same manufacturer may exhibit two different behaviour, for example if mask references are different.
    - Ex: OP470 mask A exhibits some Single Event Dielectric Rupture (SEDR)-like phenomena whereas OP470 mask G shows no destructive event

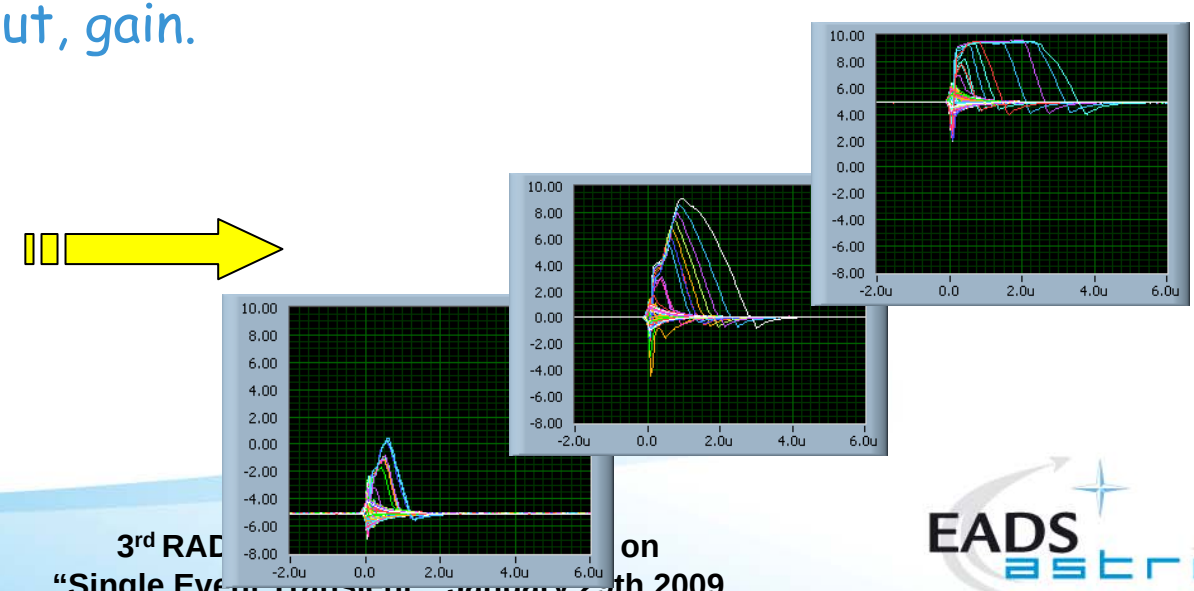
  – Record at minimum mask n°, wafer lot n°,… through die photography
    - If possible manufacturer process id.



SET ground testing – application conditions 1/3

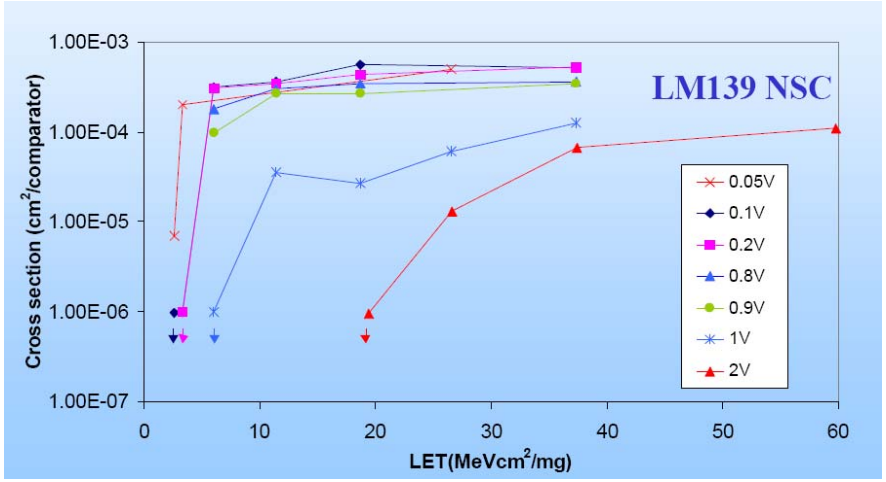
- If part aims to be used in dynamic mode, then testing in this mode is required
  - Example: 1553 bus coupler.
    - in static mode: long duration SET (>ms) could crash many 1553 messages in a frame
    - in dynamic mode: message error rate very low and not related to static results ??
- Generally speaking, SET sentitivity of linear IC's varies with Vsupply, Vin, Vout, gain.

Ex : Same amplifier with 3 different output voltages



SET ground testing – application conditions 2/3

- Comparators
  - Well known SET sensitivity increase as V_{diff} is decreasing.



- Voltage regulator or reference
  - SET (amplitude,duration) varies with external electrical configuration (Output voltage, load current, capacitor technology …).
  - A particular care to bring on SET results : suppose a voltage ref supplied at Vcc = 3.3V => some SET may raise up to such value. If this circuit is aimed to feed a FPGA core, such SET may damage the FPGA.

SET ground testing – application conditions 3/3

- Voltage regulator or reference (cont.)
  - A supply regulator used in a feed-back loop with OPA can be set in permanent oscillation when the OPA is irradiated.

- Operational amplifiers (OPA)
  - Some op amp recover on slew rate mode : in that case the worst case must be considered according to the procurement spec.
    - Ex: SR=0.1V/µs means that a 15V amplitude SET will recover in **150 µs** instead of **50µs** seen during SEE tests.
  - Opamp are built around several stages (3) mostly with internal compensation; sometime and in particular for low power opamp, middle stage may need lot of time to recover. → thoroughly analyze the internal schematic when available to explain origin of SET.

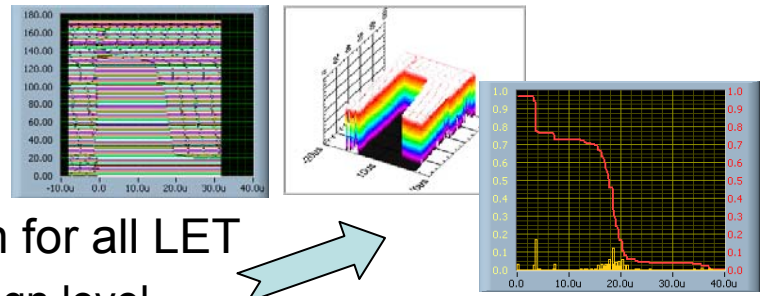
SET ground testing – measurements 1/2

- Measurements: experiment (including radiation test engineer) must be reconfigurable, in order to be able to face any type of "unexpected behaviour"

- Practical aspects to take care of
  - Oscilloscope usage : Warning :: the trigger sensitivity depends on the vertical sensitivity. Cannot detect SET under 1V when signal has 10V common mode **!**
  - The only reliable trigger is the edge trigger, all advanced trig capabilities are well suited for repetitive signal, but unfortunately not for SET (not repetitive).
  - Example on PWM : Detection system to be designed specifically and not based on oscilloscope (SET inducing a phase shift on PWM outputs)
  - Monitoring the current supply Icc with a resolution of some µA, help to understand what happen with H.I. fluence.

SET ground testing – measurements 2/2

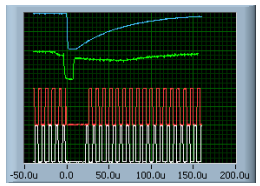
- Recommendations for SET ground testing



– Record all events at all LETs

– Derive statistics on amplitude, duration for all LET
  - This helps for part assessment at design level

– Record the time for each event, and check whether simultaneous SET has occurred on several outputs (PWM..)



– If part contains several technologies (ex: CCD clock-driver that contains digital control circuit and power MOSFET output), then performing irradiation using local shield allows to separate contributions respective to the events.

SET ground testing – test facility

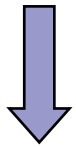
- Heavy ions
  - Heavy ions range has an effect on the SET waveform (amplitude, duration), and in a lesser extent on the SET sensitivity itself.
  - 2 heavy ions cocktails at UCL :

    (LET=34, R=43µm) and (LET=32, R=92µm).

    We use both especially to check for range effect, even on linear parts built on bipolar technologies.
  - Flux effect on part behaviour must be checked. Generally low flux is preferred (<10^3 ions/cm²/s)
- Most of the devices exhibit a LET_{th} < 15 MeV.cm²/mg
  - Are they also sensitive to proton induced SET?

SET ground testing - Lessons learnt

Testing parts as a "black box" gives "black results".



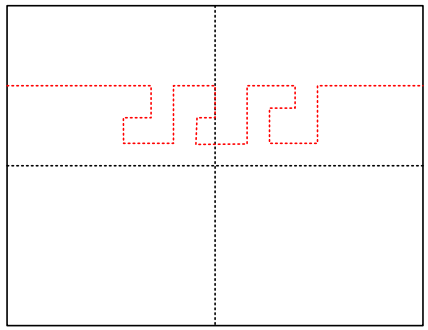
Good understanding of device internal circuits is needed before SET testing and … after to explain.

Need to test according to application

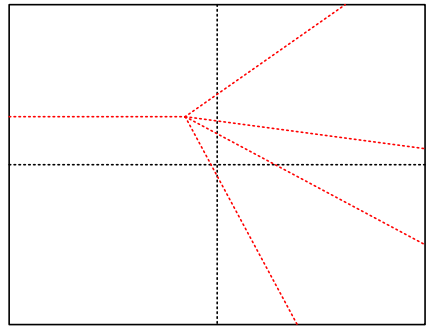
- Determination of generic SET test conditions would be very complex
  - Generic test could lead to over-design or risk underestimation

Radiation Hardness Assurance (RHA) templates are necessary; however, they shall be used with cautious, especially when function is critical for the mission.

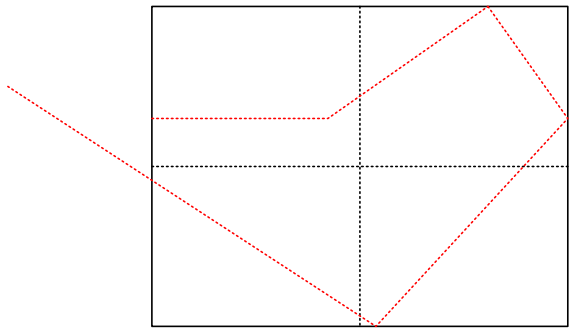
Unexplainable SET's collection



Only seen in Greece



Multiple impact SET ???



Bouncing effect, ion reppelled by device ??

Hypothesis
-Beer effect
-Pizza effect
-Any other idea !!