

**NANYANG
TECHNOLOGICAL
UNIVERSITY**

Temasek Laboratories@NTU

Integrated pulsed laser scanning microscope system at NTU, Singapore

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Space industry landscape in Singapore



COTS Devices in Space Applications

- Small satellites (micro, nano, pico, etc) => Shorter Development Time/Lower cost => COTS?
- COTS Devices for space applications:
 - High volume manufacturing => Cost/performance ratio optimization 😊😊😊
 - Most advanced technologies => Higher payload capacity 😊😊😊
 - Not designed nor qualified for space applications 😞😞😞
 - Essentially a Black-Box 😞😞😞
- Laser testing of COTS:
 - No information on design => Is the area under test relevant?
 - No international standard procedure => Is the test procedure relevant?

Strategies for laser SEE testing setup

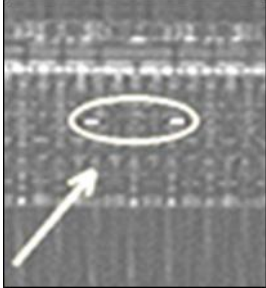
Type of System	SEE Custom/DIY	SEE Commercial
Development Time	☹️	😊
Development Cost	😊	☹️
Flexibility/Evolutivity	😊	☹️
Maintenance	☹️	😊
Legacy	☹️	😊

- SEE testing => Small market
- FA System:
 - Long Legacy
 - Various analysis capabilities
- Typical Optical FA system:
 - Microscope (Bright field or CLSM)
 - Laser Sources
 - NIR Sensor

Why not integrate SEE capabilities to standard FA system?

NTU Pulsed Laser SEE setup

1064nm CW
OBIC, LIVA



E.I. Cole (1994)

1340nm CW
OBIRCH, TIVA



P. Perdu, D. Lewis (2004)

SMU/PSU/FG

SIL lens

120 nm resolution

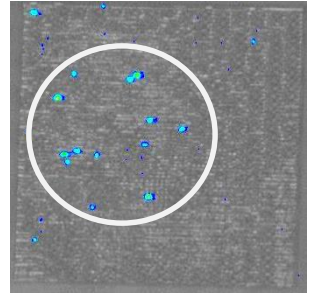
Locate opens

Locate shorts

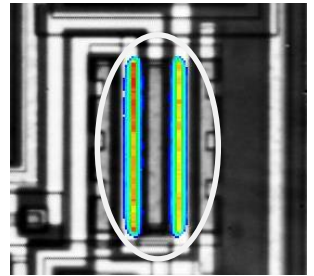
Locate signals

SEE, Fault injection

1319nm CW
LTP



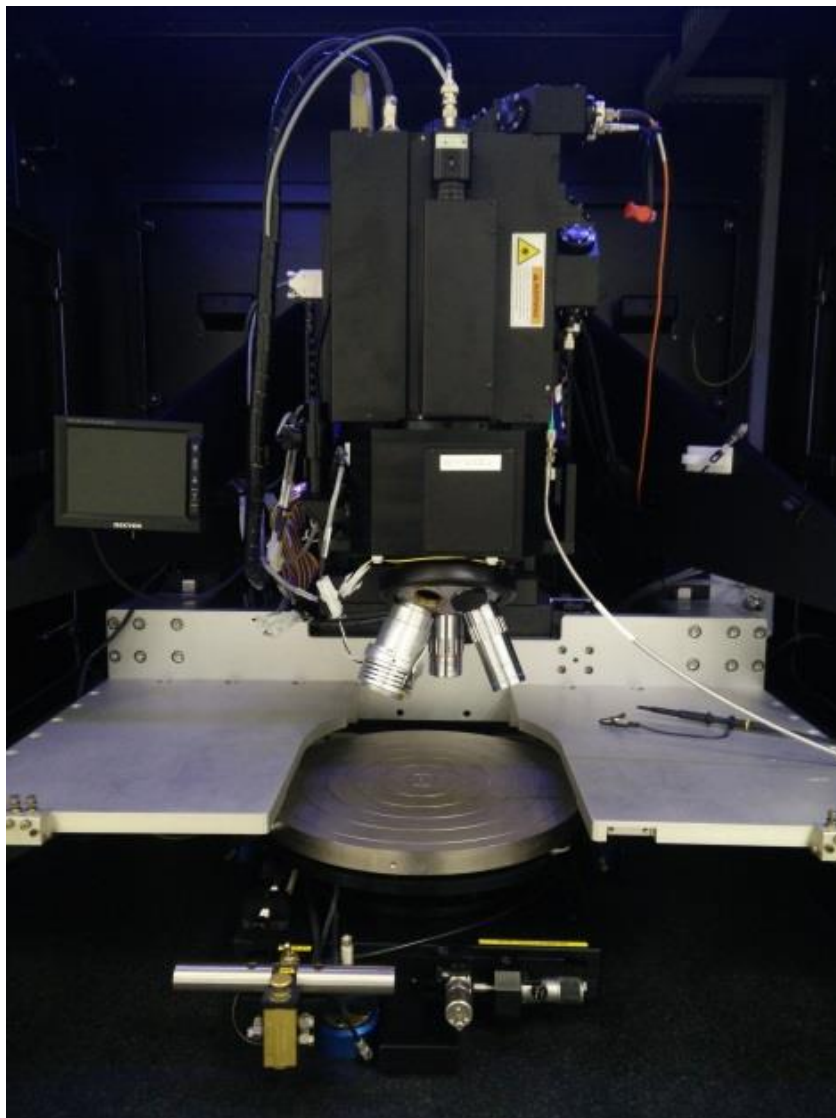
InGaAs camera
PEM



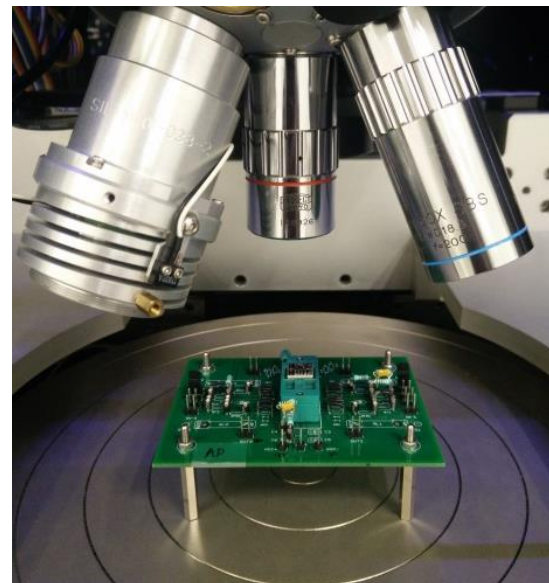
8GHz oscilloscope

1064nm Pulsed

NTU Pulsed Laser SEE setup



Parameter	Description
Wavelength	1064 nm
Pulse width (FWHM)	10 ps
Pulse energy	Up to 11 nJ (at source)
Repetition rate	Single shot to 50 MHz
Sync	Possible with DUT clk

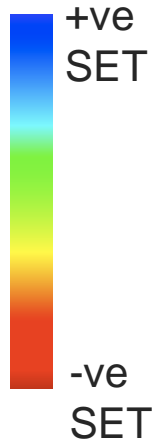
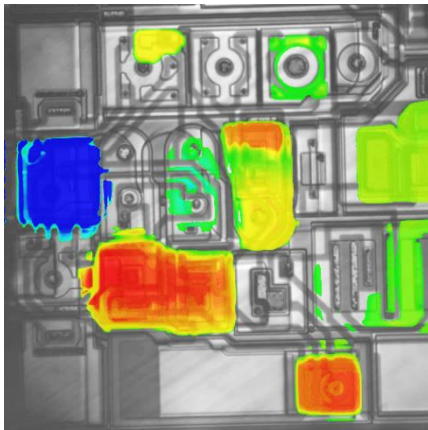


System Evaluation: Test Replication

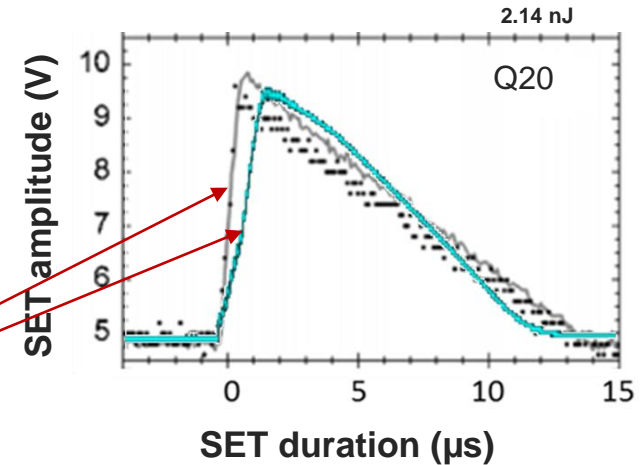
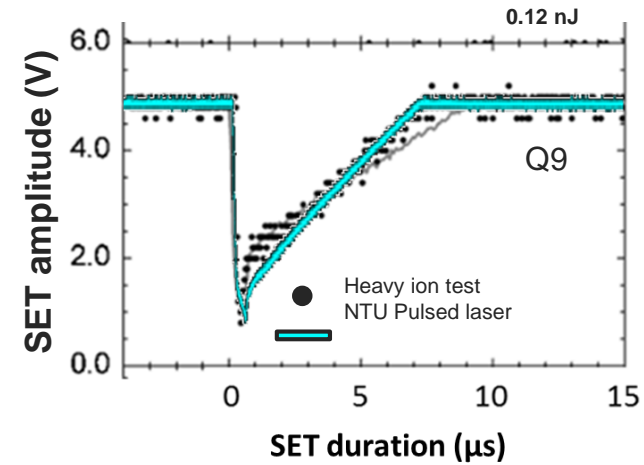
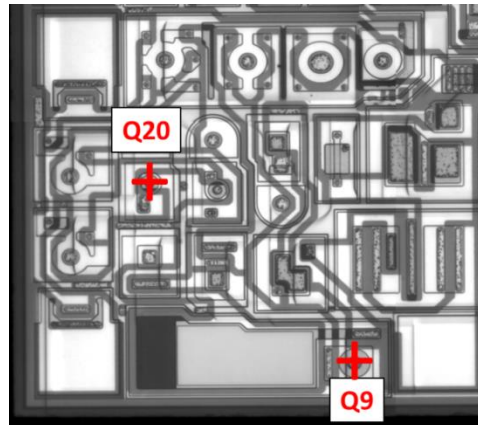
DUT: LM124 bipolar op amp

Localizing SET-sensitive area

1.51 nJ



Single point irradiation



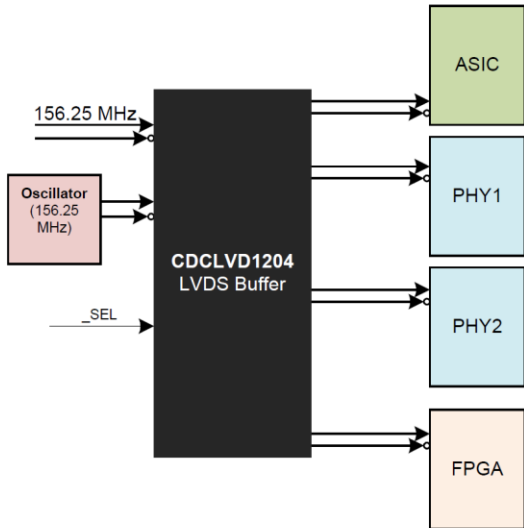
DUT?
Test Board?
Measurement setup?

EXAMPLE OF APPLICATIONS

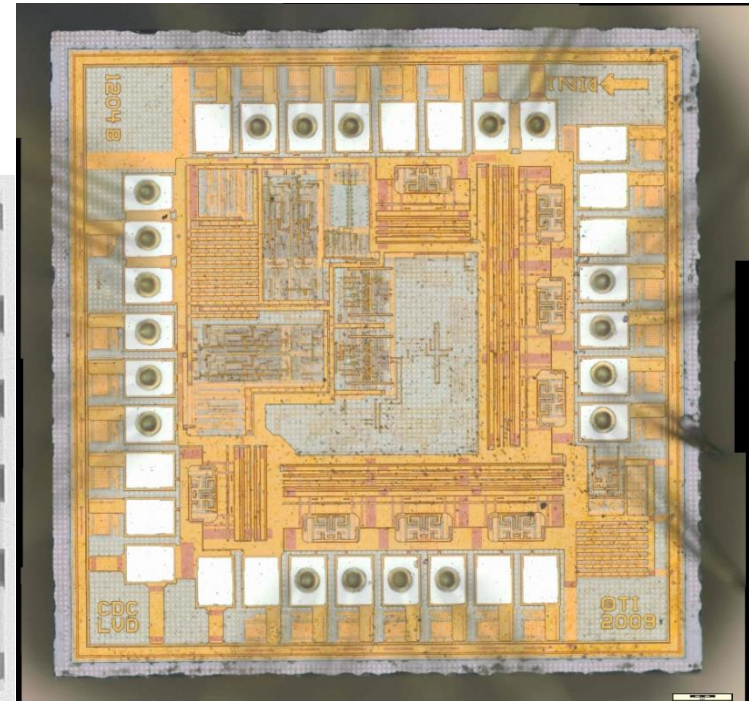
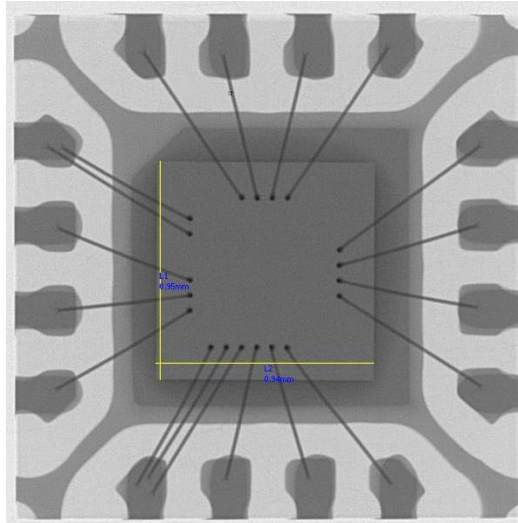
Test of LVDS Buffer



Application Example



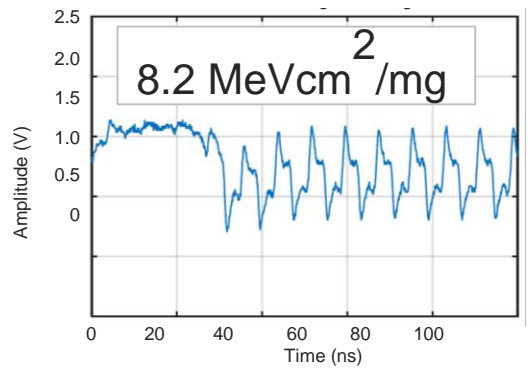
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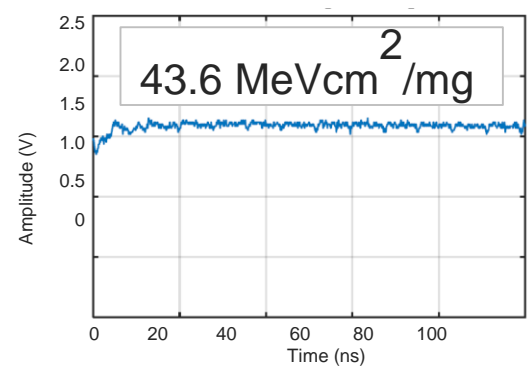
Test of LVDS Buffer: Laser vs heavy ion

Heavy ion results

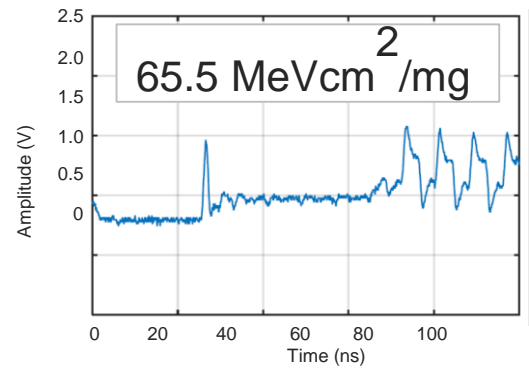
Positive SET (short)



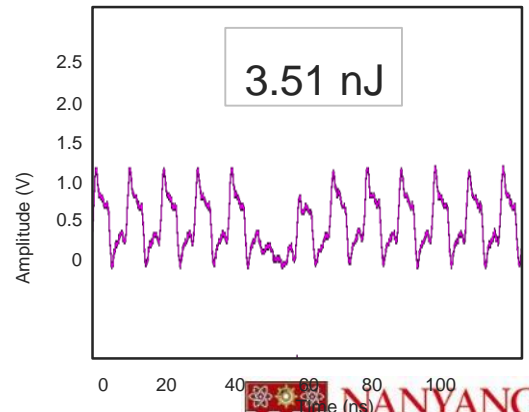
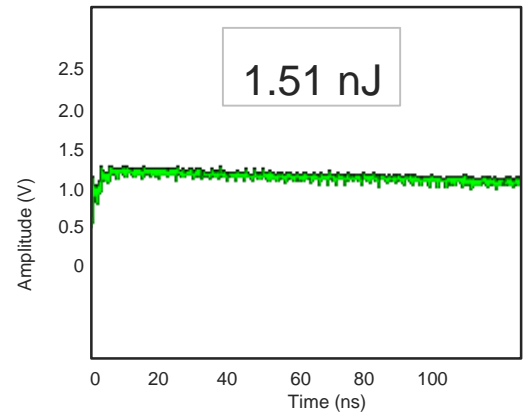
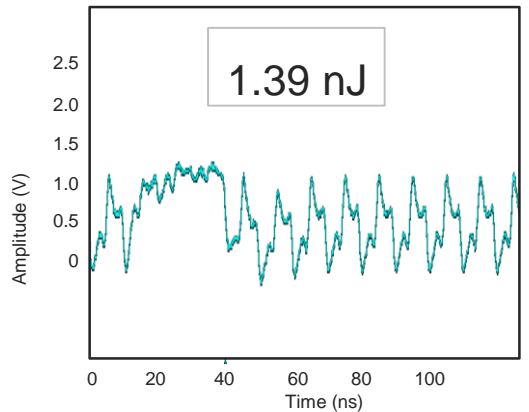
Positive SET (long)



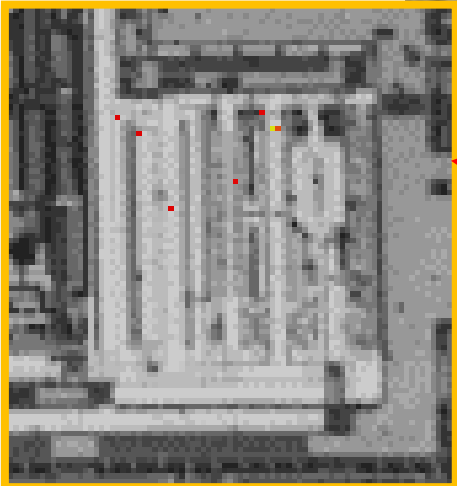
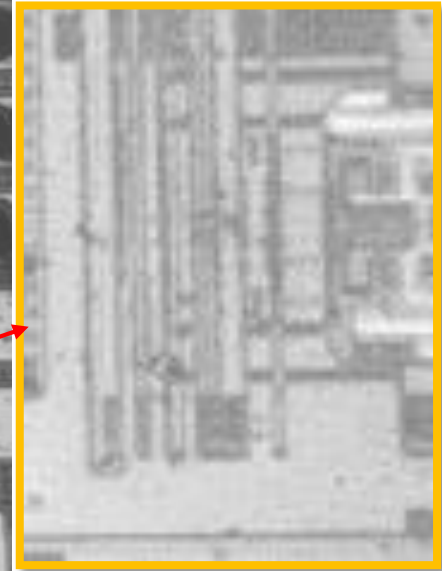
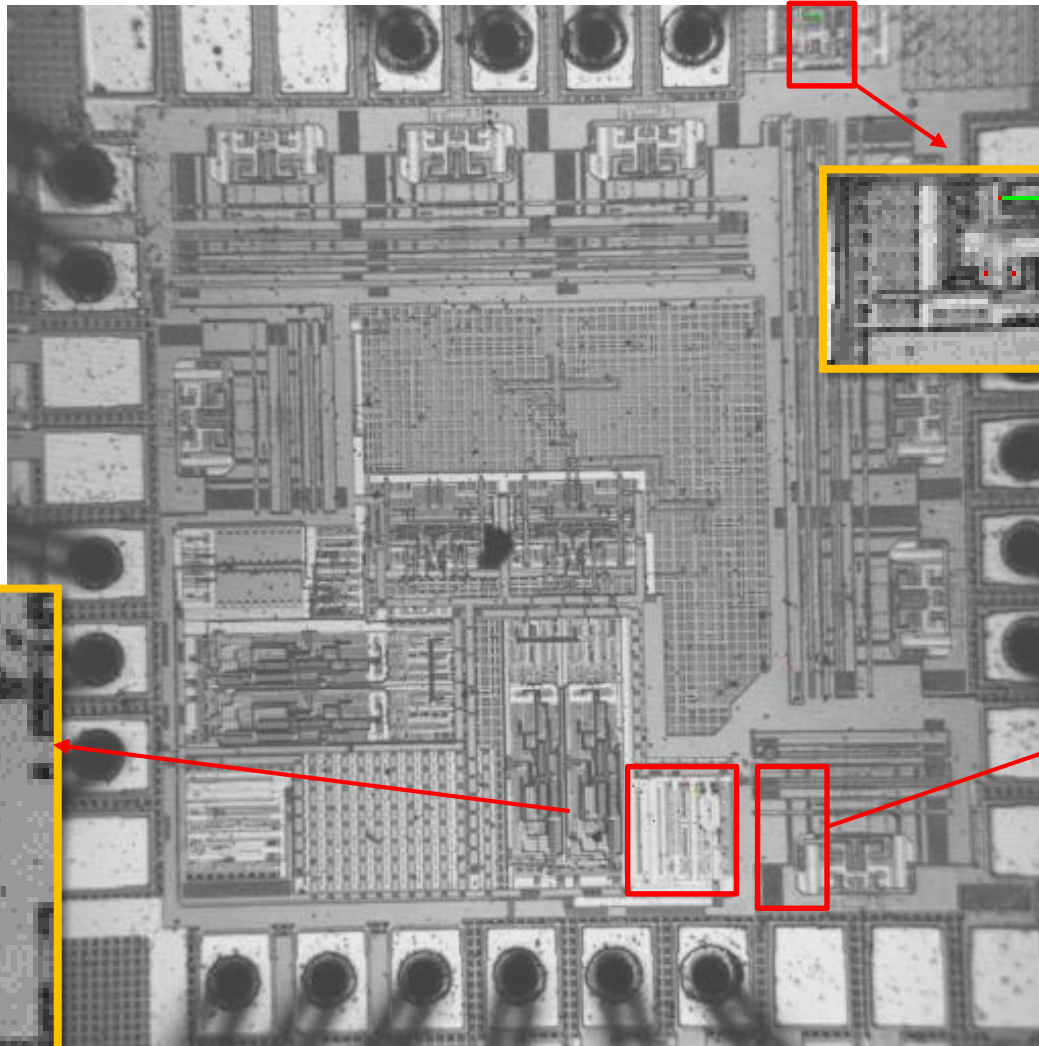
Negative SET



Pulsed laser results

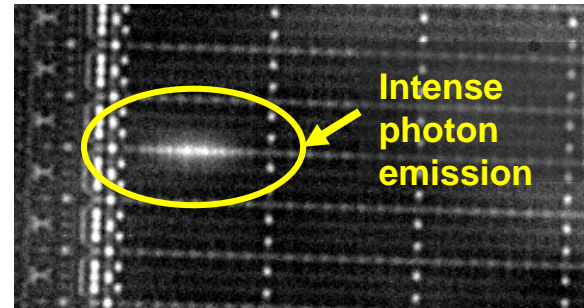
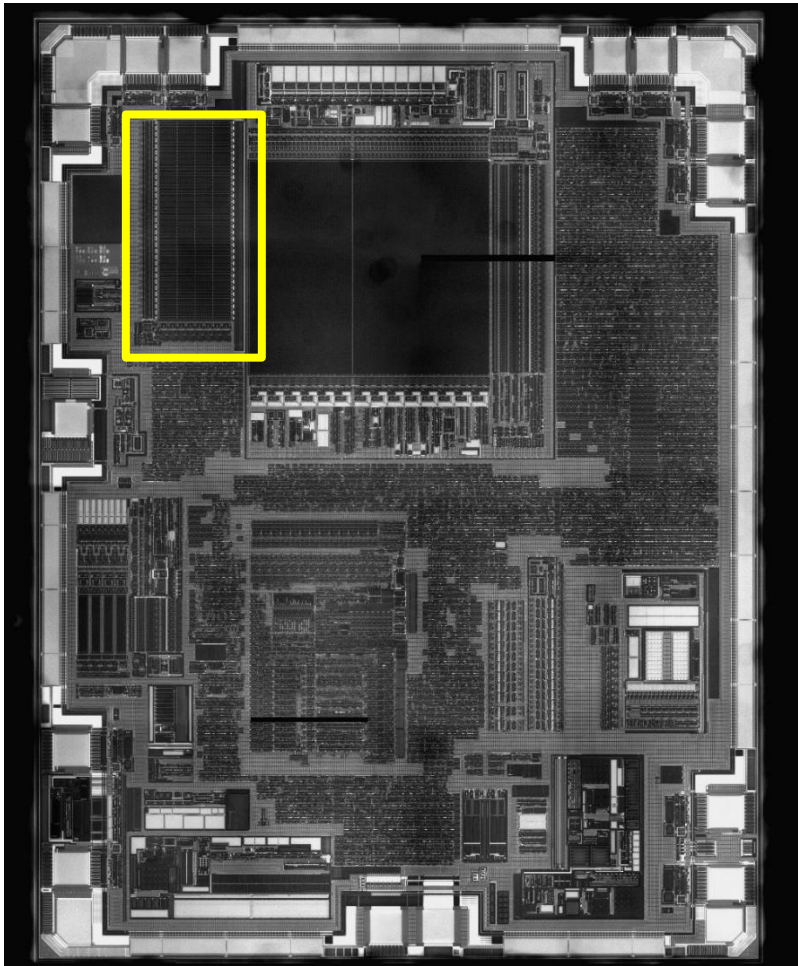


Test of LVDS Buffer

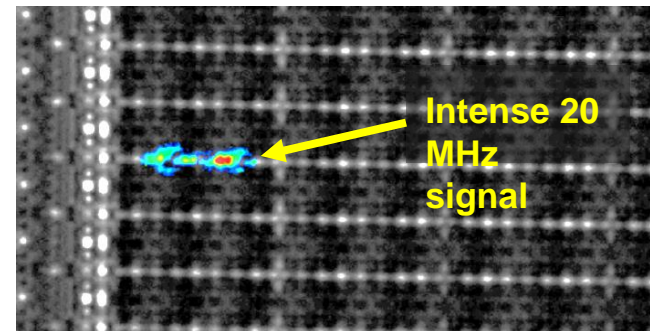


SYNERGY BETWEEN TECHNIQUES

Synergy of techniques : SEL Analysis



InGaAs camera

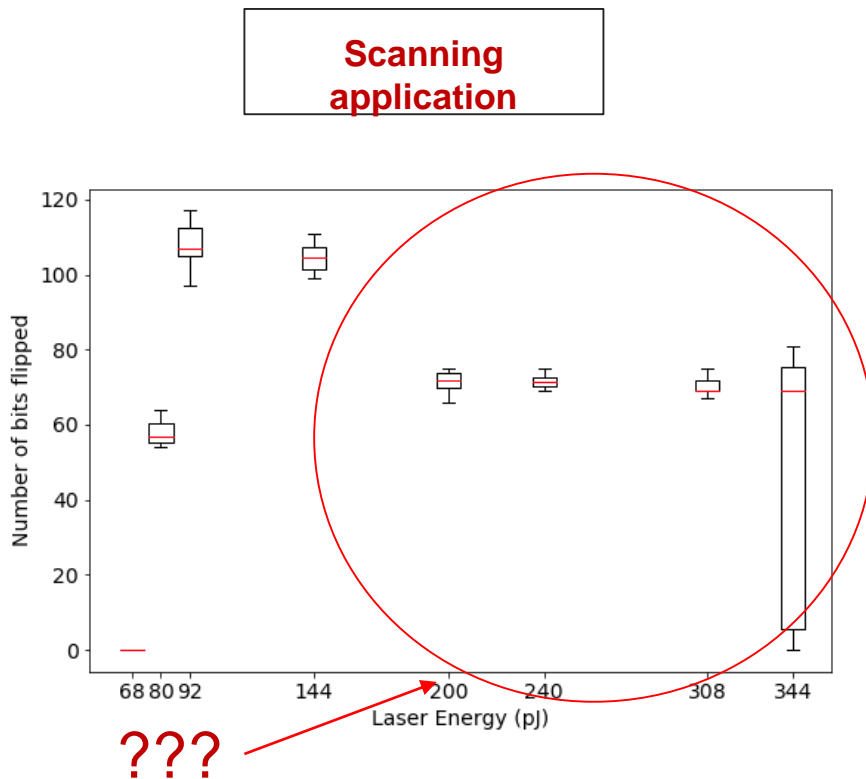


Laser Timing Probe

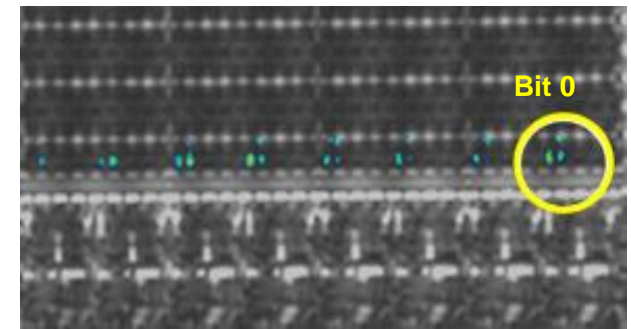
- Latch-up triggered at 90 pJ with scan at 10 kHz
- Seems to be maintained by sinking from the function generator
- Lower susceptibility with internal oscillator

[S.Chef, C.L.Gan, et al, to be presented at ISTFA 2017]

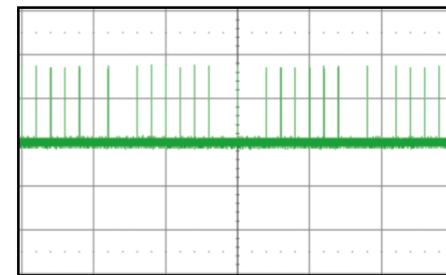
Synergy of Techniques: Identification of areas of interest



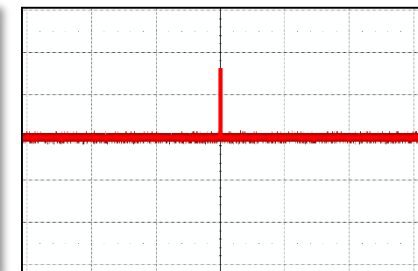
Single Bit Irradiation



Laser Probing



Irradiation at 480 pJ



Irradiation at 2 nJ

- Laser probing helps in identifying areas of interest
- Bring additional information about test procedure

Summary and conclusion

- SEE laser test system in NTU
 - Customization of a standard FA system
 - Brings multiple analysis capability
- FA optical analysis techniques can be used for
 - Additional information on the DUT
 - Perform FA during laser generated fault (SEE)
 - Improve knowledge on the way to perform laser SEE

Thank You!

