



# **Correlation of Pulsed Laser and Milli- Beam™ Heavy Ion Results for NAND Flash Memory**

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# Outline

- **Introduction/ Background**
- **Experimental Plan**
- **New Experimental Results**
- **Experimental Comparisons**
- **Conclusions**



# Broad Beam Heavy Ion Results

- On 38 beam runs, observed 52 high current events
- None less than 1 sec in duration, most 10's of seconds, or minutes
- 48 of 52 had stair-step structure characteristic of LSEL (Localized SEL)—changes in DC level
- Remaining four events appeared to have been due to bus contention

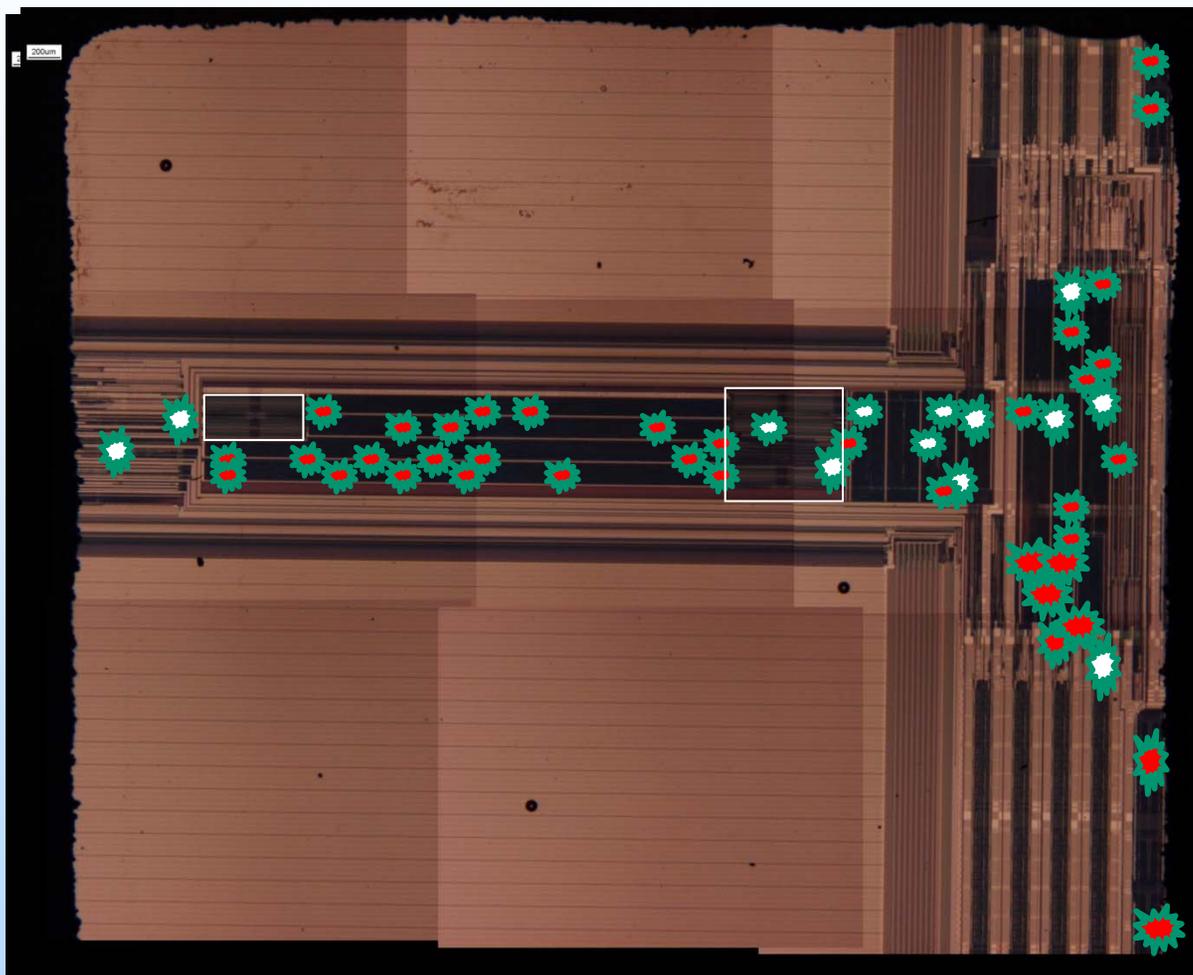


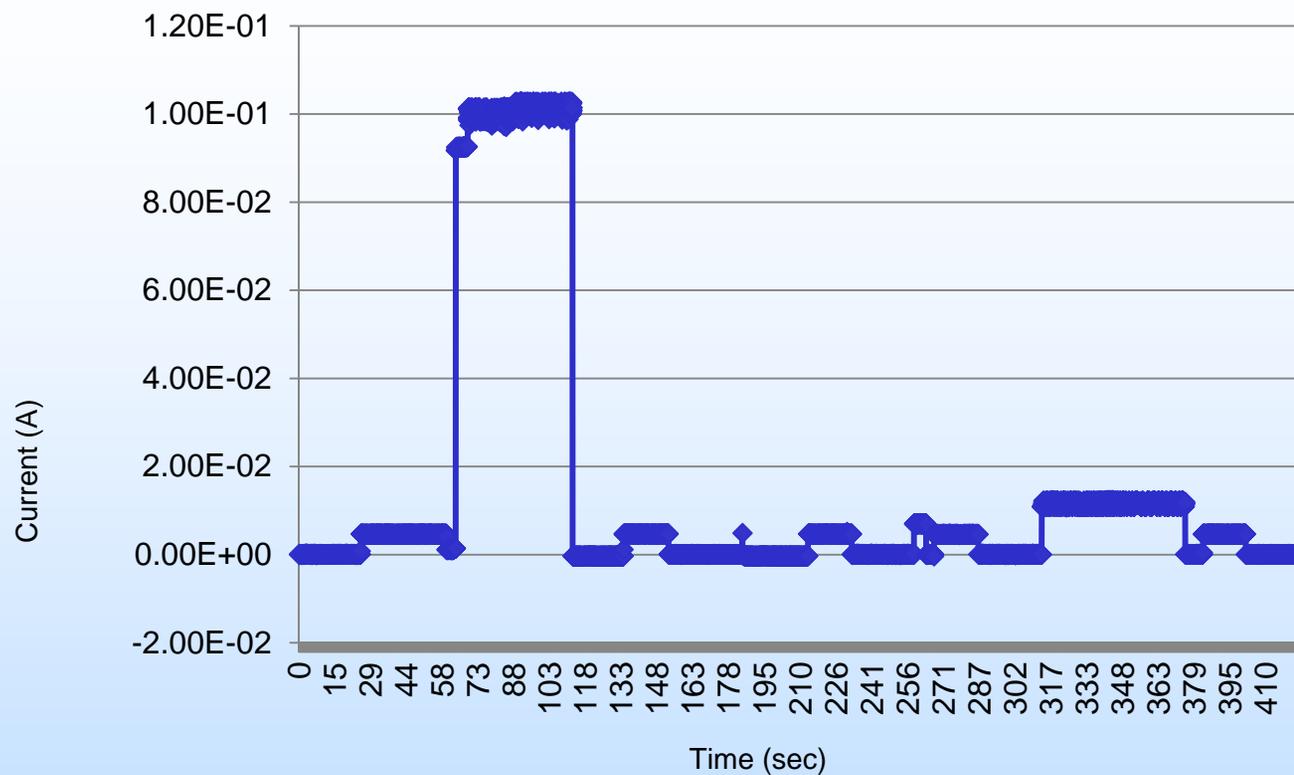
## Initial Laser Experiment (2011)

- **Total of 50 SEFIs, locations indicated in Fig.**
- **37 events (red spots)—high current, 80 mA or more, DUT reset cleared high current in every case**
- **13 events (white spots)—functional interrupt, without high current, many required power cycle to restore normal operation**



# *Micron 4G NAND—Dynamic Read*

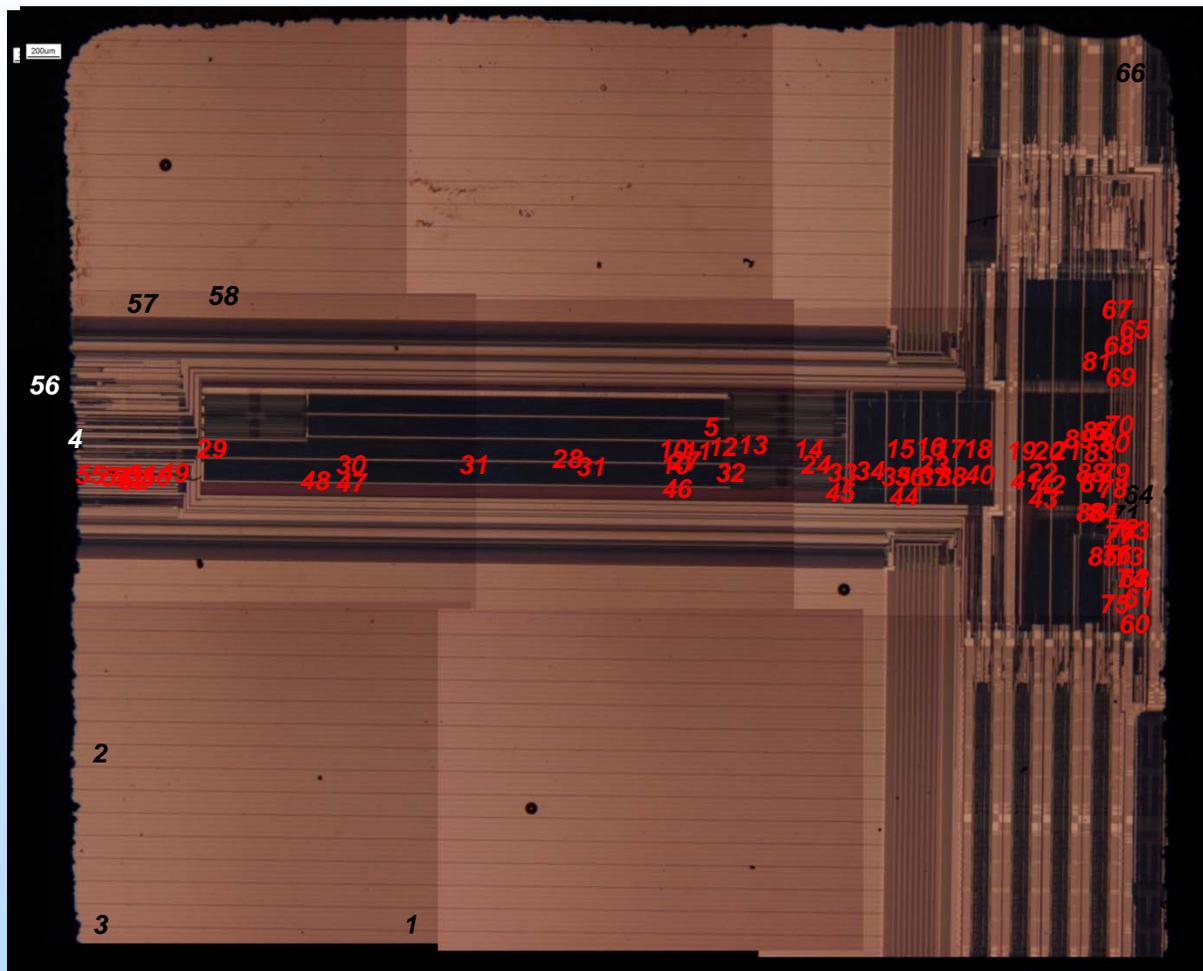




***Micron DUT 20, Run 13, Au, Dyn R/E/W,  
Watchdog, OK after reset***



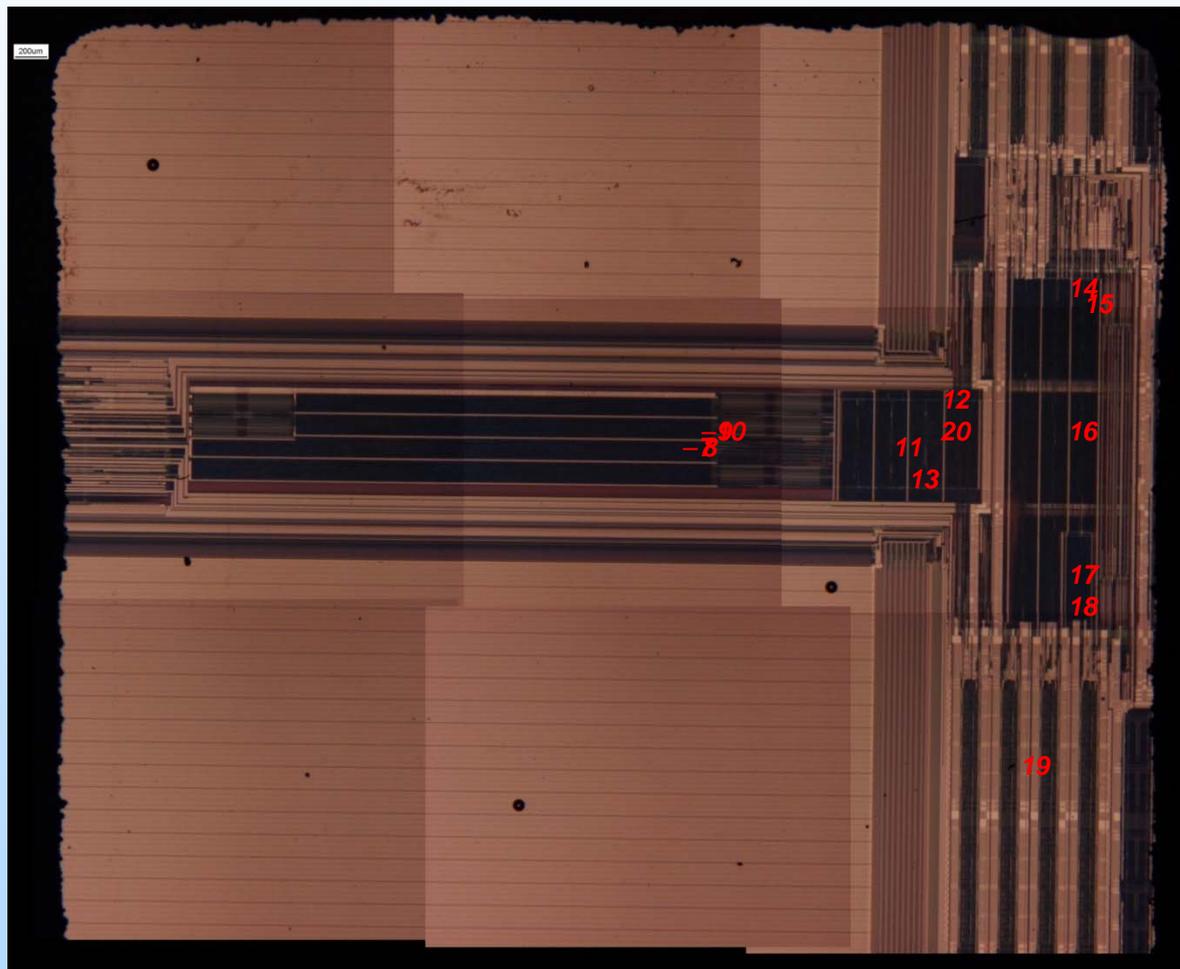
# Micron 4G NAND—Dynamic Read





# Micron 4G NAND—Dynamic Read/R/E/W

Laser – OD = 0.5





## Laser Parameters

- $E \text{ (pJ)} = A (10/10^{\text{OD}}) * (1.424)$
- Optical density = 0, 0.5, and 1.0
- $LET = 3.05 * E(\text{pJ})$  (NRL Opinion)
- $LET = 14.7 * E(\text{pJ})$  (Sandia Opinion)
- J.R. Schwank et al., IEEE TNS, 58, 2968 (2011).
- Empirical correction—fraction of light reaching Si surface
- Laser FWHM 0.91  $\mu\text{m}$ , formerly 1.1  $\mu\text{m}$



## Laser Power Levels

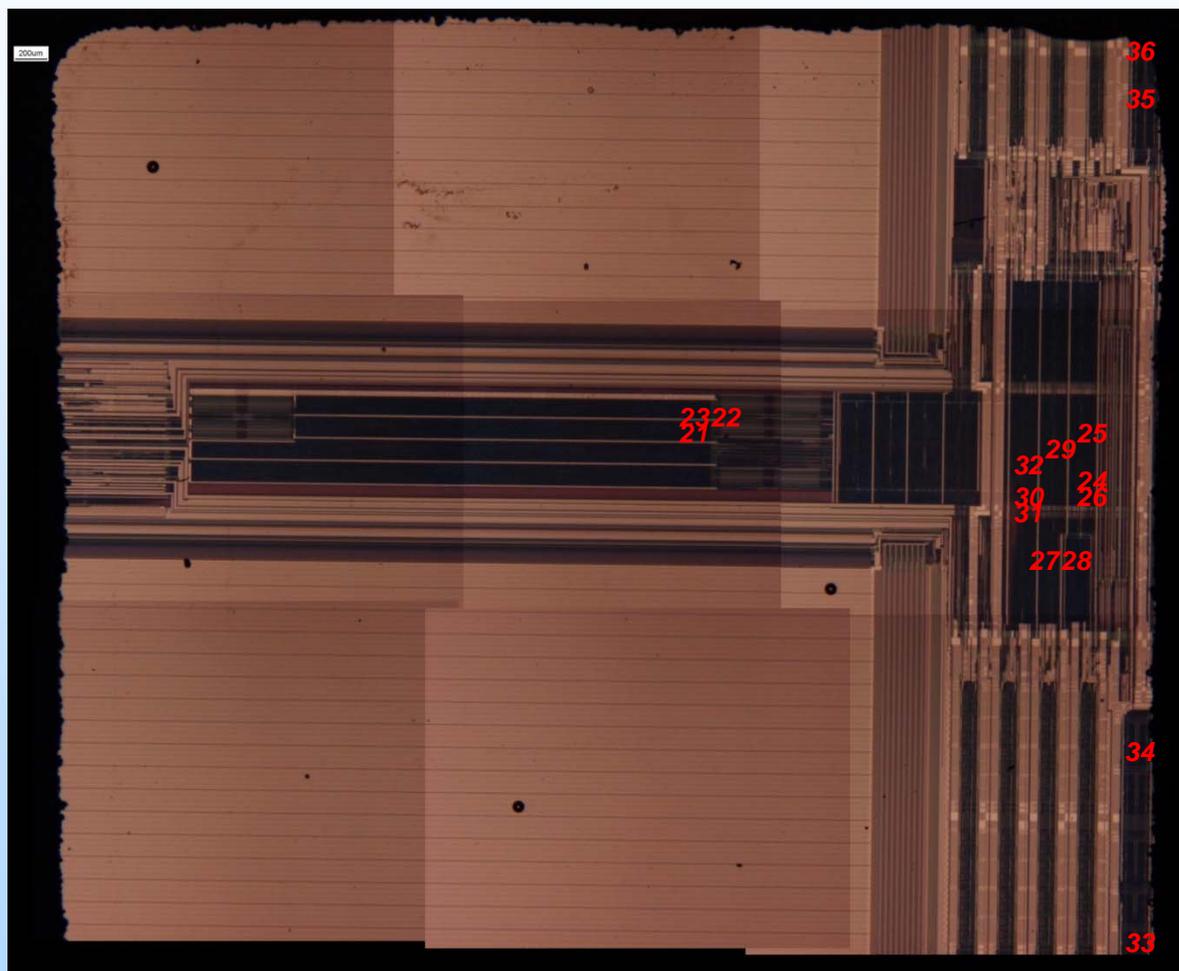
OD	Scope (mV)	E(pJ)	Eq. LET
1.0	45	64	195
0.5	50	225	680
0.0	50	700	2100

**Milli-Beam™ HI test used Xe ions, LET~60**



# Micron 4G NAND—Dynamic Read/R/E/W

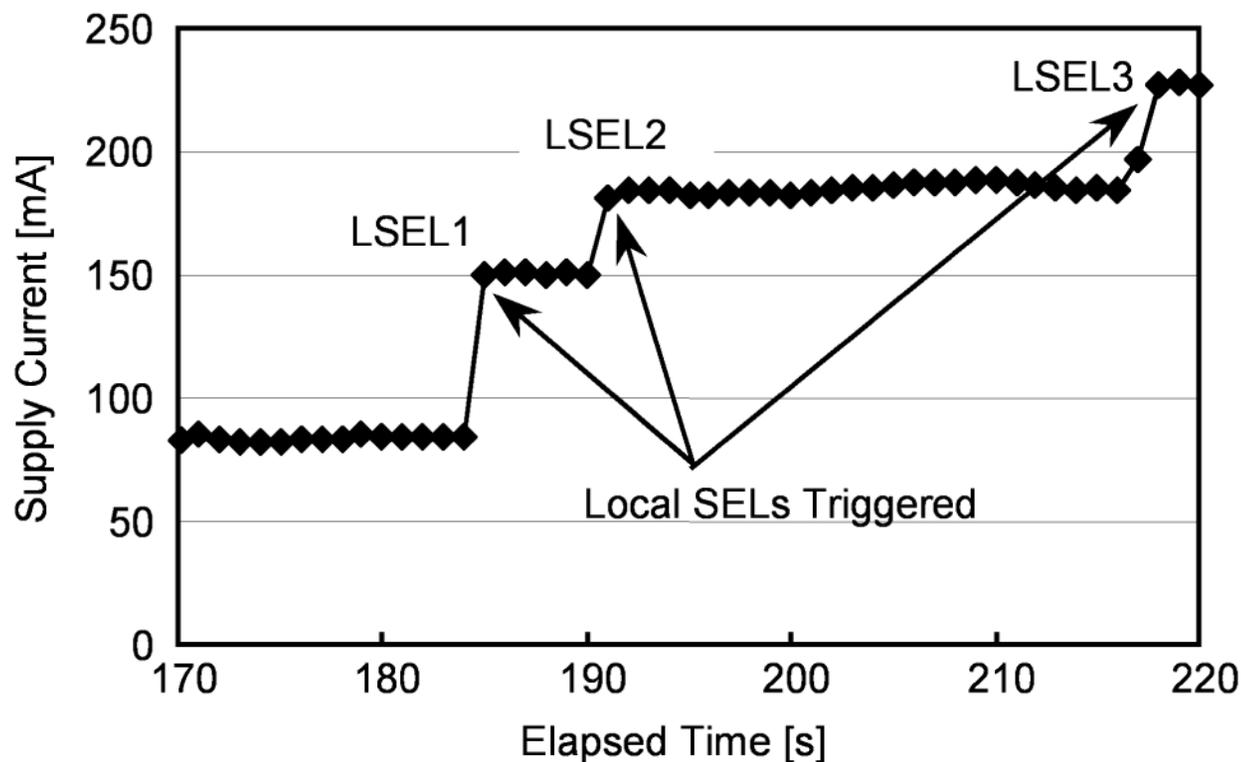
## Laser – OD = 0.0





# Backup Slides

# Localized SEL in Combinational Logic



**H. Shindou et al., IEEE TNS, 52, 2638 (2005).**



# ***Micron 4G NAND—Dynamic Read/R/E/W Laser –1/27/2012, first scan***

