



# IRRADIATION CHARACTERIZATION OF DDR2 AND SDR - SDRAM

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Hirex Engineering



# DDR2 - SDRAM HEAVY IONS IRRADIATION CHARACTERIZATION FEASIBILITY

ESA PO - 13528/99/NL/MV COO-22 dated from 29/09/2008

Report: HRX/SEE/0258 issue 02 dated from December 2009

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# Summary



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- Background and Objectives
- Devices overview
- Test conditions
- Test set-up
- Irradiation characterization results
- Conclusion

# Background and Objectives



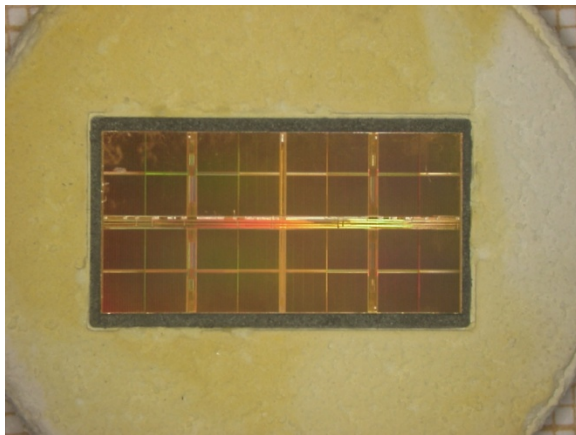
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- 2007 - Hirex built a new tester
  - 512 MB DDR2-SDRAM previously tested
    - Compare data
  - 1 GB DDR2-SDRAM test feasibility
    - Find and validate technical solutions to:
      - Open and thinned the samples
      - Samples soldering
      - Test different references
- } Keeping the functionality

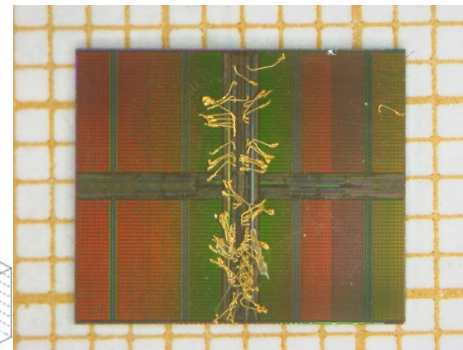
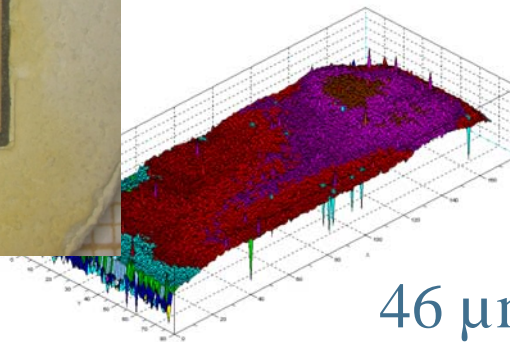
# Device overview

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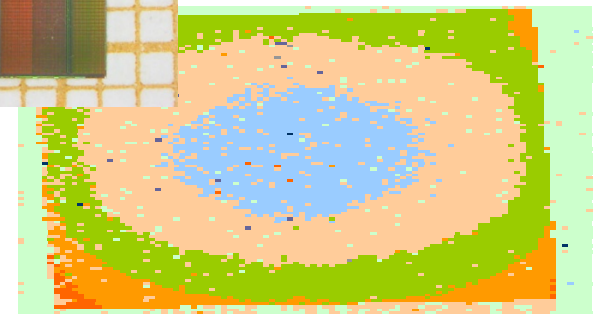
<b>Part Type</b>	EDE1108AB	MT47H64M8
<b>Manufacturer</b>	ELPIDA	MICRON
<b>Part description</b>	1 GB DDR2-SDRAM	512 MB DDR2-SDRAM
<b>Package</b>	FBGA-68	FBGA-60
<b>Marking</b>	E1108AB-5C-E 06500W057	48R9 / 6YD22 / D9GMH
<b>Die dimensions</b>	16.9 x 8.7 mm	8.5 x 7.0 mm



40  $\mu\text{m}$  thickness



46  $\mu\text{m}$  thickness



# Test conditions



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- TAMU (College Station, TX, USA)  
November 2008
- HIF (Louvain-La-Neuve, Belgium)  
May 2009
- SEL, SEFI, SEU, SET
- 1.8 V / 0.9 Vref / Room Temp / CKB
- Dynamic and static tests

# Test set-up (1 / 2)



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## □ Software:

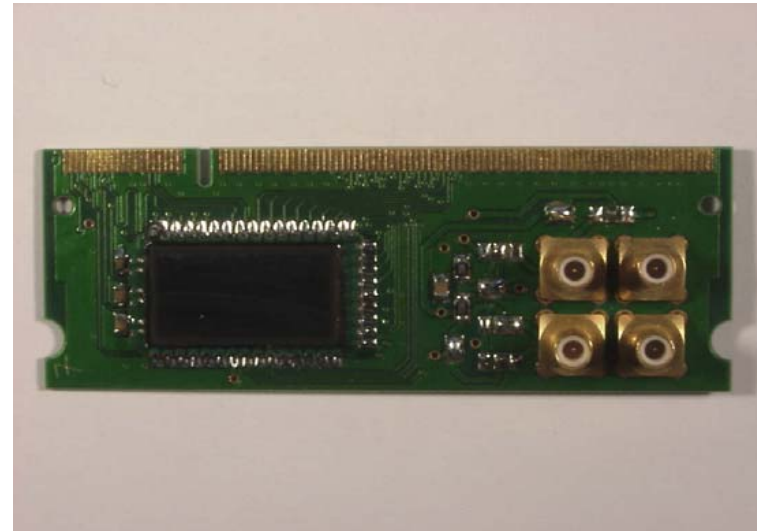
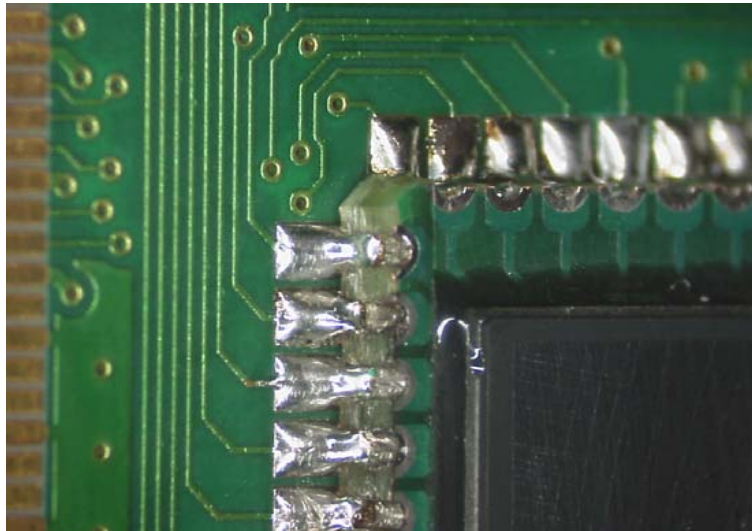
- JEDEC Standard DDR2-SDRAM  
Specification, JESD79-2E, April 2008
- Specific algorithms
  - Fill / Check
  - Error SEFI classification
- Several test sequences
  - Fill / expose / check ...
  - Initialize / fill / expose / check ...
  - Initialize / fill / expose / initialize / check ...

# Test set-up (2/2)

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## □ Hardware

- Samples soldered on stamp board (underfill)
- Samples then opened and thinned (40  $\mu\text{m}$ )
- Stamp board reported on SO-DIMM 200

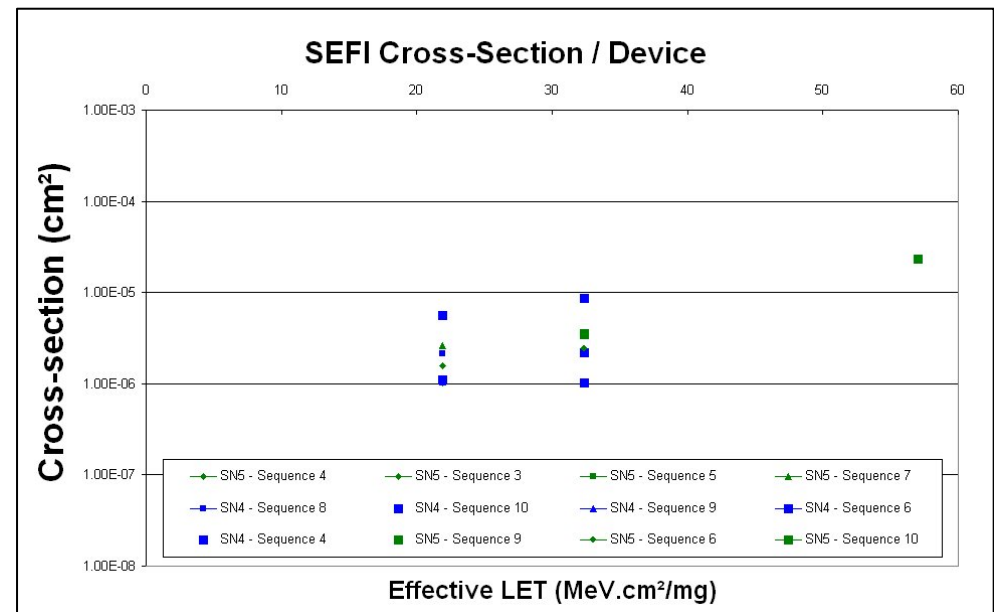




# Results (1 / 3)

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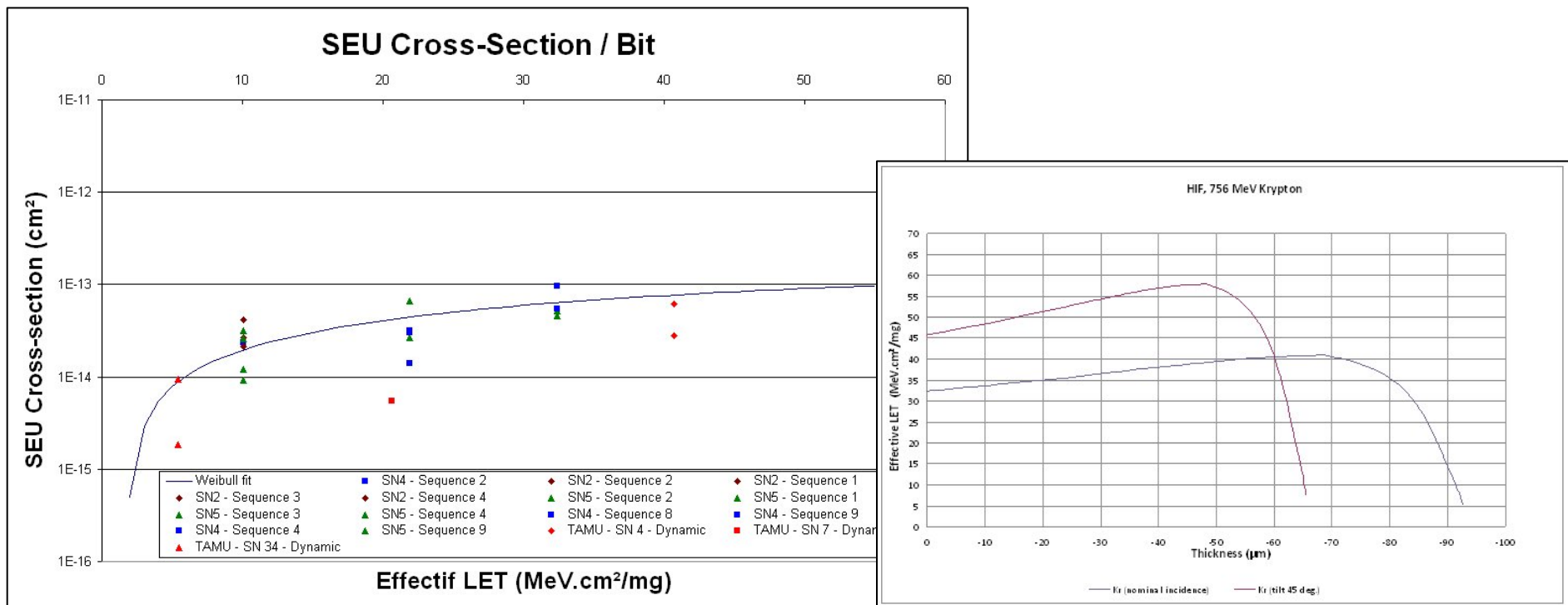
- No SEL @ 32.4 MeV.cm<sup>2</sup>/mg, 1E7 p/cm<sup>2</sup>, 1.8 V, room temp
- SEFI (2 types: Soft and Hard)
  - @ LET 57 MeV.cm<sup>2</sup>/mg => SEFI CS<sub>sat</sub> / device < 3E-5 cm<sup>2</sup>
- Row errors
  - 8191 (0x1FFF),
  - 16383 (0x3FFF)
  - highly sensitive
- Leaky cells



# Results (2/3)

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□ SEU @ LET 40.7 MeV.cm<sup>2</sup>/mg => SEU CS<sub>sat</sub> / bit < 2E-13 cm<sup>2</sup>



Calculated with SRIM 2008

# Results (3/3)



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## □ SEU specificities:

- The four word positions on the burst are not similarly sensitive to errors
- Almost all SEU are Single Bit Upset (SBU)
- Clear transitions are twice set transitions
- The bit position distribution is well balanced inside the word

# Conclusion (1 / 2)



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- ELPIDA 1 GB and MICRON 512 MB DDR2-SDRAM were heavy ions tested
- No SEL @  $32.4 \text{ MeV.cm}^2/\text{mg}$ ,  $1\text{E}7 \text{ p/cm}^2$ , 1.8 V, room temp
- 2 types of SEFI (Soft, Hard)  
@ LET  $57 \text{ MeV.cm}^2/\text{mg} \Rightarrow \text{SEFI CSsat} / \text{device} < 3\text{E-}5 \text{ cm}^2$
- Row Errors, Leaky cells
- SEU  
@ LET  $40.7 \text{ MeV.cm}^2/\text{mg} \Rightarrow \text{SEU CSsat} / \text{bit} < 2\text{E-}13 \text{ cm}^2$

# Conclusion (2/2)



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- Results are homogeneous
- Characterization of large DDR2-SDRAM is feasible
- Specific Device Interface Boards (DIBs)
  - Sample + Stamp board + SO-DIMM 200
- Initialization of the device before each write/read processes
  - Re-Initialization of device's registers



# SDR - SDRAM HEAVY IONS IRRADIATION CHARACTERIZATION

ESA contract - No 22327/09/NL/SFE dated from  
15/10/2009

Report: HRX/SEE/0287 issue 03 dated from June 2010

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# Background and Objectives



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- 256 MB SDR-SDRAM (HITACHI)
- Previous SEL tests were performed on samples not fully functional (opening and thinning)

October 2009, SEE Report: HRX/SEE/0276

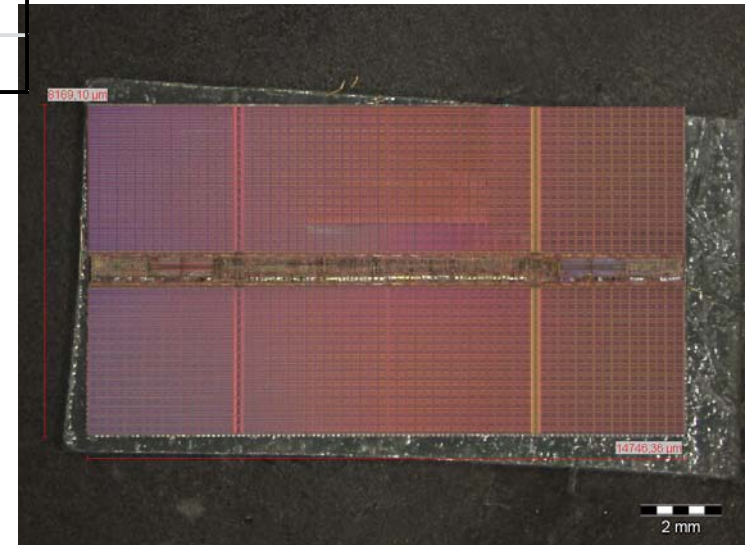
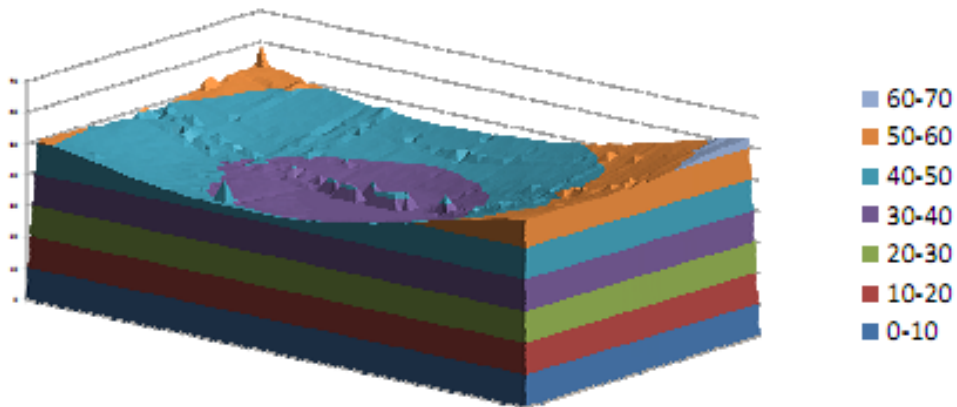
- Verification and confirmation of SEL results
- Add SEFI and SEU data

# Device overview

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Part description	256 Mbit SDR-SDRAM	256 Mbit SDR-SDRAM
Provider	Astrium	Oxygen
Package	4-pin TSOP II	4-pin TSOP II
Samples used	SN 516, SN 525, SN 526	SN 1
Package marking	225165BTT75	225165BTT75
Die dimensions	8.0 x 14.5 mm	8.0 x 14.5 mm
Date code	232	423

HM5225165  
HITACHI





# Test conditions



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- RADEF (Jyväskylä, Finland)  
December 2009
- SEL, SEFI, SEU
- 3.6 V ( $V_{nom} + 10\%$ )
- Temperature: room, 50 and 85 °C
- Checkerboard
- Auto-refresh mode (variable refresh rate)
- Test sequence:
  - Initialize / fill / expose / check / fill / expose ...

# Results

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- **SEL:** Tilt 0 ° - LET surface # 55 MeV.cm<sup>2</sup>/mg
  - room temp: No SEL
  - 50 °C, 85 °C: SEL CSsat / die = 1E-7 cm<sup>2</sup>
- Tilt 30 ° - LET surface # 64 MeV.cm<sup>2</sup>/mg
  - 50 °C: SEL CSsat / die # 3E-7 cm<sup>2</sup>
  - 85 °C: SEL CSsat / die # 4E-5 cm<sup>2</sup>
- **SEFI (3 types: 2 Softs x 200, 1 Hard x 1 600)**
  - @ LET 60 MeV.cm<sup>2</sup>/mg => SEFI CSsat / device < 2E-4 cm<sup>2</sup>
- **LE (row, col) and SEU (upset, MBU 5x SBU)**
  - @ LET 60 MeV.cm<sup>2</sup>/mg CSsat / bit = 1.4E-9 cm<sup>2</sup>

# Conclusion



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- 256 MB SDR-SDRAM (HITACHI) was heavy ions tested
- SEL Tilt 0 ° - LET surface # 55 MeV.cm<sup>2</sup>/mg
  - room temp: No SEL
  - 50 °C, 85 °C: SEL CSsat / die = 1E-7 cm<sup>2</sup>
- Tilt 30 ° - LET surface # 64 MeV.cm<sup>2</sup>/mg
  - 50 °C: SEL CSsat / die # 3E-7 cm<sup>2</sup>
  - 85 °C: SEL CSsat / die # 4E-5 cm<sup>2</sup>
- SEFI (Mainly hard, some 2 types soft)
- LE (row and col), SEU (upsets, MBU 5x SBU)

THANK YOU!

Any question?