

NASA Electronic Parts and Packaging (NEPP) Program SEE Test Results and Community Efforts

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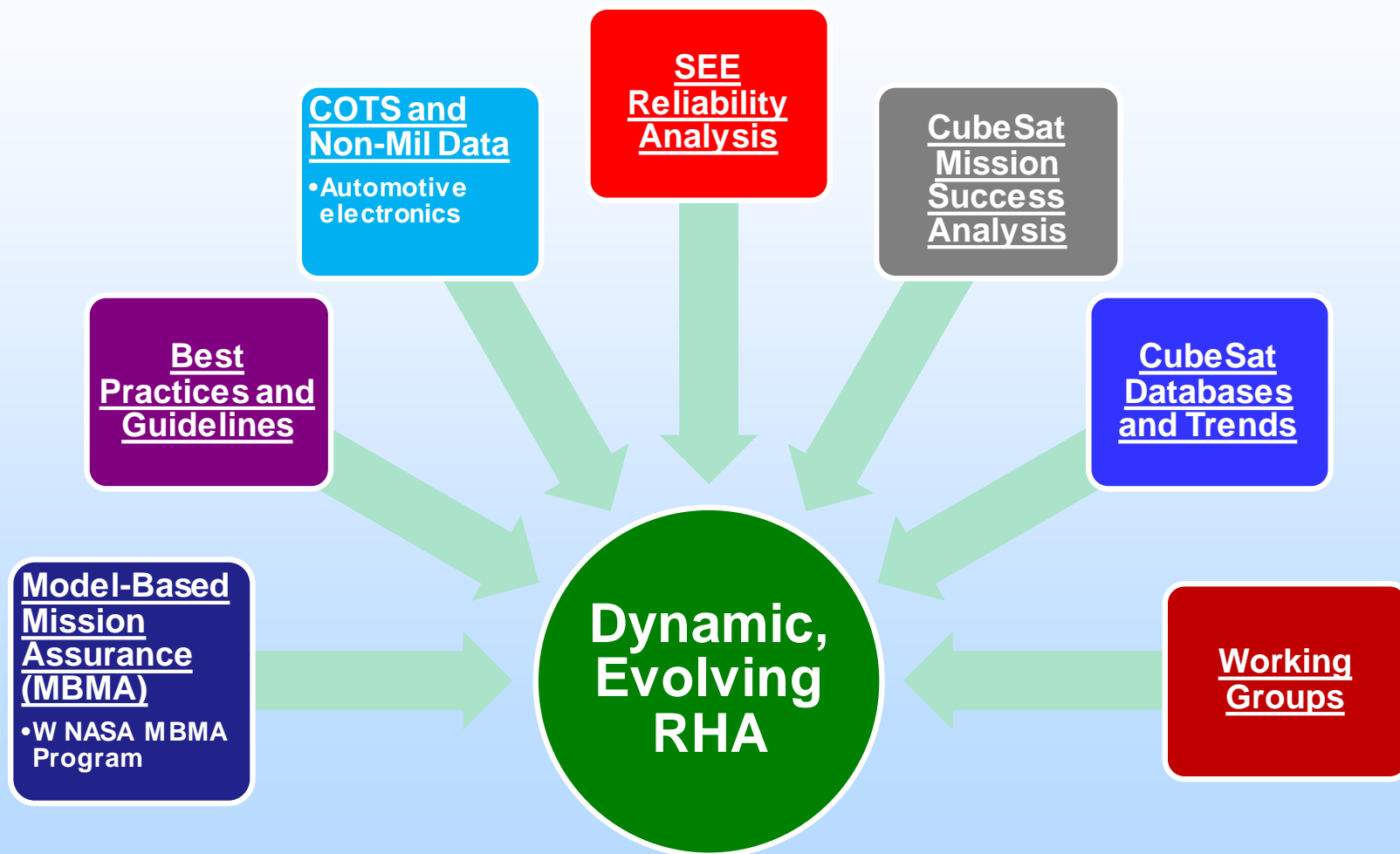
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NEPP - Small Mission and Emerging Architectures Efforts





Outline

- Introduction – Current issues facing SEE testing

Best Practices and Guidelines

COTS and Non-Mil Data

- Automotive electronics

CubeSat Databases and Trends

Working Groups

- Laser User Guide
- COTS de-packaging
- SEE Database
 - Laser Database
- Metadata Analysis
- Recent SEE Results/Challenges
- GaN SEE-Reliability
- Generic SEE RTC?



Current Issues Facing SEE Testing

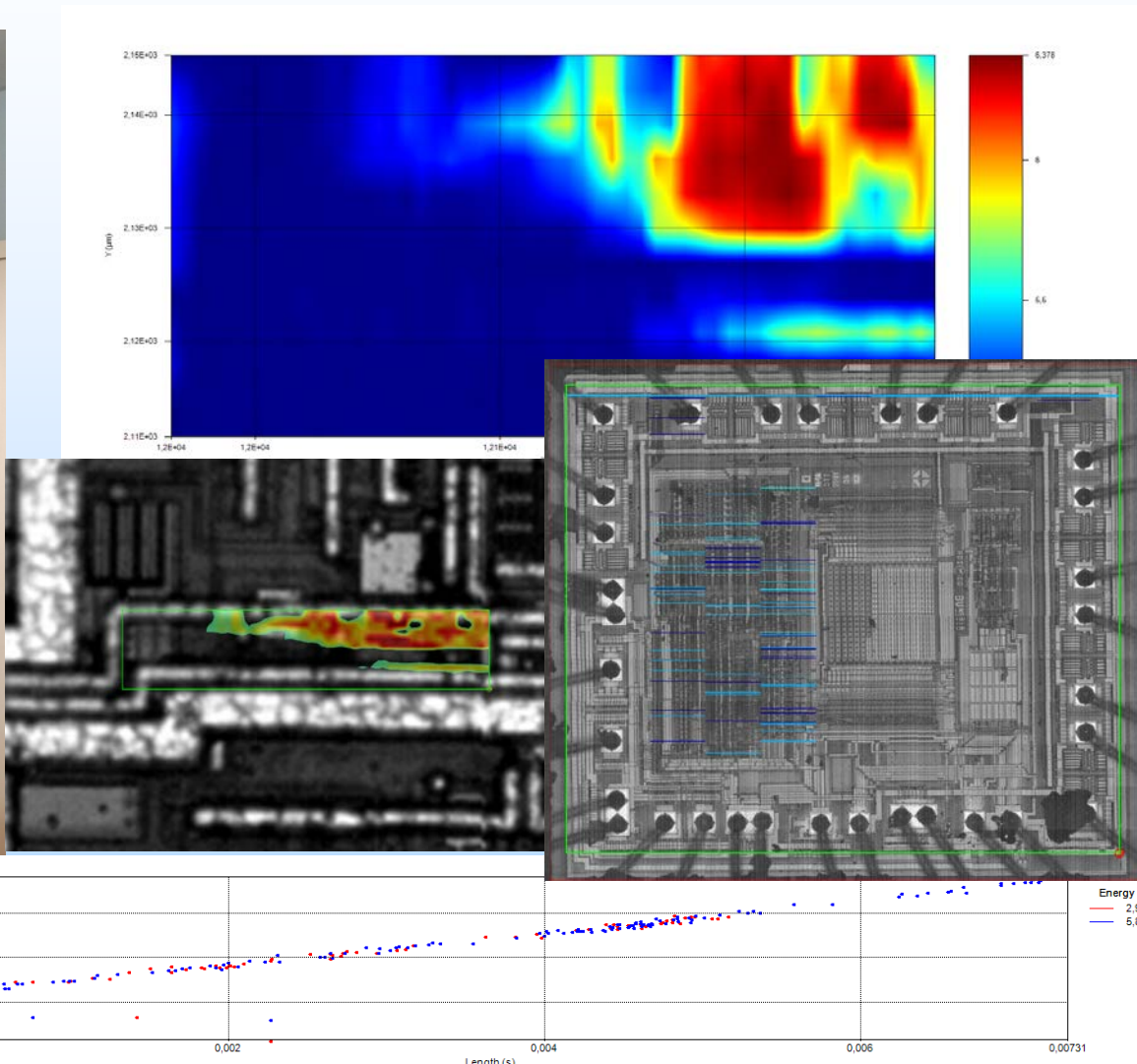
- **Device Complexity and Testability**
- **Beam Availability & Beam Energy**
- **Workforce**
- **Siloed community efforts**



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Single Photon Laser – PULSCAN SPA 1064nm pulsed

Best
Practices and
Guidelines





Initial Laser Usage

Best
Practices and
Guidelines

CubeSat
Databases
and Trends

- Intend to run every single device we SEE test through the pulsed laser system to develop a correlated library.
- Die micrographs, laser sensitivity maps, and correlated heavy ion characterization data will be populated in a database.
- Practical user's guide for SEE laser testing
 - Scanning approaches
 - Device preparation
 - Lessons Learned

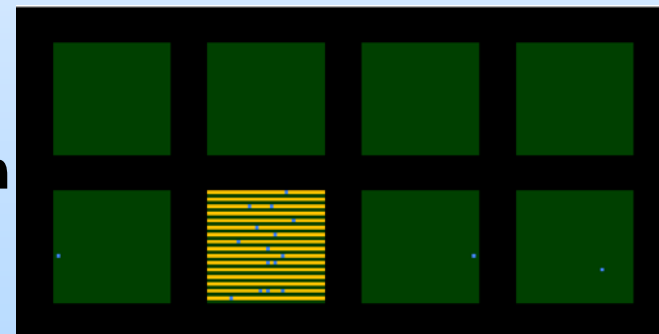
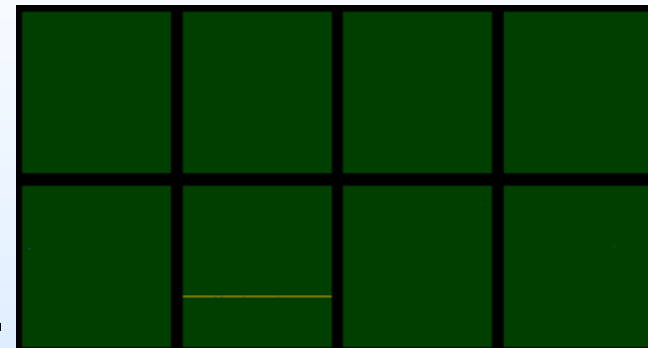


Recent Challenges: DDR2

**COTS and
Non-Mil Data**

• Automotive
electronics

- **Multiple test setups required for full radiation characterization campaign**
 - Automated test equipment used to measure parametric degradation over TID.
 - Custom test system used to gather stuck bits at room temp (varying refresh rate).
 - High speed test system to collect data at different clock frequencies DLL enabled.
 - Flight like test system with SEFI mitigation for validation.





Recent Challenges: DDR2

**COTS and
Non-Mil Data**

• Automotive
electronics

- **Observation**

- Different test systems (board/controller/component) with same memory component have different cross sections
- Memory controller / routing affects sensitivity to certain mode register SEU and interface handshaking affects SEFI rates (specifically handling of data strobes or off beat data).
- Signature of SEFI depends on system (processor hang vs. junk data vs. controller reported failure mode)
- Observed order of magnitude difference in SEFI rate between unmitigated controllers.
- Further substantiates the “test it like you fly it” mantra
- Testing of flight memory controller IP required for flight SEFI rates.

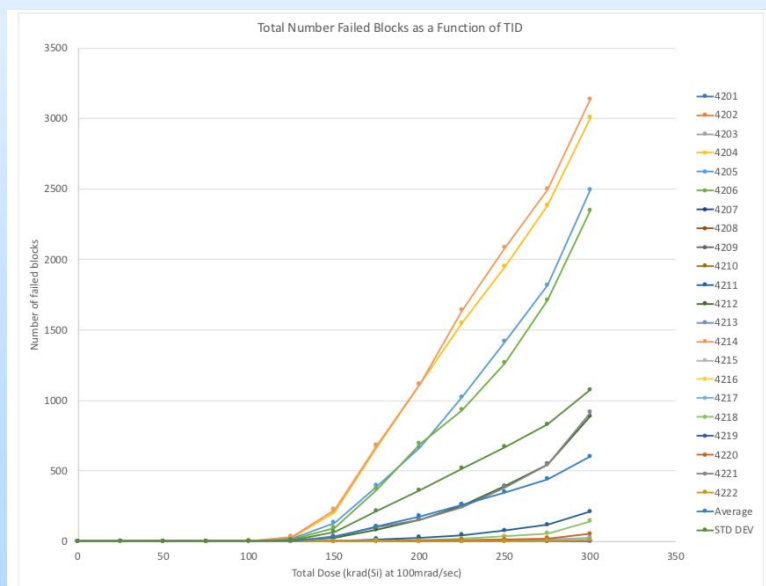


Recent Challenges: NAND Flash

**COTS and
Non-Mil Data**

• Automotive
electronics

- **High Density NVM always of value**
 - Detailed testing can yield extreme variability (true of SEE and TID).
 - Dose steps, fluence steps, refresh period can change part usability.



60 Number of bad blocks as a function of TID, lot 308

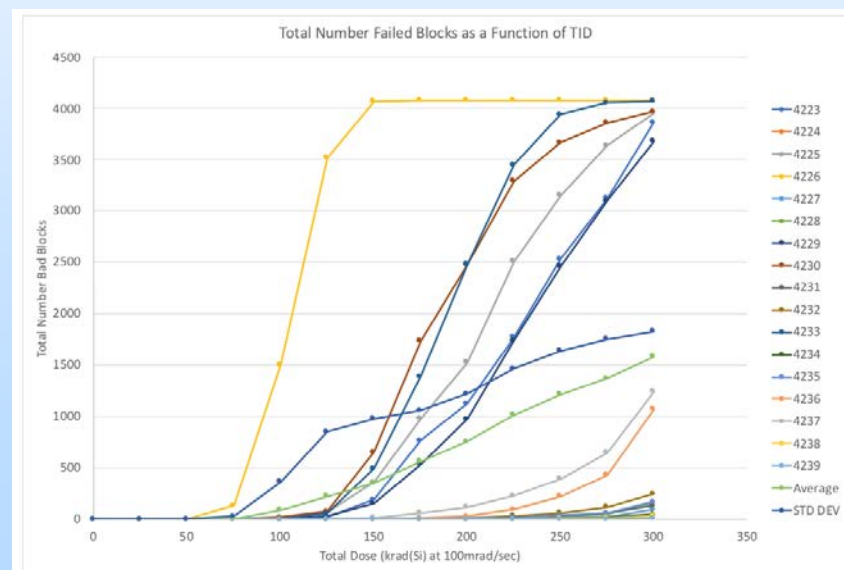
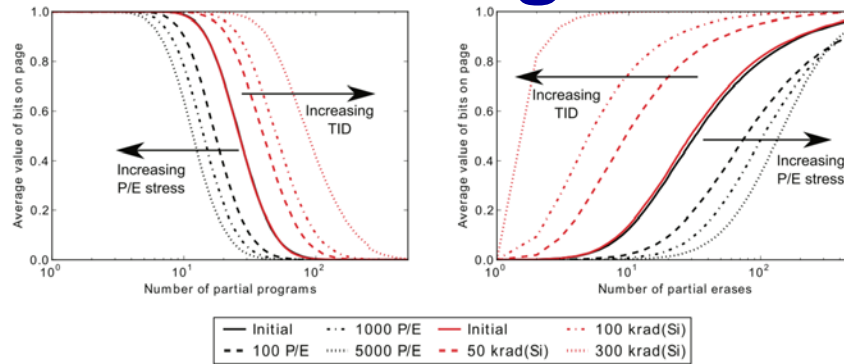


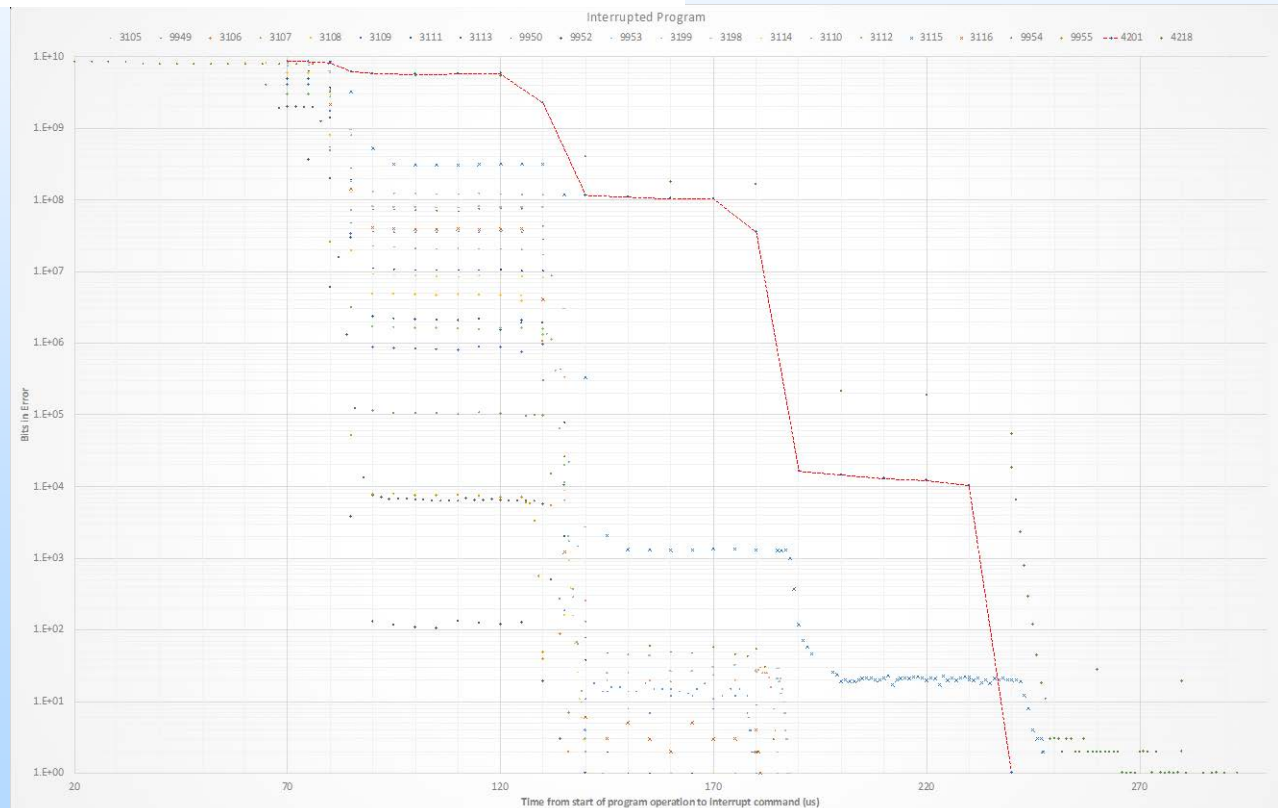
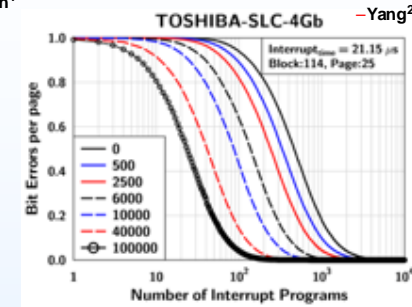
Figure 61 Number of bad blocks as a function of TID, lot 320.

Recent Challenges: NAND Flash



Roach¹

Yang²



¹ A. H. Roach, M. J. Gadlage, A. R. Duncan, J. D. Ingalls and M. J. Kay, "Interrupted PROGRAM and ERASE Operations for Characterizing Radiation Effects in Commercial NAND Flash Memories," in *IEEE Transactions on Nuclear Science*, vol. 62, no. 6, pp. 2390-2397, Dec. 2015.

² J. Yang-Scharlotta, "Method of Smart-Screening for NAND Flash Memory Parts Based on Weak Bits", *JPL R&TD 2017*, JPL Task #R17002

To be presented by Gregory R. Allen at the NEPP Electronics Technology Workshop, June 17th-20th.



Recent Challenges: NAND Flash

**COTS and
Non-Mil Data**

• Automotive
electronics

Initial Test Results

Dose krad(Si)	125	150	175	200	225	250	275	300	110us @ 0krad	160us @ 0krad	160us @ 300krad	Threshold (krad(Si))	Date Code
Site:	Number Failed Blocks (Program)								Number Errors				
CH2	0	0	0	0	0	0	0	0	3333	1	7829	325	749
CH3	0	0	0	0	0	0	0	0	120	0	400867	325	749
CH0	0	0	0	0	0	0	0	1	2	0	19104	300	749
CH1	0	0	0	0	0	1	3	3	3	0	44038	250	749
CH4	0	0	0	0	0	4	7	15	171	0	625464	250	004
CH12	0	0	0	0	0	0	0	0	5.71E+06	17	337002235	325	749
CH7	0	0	0	0	1	1	1	3	5.83E+07	257	536248796	225	749
CH10	0	0	0	0	0	7	22	49	7.61E+07	27	838911278	250	004
CH9	1	3	3	4	8	21	38	57	2.81E+07	35	919952124	125	749
CH14	0	0	2	5	20	53	119	252	4.46E+07	10	545489447	175	004
CH8	0	1	9	30	80	140	328	584	8.77E+07	74	709161252	150	004
CH11	0	1	5	23	65	145	349	632	1.25E+08	23	1194042440	150	004
CH6	1	3	11	48	149	269	489	828	2.69E+08	772	1433695202	125	004
CH13	0	1	11	63	179	360	825	1461	3.74E+07	13	767066038	150	004



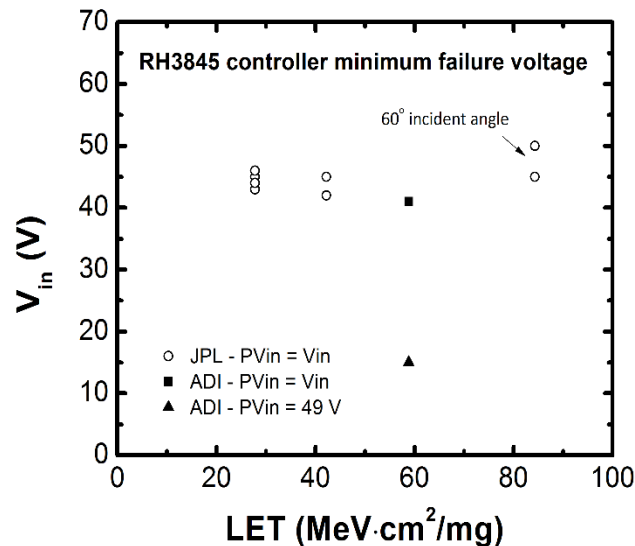
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Recent Challenges: Analog Devices

COTS and Non-Mil Data

• Automotive electronics

- Destructive Effects
- Load Dependent SEFI modes
- Transient Effects



TYPICAL APPLICATION

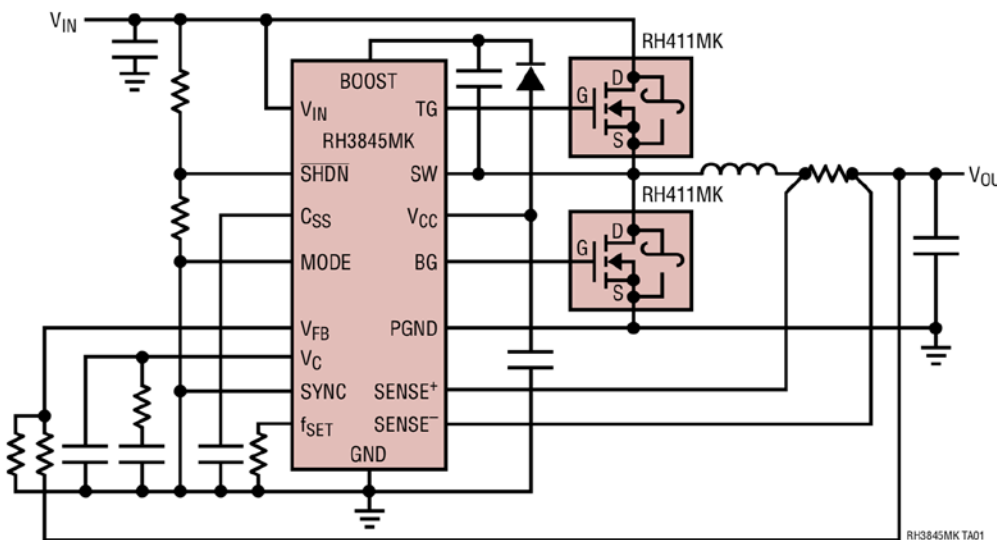


Fig. 7 Photomicrographs of a RH3845 that exhibited destructive SEE.

TABLE III
RH3845 SEE test results.

Device	SEDR Threshold (MeV·cm²/mg)	SEDR Saturation Device Cross-section (cm²)	SET Threshold (MeV·cm²/mg)
RH3845	< 20	1x10 ⁻⁵	< 20



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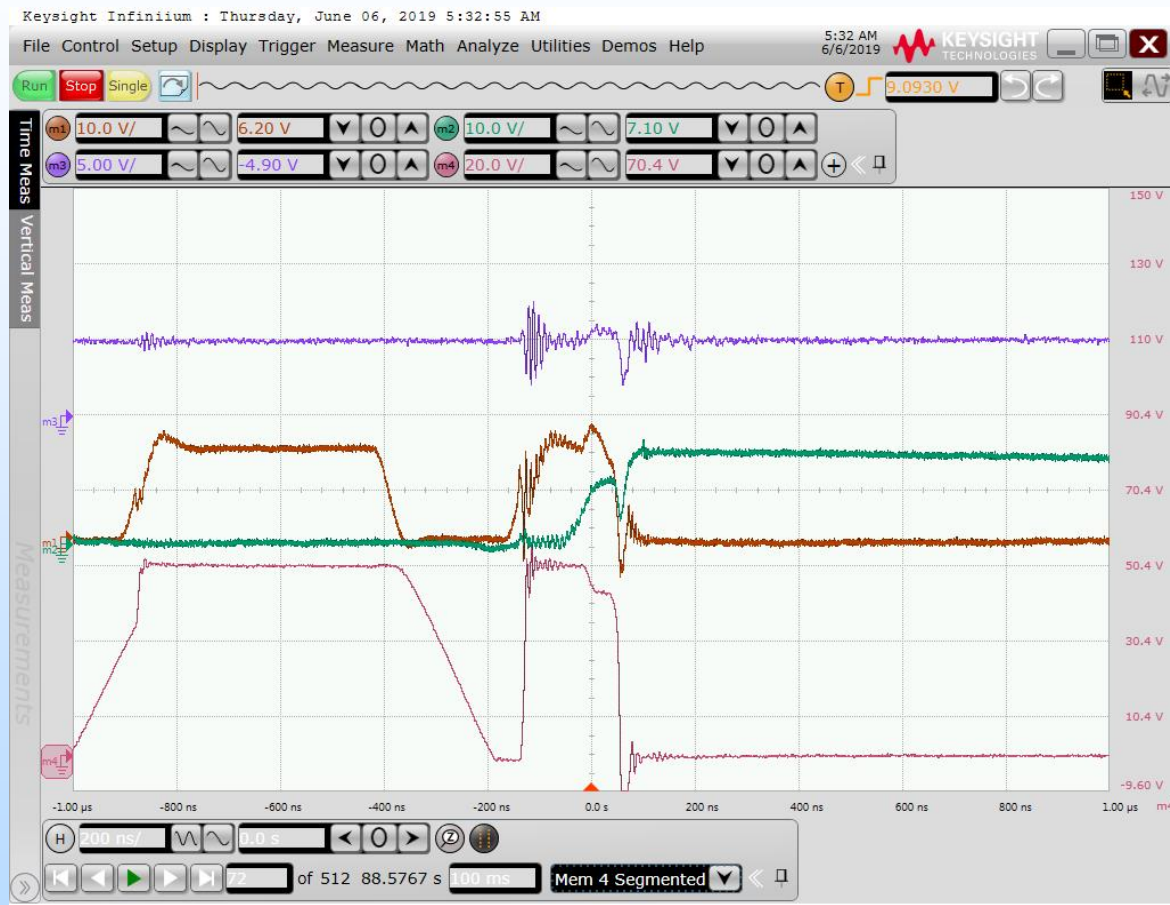
Recent Challenges: Analog Devices

COTS and Non-Mil Data

• Automotive electronics

Signal	Color
Top V_{GS}	Orange
Bot V_{GS}	Green
Switch Node	Pink
V_{OUT}	Purple

Parameter	Value
PV_{IN}	50V
V_{IN}	12V
V_{CC}	12V
V_{OUT}	5V
I_{LOAD}	10mA






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RADCENTRAL – Don't Call it a Comeback

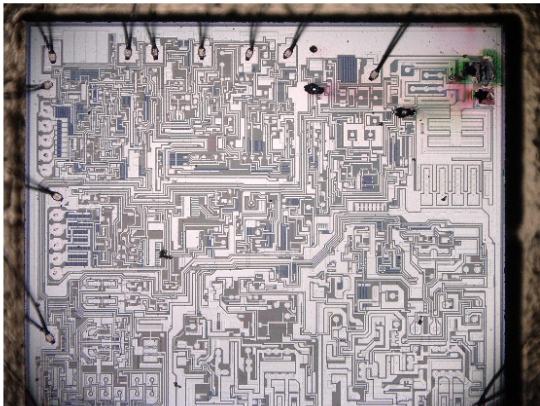
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Welcome to Radiation Tracking Database

Radiation Information and Test Status Database for the Radiation Effects Group at NASA JPL

The Radiation Effects Group at JPL investigates radiation effects on EEE parts, provides mitigation paths against these effects and assures that these effects do not affect JPL missions. Additionally, the Group works to advance mission enabling technology for upcoming JPL missions.

This database is a tool to communicate with our radiation test customers the status of current testing, and is a distribution point for reports on completed tests. The Radiation Effects group fully supports the Project Parts Review process. Candidate parts are carefully reviewed for their susceptibility to the flight radiation environment, according to project requirements and JPL/NASA standards. Part selection and radiation risk issues on parts not passing a radiation review are resolved by working with instrument Cog-E's, project PPE's, and the Product and Circuit Reliability Group. The Radiation Effects group supports any needs for radiation testing, while also supporting the verification of complex test results.

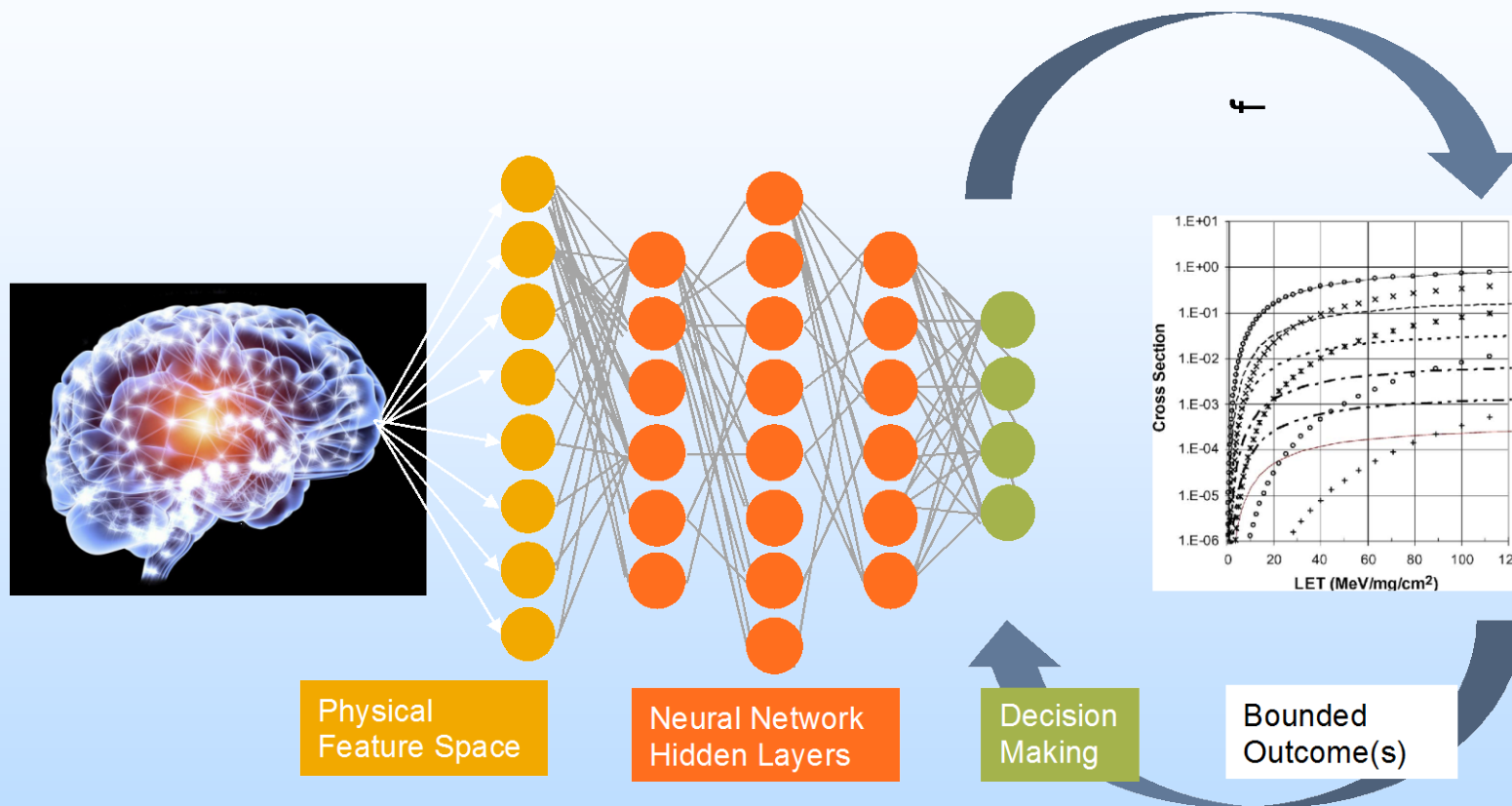
Dotnet Core 2.1

JPL is a federally funded research and development center staffed and managed for NASA by the California Institute of Technology.



Metadata Analysis

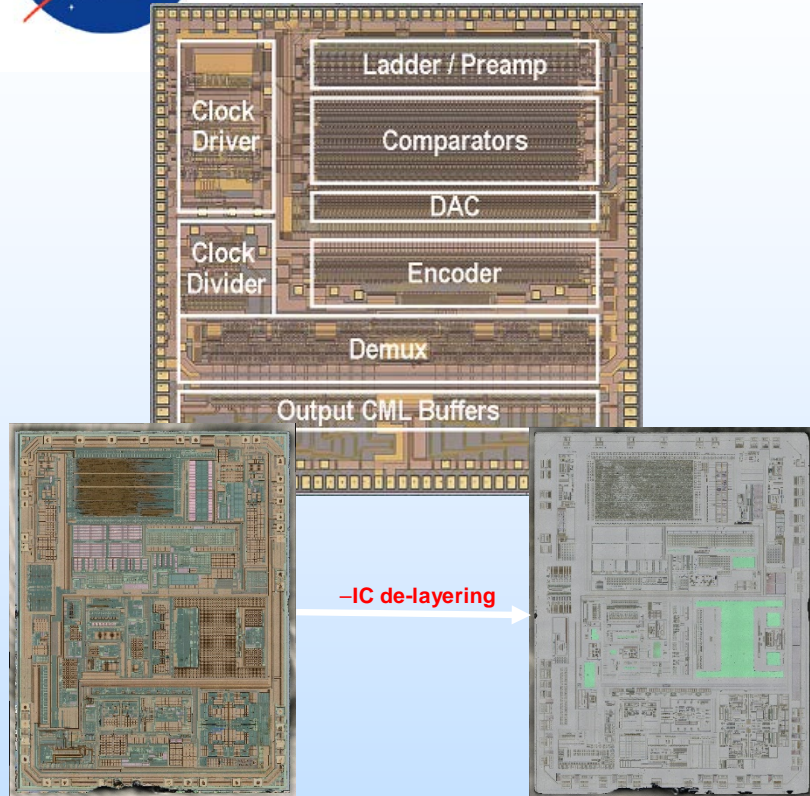
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Metadata Analysis - Physical Feature Space

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Small Sat Radiation Tool Utilities

Home Search Parts

Search and Select

Scrape a New Part

If you don't see your desired part in the table to the right, you can try and launch a scraping session by entering a part number or part number variant. We then go out and attempt to collect and clean information related to your search term.

Don't worry about overwriting existing data. We take care of deduping and only indexing new data that is found.

Part Number

AD571

Search

Select Your Columns

selected

Topology

Technology

Process

Voltage

Analog Input Voltage-Max

Analog Input Voltage-Min

Analog Output Voltage-Max

Analog Output Voltage-Min

Conversion Time-Max

Converter Type

Input Bit Code

Input Format

☒ JESD-30 Code

☒ JESD-609 Code

Part Database (32 parts scraped and counting!)

Topology	Technology	Analog Input Voltage-Max	Analog Input Voltage-Min	JESD-30 Code
		2.5	-2.5	R-PCSO-G26
		2.5	-2.5	R-PCSO-G26
		2.5	-2.5	R-PCSO-G26
	BIPOLAR	5	-5	R-CDIP-T18
	BIPOLAR	5	-5	R-CDIP-T18
		2.5	-2.5	R-PCSO-G26
		2.5	-2.5	R-PCSO-G26
	BIPOLAR	5	-5	R-CDIP-T18

Previous Page 1 of 4 10 rows Next

—Image recognition – machine
—learning based feature
recognition

—Automated datasheet driven
data scraping

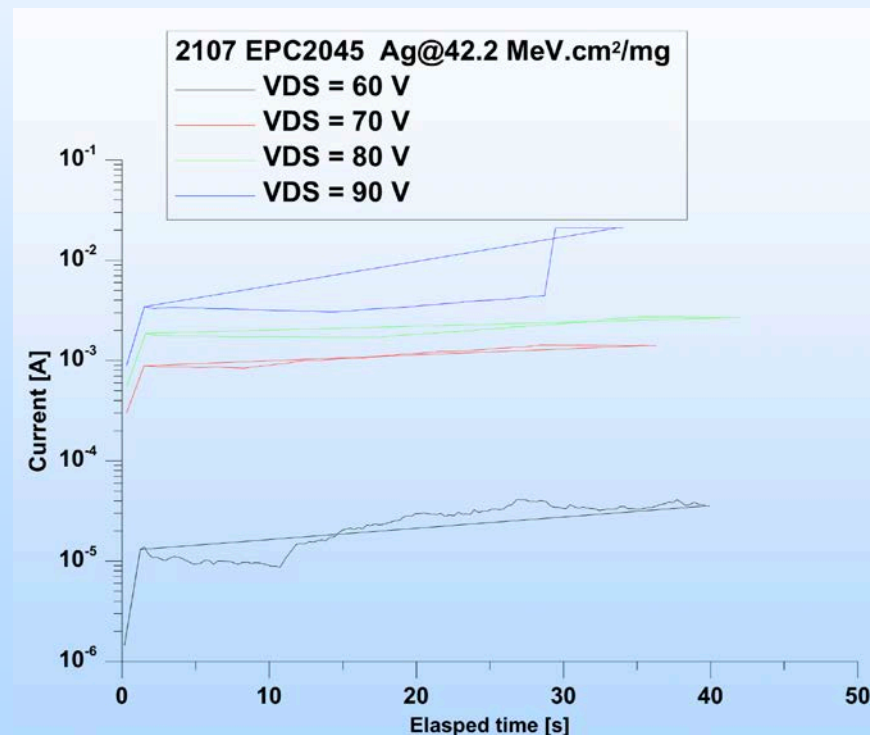


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Current Collaborations – GaN Radiation-Reliability

Working
Groups

- SEE Mechanisms fairly well understood, but combined SEE reliability needs work.
- Collaboration brewing between JPL, GSFC and ESA to understand the impact of combined effects.





Future Collaborations – RTC?

Working
Groups

- **How do we drive the future of collaboration for JPL, the Agency, and the radiation effects community?**
- **How is this syndicate structured?**
- **How do we leverage wide engineering resources across the aerospace community and efficiently use the limited facility resources?**
- **How do we share “trusted data” – a unified radiation database?**