



Heavy-Ion Induced Leakage Current in Power Devices

F. Ahmad, A. Billa, X. Luo, J. Debnath, H. Parra, B. Bolton, and E. X. Zhang

Radiation Effects and Reliability Lab, Department of Electrical and Computer Engineering
University of Central Florida, Orlando, FL 32816

Email: enxia.zhang@ucf.edu. Phone: 407-823-1332.



We thank AFOSR for their support of my work while at Vanderbilt University

➤ Outline

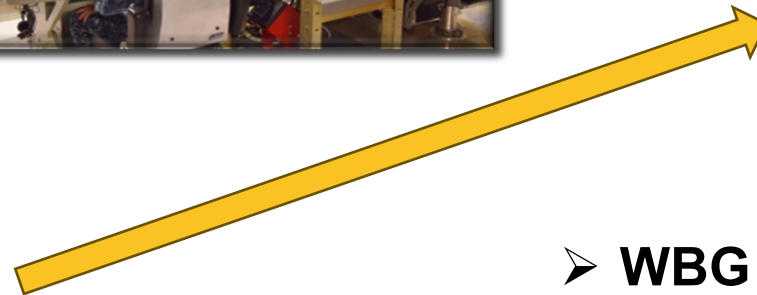
- **Motivation**
- **Testing, packaging and integration**
- **Reliability and heavy ion induced single event effects in GaN**
- **Future plans**
- **NASA Electronic Parts Engineering Certificate Program**

- D. M. Fleetwood, E. X. Zhang, R. D. Schrimpf, and S. T. Pantelides., "Radiation effects in AlGaIn/GaN HEMTs", *IEEE Trans. Nucl. Sci.* vol. 69, no.5, pp.1105-1119, May 2022.
- X. Li, X. D. Zhao, P. F. Wang, X. Y. Luo, H. Qiu, M. W. McCurdy, R. D. Schrimpf, E. X. Zhang, and D. M. Fleetwood,., "Threshold Voltage Hysteresis and Gate Leakage in AlGaIn/GaN HEMTs", IEEE RADECS 2024, September 2024.



Resilient Electronics for Successful Missions

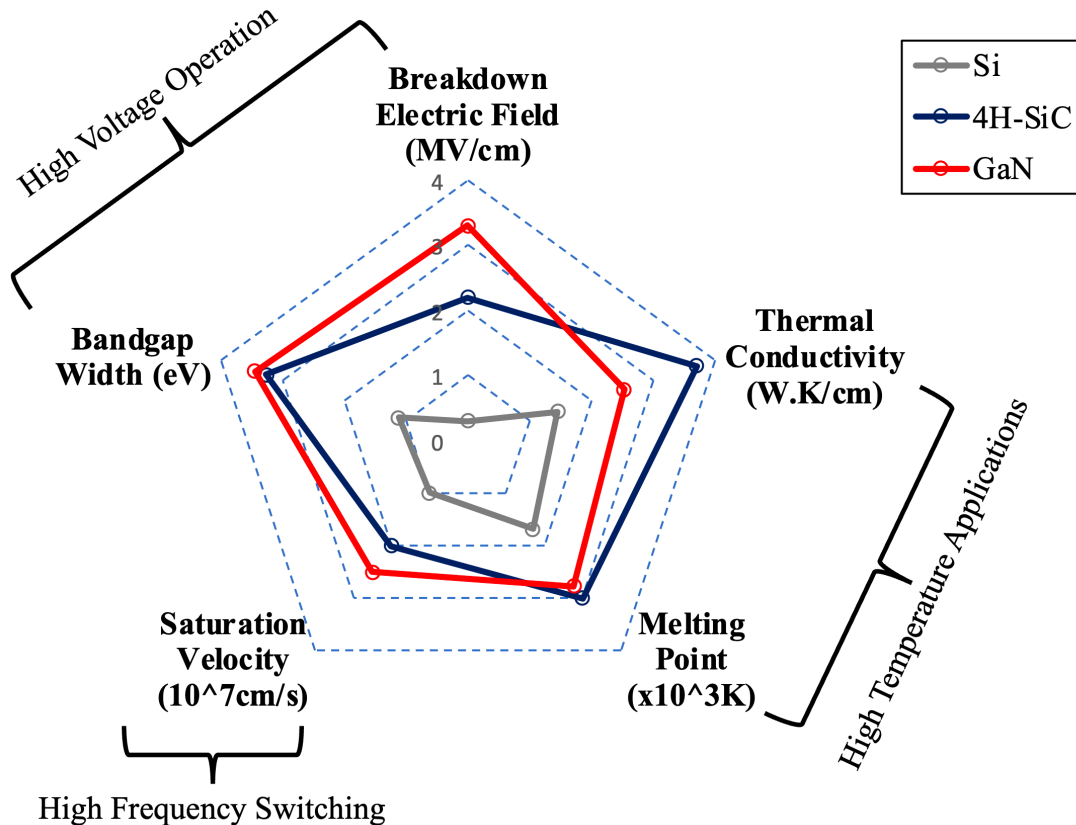
- Safe, reliable, and trustworthy electronics for critical space systems.



- WBG power device for high efficiency power systems



Resilient Electrons for Successful Missions



- Merit of GaN devices: Size Weight and Power (SWaP).
- High performance and long-term reliability for GaN RF and power devices.



Sustainability of Successful Missions

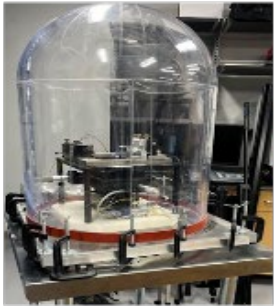
- Significant needs for highly trained engineers, technicians and professionals in the field of electrical electronic and electromechanical (EEE) engineering.
- Resilience education program is urgently needed.
- Success of future deep space exploration and other space missions.



Testing, packaging and integration

➤ Radiation, reliability and electrical characterizations

**Ion irradiation chamber
E-shutter and T-control**



**SET and
circuit testing**



**Ion-Induced
Single Events**

Cf-252



Am-241

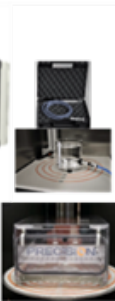


**LF Noise spectrum
analyzer and cryostat
(77-500 K)**



B1505A

**X-ray radiation system
with humidity control chamber**



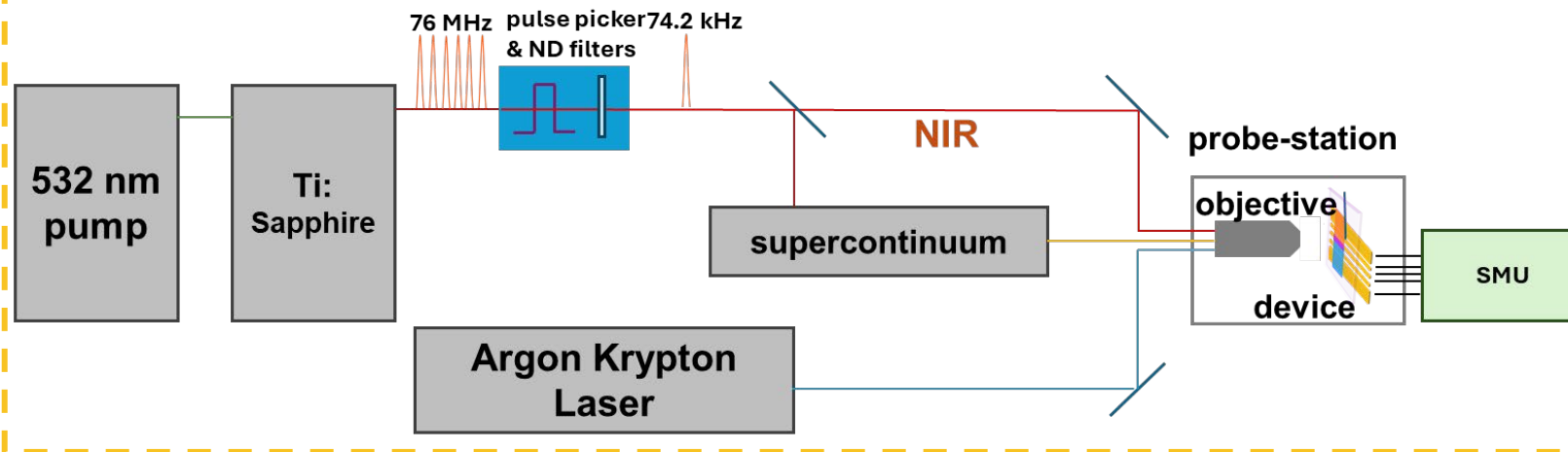
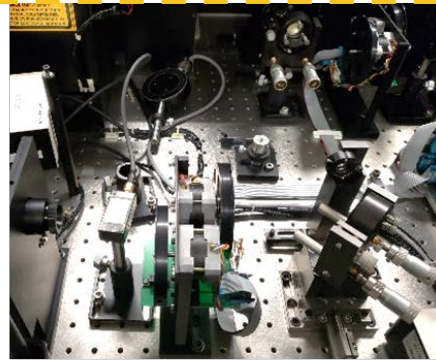
**X-Ray 320 System, provides 10 keV -
320 KeV X-ray with 8" probe-station
electrical feedthrough, humidity
chamber and Temperature controller.**



**-40 C to 180 C
Constant Climate
Chamber with
electrical testing
feed through.**

Testing, packaging and integration

➤ Radiation, reliability and electrical characterizations



A tunable (titanium-sapphire (TS)) laser provides 76 MHz 160 fs ultra-fast pulses and covers a near-IR spectrum ranging from 750~1000 nm, providing capability of SEE testing with TPA and SPA lasers.

Testing, packaging and integration

➤ Packaging and FA analysis

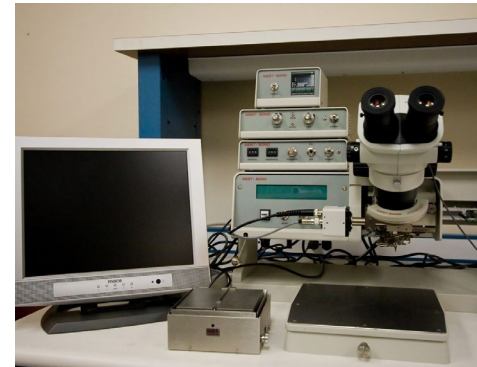


**Nanonex NX-2500
Nanoimprinter**



PCB printing and SMT

Milling
machine



Bonder



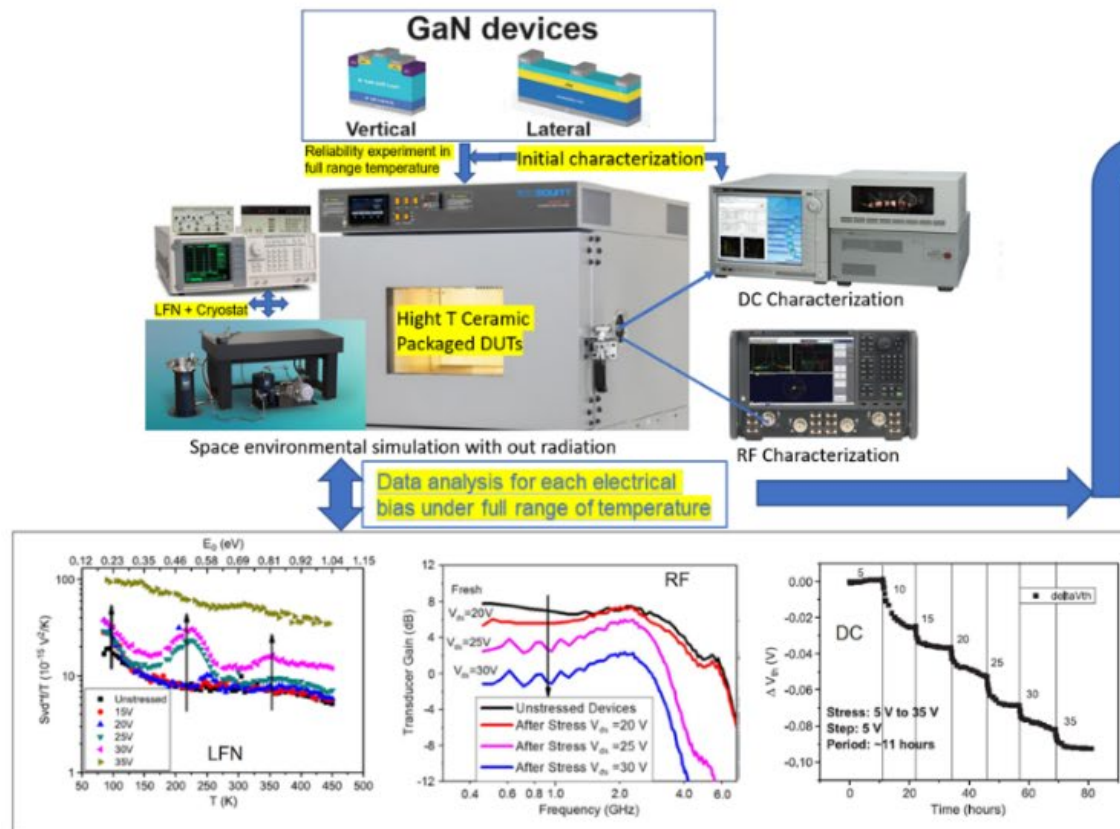
Reflow Machine



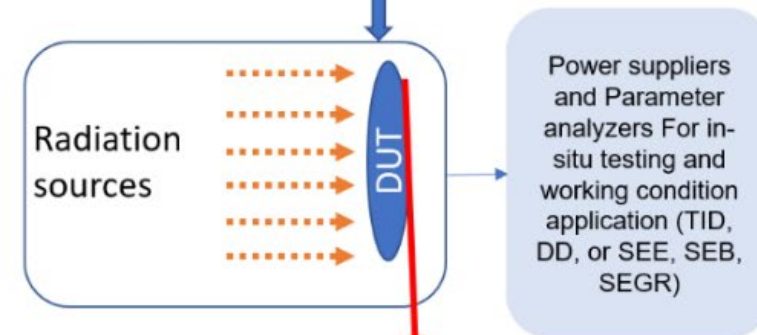
Inspection

Reliability and heavy ion induced single event effects in GaN

➤ Experimental details/Hands-on experience



- Understanding electrical stress induced degradation, defect evolution impacted by combination of stress and Temperature
- Developing reliability evaluation methodology for space application



Thermal control setup for variety of temperatures to simulate space and defense mission environments

Data analysis + Simulation

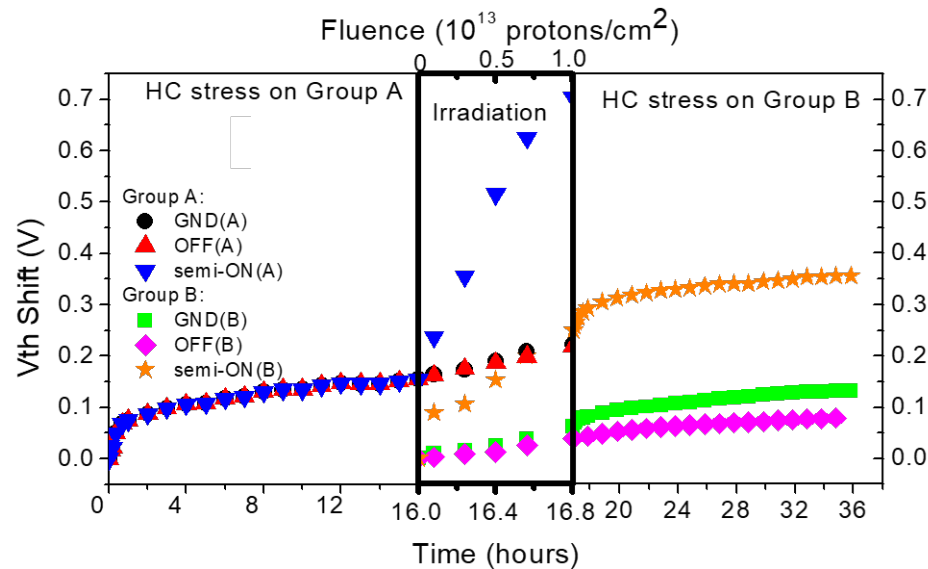
Reliability evaluation methodology for application in harsh environment with combination of radiation, electrical stress and temperature

- ❖ DC Electrical characterization for V_{th} , I_{ON} , I_{off} , G_m , I_G
- ❖ RF characterization for f_{max} , f_{cutoff} , $Gain_{output}$
- ❖ LFN vs T characterization for defects evolution
- ❖ TCAD Simulation to help with understanding and improved structural design

Reliability and heavy ion induced single event effects in GaN

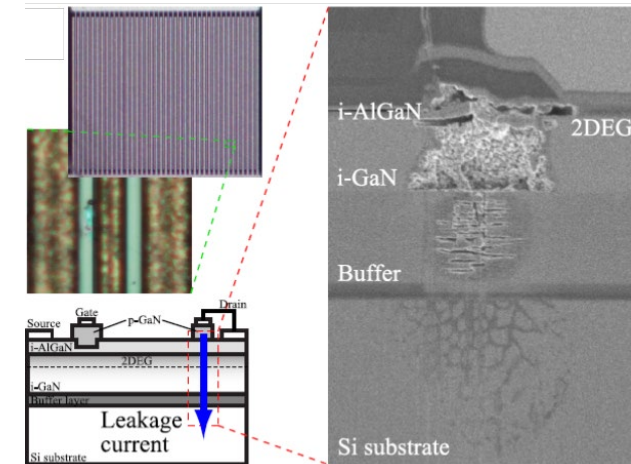
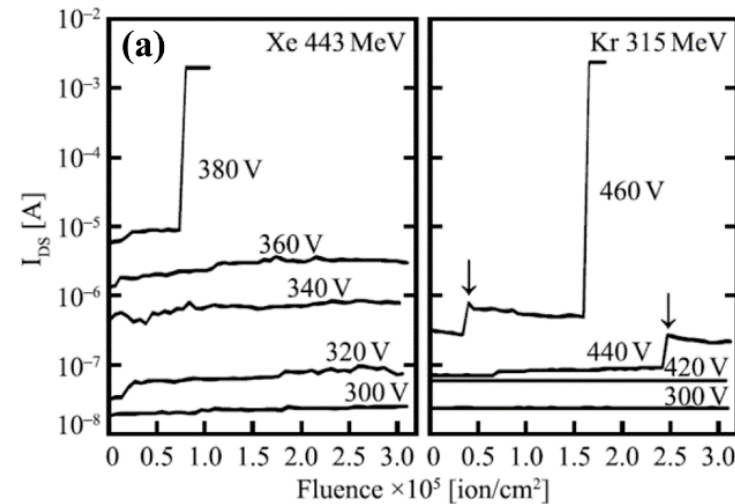
➤ Previous study in GaN HEMTs and power diodes

Low energy proton



Combined Effects: High Field Stress and Proton
Irradiation: V_{th} Shifts and G_m degradation

Heavy ion



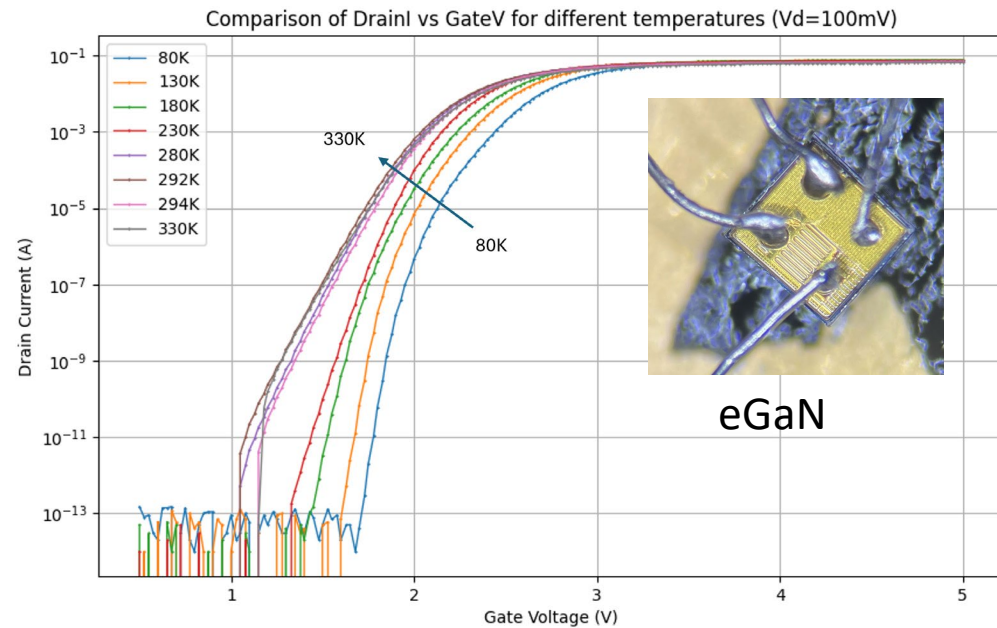
Normal Incidence Ion Strike induced Source-Drain Short: **SEB**

Electrical bias can significantly affect radiation effects in devices

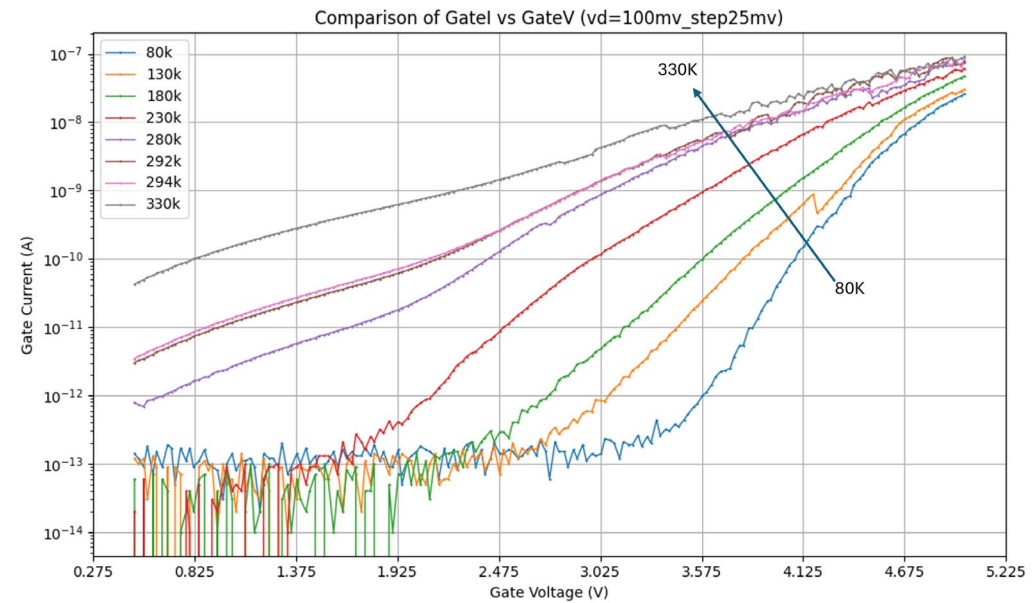
- J. M. Lauenstein, "Wide Bandgap Power SiC, GaN, Radiation Reliability", NSREC 2020 Short Course (2020)
- J. Chen, Y. S. Puzyrev, R. Jiang, E. X. Zhang, M. W. McCurdy, D. M. Fleetwood, R. D. Schrimpf, S. T. Pantelides, A. R. Arehart, S. A. Ringel, P. Saunier, C. Lee., *IEEE Trans. Nucl. Sci.*, vol. 62, no. 6, pp. 2423-2430, Dec. 2015
- D. M. Fleetwood, E. X. Zhang, R. D. Schrimpf, and S. T. Pantelides., *IEEE Trans. Nucl. Sci.* vol. 69, no.5, pp.1105-1119, May 2022.
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Reliability and heavy ion induced single event effects in GaN

➤ Preliminary results on eGaN HEMTs



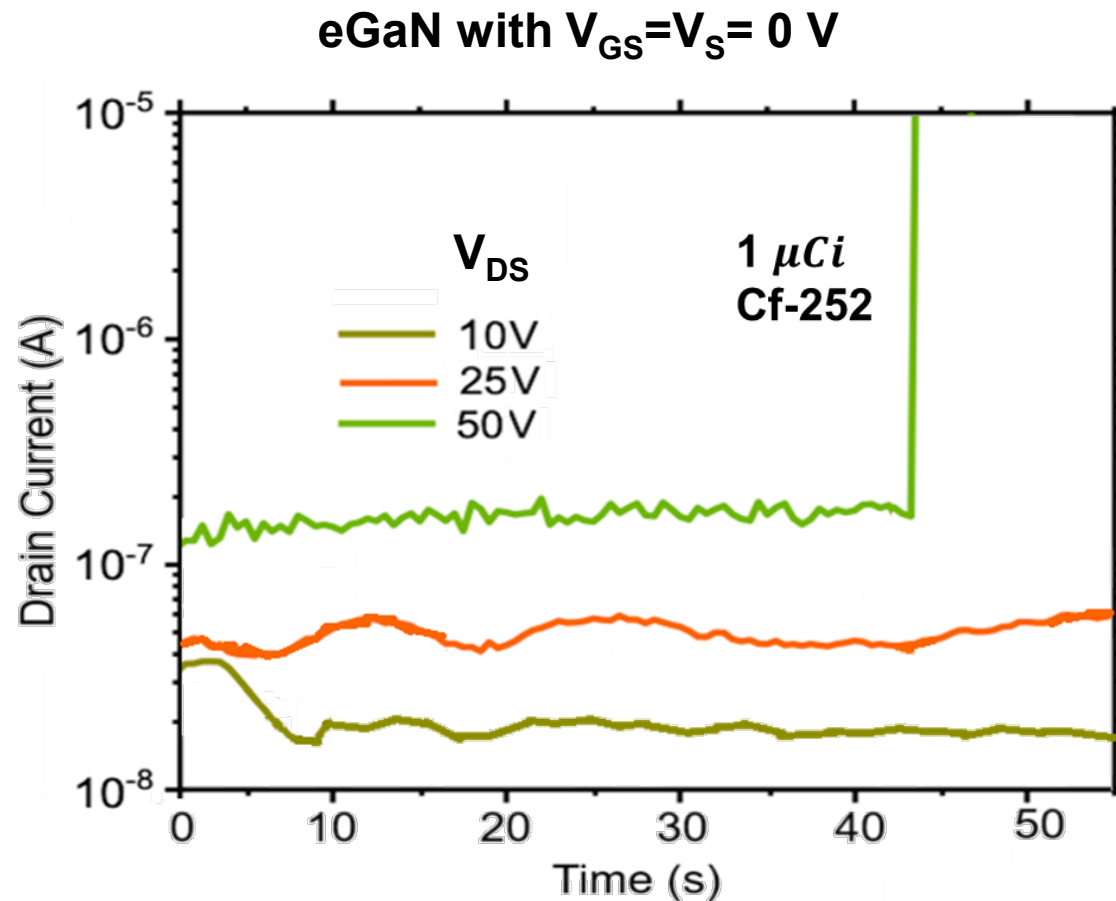
- Temperature dependent $I_D - V_G$ for eGaN



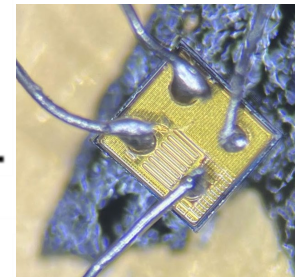
I_{GS} vs V_{GS} at $T = 80\text{ K} \sim 330\text{ K}$

Reliability and heavy ion induced single event effects in GaN

➤ Preliminary results on eGaN HEMTs

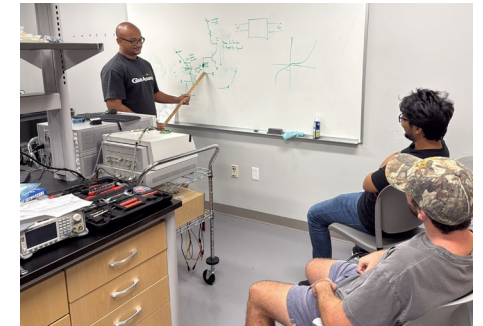
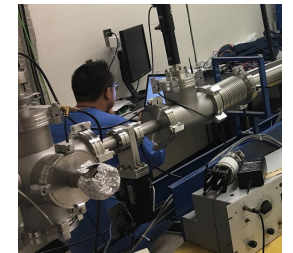
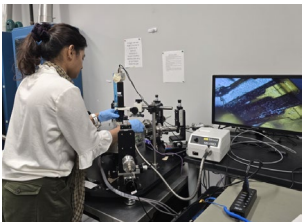


- Drain Current vs. time for SEB test under Cf-252 with $V_D=10, 25, 50$ V.



Future Plans

- **Design and build rad-hard GaN RF and power devices.**
 - ❖ Using simulation tools to design structures with improved breakdown voltage and high efficiency charge and heat dissipation (On-going).
 - ❖ Combination of experiments, simulation and data verification through heavy ion experiments.
- **Radiation Effects and Reliability in emerging technologies.**
- **Student training and workforce development.**
 - **Electronics Parts Engineering Certificate program (17 current enrolled)**




Electronic Parts Engineering (GC)

Students graduated from this program will be qualified to:

- Conduct engineering assessments and reviews all EEEE parts for reliability-related performance.
- Support projects with part selection that maximizes reliability appropriate for the project life cycle while considering schedule and cost constraints.
- Oversee part procurement and works with parts manufacturers to ensure compliance with engineering requirements.
- Establish test plans for EEEE parts, including screening and qualification test campaigns and any required failure analysis, and evaluates test results for proper disposition for space flight usage.
- Assess the capabilities of new EEEE technologies and suppliers for spaceflight use.

**New for Fall
2024**

**GRADUATE PROGRAMS:
CERTIFICATE IN ELECTRONIC PARTS ENGINEERING**



PROGRAM HIGHLIGHTS:

- This certificate is part of a new partnership between UCF and the NASA Electronic Parts and Packaging Program.
- Courses are available both online and in-person.

COURSEWORK INCLUDES:

- Semiconductor Material and Device Characterization
- Reliability Engineering
- Power Electronics
- Radiation Effects and Reliability
- Introduction to Space Electronics
- Radio Frequency Integrated Circuit Design
- Semiconductor Device Modeling and Simulation
- Introduction to Sensors
- Field-Programmable Gate Array Design

For complete program requirements, see the UCF Graduate Catalog at graduatecatalog.ucf.edu

ECE.UCF.EDU

Electrical and Computer Engineering

DEVELOP EMERGING TECHNOLOGY WITH A GRADUATE CERTIFICATE IN ELECTRONIC PARTS ENGINEERING

There is a global need for electronics that are safe, reliable and trustworthy, particularly for environments with extreme levels of heat, humidity or radiation. With a graduate certificate in electronics parts engineering from UCF, you'll be ideally positioned to manufacture the integral components that power everything from cell phones to satellites.


You'll learn how to assess engineering equipment, verify the reliability of electromechanical components and ensure that the manufactured elements are produced on time and on budget. While working with parts manufacturers, you'll establish testing plans, including screening and qualification test campaigns and any required failure analyses, and evaluate test results for proper disposition for space flight usage.

The graduate certificate is part of a partnership with the NASA Electronic Parts and Packaging Program, an initiative designed to address a shortage of parts engineers in the workforce. As part of the program, you'll have the opportunity to conduct hands-on training at the Kennedy Space Center, helping assess the capabilities of new electronic parts engineering technologies and suppliers for spaceflight use.

Earn the certificate and change your career trajectory by supporting the rapidly growing space industry, as well as critical infrastructures that rely on microelectronic devices and integrated circuits in harsh environments.

LEARN MORE >>>

**GRADUATE PROGRAMS:
CERTIFICATE IN ELECTRONIC PARTS ENGINEERING**



ABOUT THE UCF DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

At the UCF Department of Electrical and Computer Engineering, we strive to achieve national and international prominence in graduate study and research. We boast an outstanding faculty that is engaged in cutting-edge research through several highly competitive, prestigious grants. As a graduate student, you have the opportunity to pursue research in an area of your interest under the tutelage of our faculty.

- Our research faculty received more than \$6 million in funding over the last academic year.
- Our electrical and computer engineering programs are consistently ranked by U.S. News and World Report.
- The department has formed partnerships with pioneers such as Texas Instruments, AMD and Intel to provide internship opportunities for its students.
- UCF is located in Orlando, close to industry giants such as Lockheed Martin, Siemens Energy, Northrop Grumman and NASA's Kennedy Space Center.

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Electrical and Computer Engineering

INTERNATIONAL APPLICANTS:

Fall — Jan. 15
Spring — July 1
Summer — Nov. 1

Program Highlights:

- Interdisciplinary
- Backgrounds: EE, ME, MSE
- Syllabi available
- 40% of MS in EE/CpE



Modality	FL-Resident	Non-FL Resident
In-Person/Hybrid (Fully Online)	\$369.15 (\$327.32)	\$1,194.05 (\$1,151.72)

Certificate Program Coordinator: Dr. Enxia Zhang (Enxia.Zhang@ucf.edu) |
Department of ECE, Grad. Program Director: Dr. Mingjie Lin (Mingjie.Lin@ucf.edu)

Glance at certificate program kick off

