Reliability Test Station

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Overview

• Turnkey vs. In-house
• Electrical Stress Protocols
• System Specifications & Features
• UF Semiconductor Reliability System
• Development
## Turnkey vs. In-house

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<tr>
<th></th>
<th><strong>Turnkey</strong></th>
<th><strong>In-house</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Timeline</strong></td>
<td>Purchase lead time</td>
<td>On-going</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td>Proven</td>
<td>Custom design</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Determine Lifetimes</td>
<td>Research</td>
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<tr>
<td></td>
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<td>Determine failure mechanisms</td>
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<tr>
<td><strong>Test Types</strong></td>
<td>Industry standards</td>
<td>Flexible</td>
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<tr>
<td>DC Drain Gate</td>
<td>0-100V, up to 4A, 400W max 0-18.5V, up to 200mA</td>
<td>0-60V, up to 6A, 300W max ±10V, up to 20mA</td>
</tr>
<tr>
<td>RF</td>
<td>600MHz-3 GHz 2-18 GHz 58-60 GHz 900MHz-10GHz 36-40 GHz 76-78 GHz</td>
<td>1.8-2.2 GHz expandable with additional hardware</td>
</tr>
<tr>
<td>Temperature</td>
<td>50° to 250° C</td>
<td>25° to 250° C</td>
</tr>
<tr>
<td>Optical</td>
<td>NA</td>
<td>Research with wavelength and intensity</td>
</tr>
<tr>
<td>Thermal Imaging</td>
<td>NA</td>
<td>IR, Micro Ramon additional hardware</td>
</tr>
<tr>
<td>Pulse</td>
<td>1-100kHz</td>
<td>Up to 80MHz</td>
</tr>
<tr>
<td>Data Storage</td>
<td>Independent test files</td>
<td>SQL database</td>
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</tbody>
</table>
Electrical Stress Protocols

- Look for dominant factor causing degradation and is there recovery during OFF-state (trap generation)
- Ambient (oxidation, hydrogen effects)
- Field distributions (including inspection of non-uniformity in gate dimensions)
- Visual inspection, dc, rf, base noise spectra (f,V)-check for high leakage, etc.
- Define failure (e.g., often 10-20% degradation in HBT current)
System Specifications & Features

- 32 Device Capacity
- Long-term DC Stress
  - Individual gate bias control (±10Vdc up to 20mA)
  - Drain bias control (0-60Vdc, up to 6A, 300W max)
  - Pulse, step, pulse-step control
- RF Stress
  - 2GHz Gate control
  - Pulse, step, pulse-step control
- Temperature Control & Measurement
  - 25-250° C, peltier heating
  - PID control
System Specifications & Features

- Device Characteristics
  - IV curves
  - Transconductance

![IV Characteristics](image.png)
System Specifications & Features

- Long Term Stress Tests
  - DC & RF
  - Pulse, step, pulse-step
  - Data sampled every second
    - Gate voltage and current
    - Drain voltage and current
System Specifications & Features

- Gate and Drain Pulse Tests
  - High-speed 100kHz @ 10% duty cycle
  - Indicator of traps
  - Apply to gate $V_g$ and measure $I_d$ response
System Specifications & Features

- Data Storage
  - Test Result Record: Timestamp, $V_G$, $I_G$, $V_D$, $I_D$, Temperature
  - SQL Server: Design flexibility, Data queries
System Specifications & Features

- Sequencing
  - IV curve ⇒ DC Stress ⇒ Pulse ⇒ IV curve ⇒ DC Stress …
  - Pile plot IV curves
UF Semiconductor Reliability System

Bias & Control

Gate Bias
NI 9224 analog output
±10 Vdc @ 20 mA

Source Drain Bias
Programmable DC Power Supply
60Vdc @ 3.5A

100kHz 10% duty cycle

RF in

Z load

http://www.testequipmentdepot.com/instek/powersupplies/PSMSeries.htm
A 21st Century Approach to Reliability

UF Semiconductor Reliability System

Data Acquisition

- Power In: NI 9205 Analog Input 16 bit ±10V
- Coupler diode detector
- RF in
- Power In: NI 9205 Analog Input 16 bit ±10V
- Gate Vg, & Ig: NI 9205 Analog Input 16 bit ±10V
- Multiplexor Control: NI USB 6225, NI USB 6255
- Digital Output
- Attenuator (30 dBm)
- Power Out: NI 9205 Analog Input 16 bit ±10V
- Drain Ic
- TI INA196 Current Shunt Monitor 100V/V
- Power Out: NI 9205 Analog Input 16 bit ±10V
- Drain Vd
- NI 9221 Analog Input
- 12 bit ±60V
- NI 9205 Analog Input 16 bit ±10V
- 32:1 Mux
- 32:1 Mux
- 32:1 Mux
- High Speed Pulse
- HS4 14bit 3.125MHz
- High speed pulse measurement
- High Speed Pulse 16 bit ±10V
- NI 9221 Analog Input
- 12 bit ±60V
- Power Out: NI 9205 Analog Input 16 bit ±10V
- Drain Vd
- NI 9221 Analog Input
- 12 bit ±60V
- Attenuator (30 dBm)
- Power Out: NI 9205 Analog Input 16 bit ±10V
- Drain Ic
- NI 9205 Analog Input 16 bit ±10V
- NI 9221 Analog Input
- 12 bit ±60V
- NI 9205 Analog Input 16 bit ±10V
A 21st Century Approach to Reliability
UF Semiconductor Reliability System

RF System Layout

Power Sensors (Reverse) (Forward)

Directional Couplers

Power Sensor (Output)

Attenuator (30 dBm)
A 21st Century Approach to Reliability

UF Semiconductor Reliability System

Device Board

Thermistor slot

TEC 2

TEC 1

Thermistor: McShane TS104-170
TECs: Melcor HOT2.0-65-F2A

Temperature Measurement and Control

http://www.ovenind.com
Development

☑ Single Device Test: IV or DC

- Multiple Device Testing
  - Multi-threading single device tests

- High-speed Pulse Test
  - Integrate existing hardware
  - Implement Switching network

- Sequencing
  - Software development

- RF Testing
  - Tuning expertise

- Optical pumping
  ★ PhD research topic