Ceramic and Metal Repackaging of Plastic Encapsulated Microcircuits for Hermetic Solutions

Topic: Alternate Grade Parts for use in Harsh Environments

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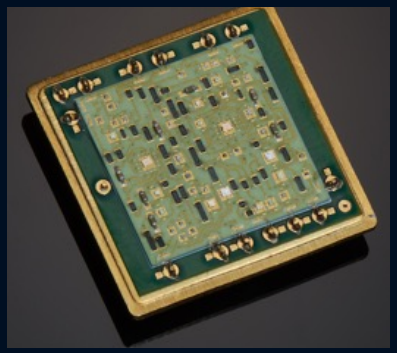
Microcircuit Component and Circuit Card Design and Assembly Manufacturer

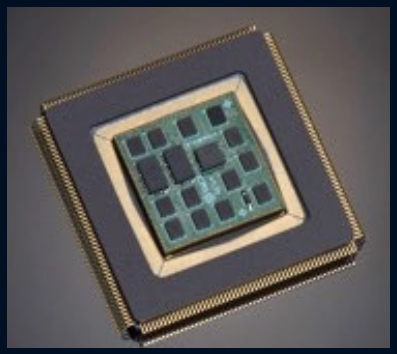
platinum REGISTRATION, INC.
AS9100:2016 - ISO 9001:2015
CERTIFIED

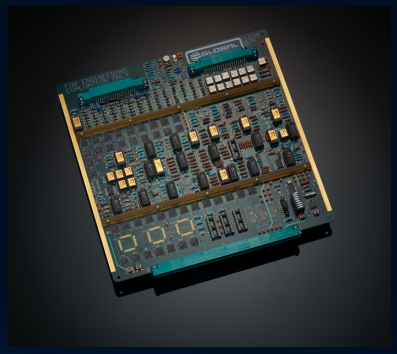
www.GCI-Global.com

Introduction To Global Circuit Innovations

- Founded 2006 in Colorado Springs, Colorado - 27 Employees
- Established design and manufacturing engineering solutions house for Industrial and DoD electronics in extreme environments, rugged COTS replacements, and electronics obsolescence solutions
- Thorough understanding of Integrated Circuit (IC) device physics, fabrication processes, design, and potential failure mechanisms
- GCI currently holds 20 patents, with 2 pending





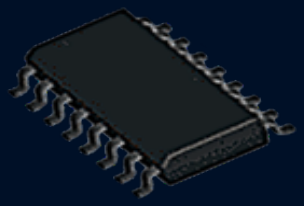


GCI's ***DER***™ and ***DEER***™ Technologies and Benefits

- ***DER***™ - Die Extraction and Re-Assembly: Removal of Die from either Plastic or Ceramic Package for Re-Packaging within any other Package.
- ***DEER***™ - ***DER***™ Process, but with Gold Ball Remnant Removal Followed by ENEPIG Die Pad Processing (Electroless Nickel, Electroless Palladium, and Immersion Gold Plating)
- Increased High-Temperature IC Reliability (150° C - 250° C Exposure) due to Ceramic Package Integrity and Removal of Gold Bond to Aluminum Die Pad Interface
- Increased Operating Temperatures due to Greater Heat Transfer Coefficient for Ceramic Package vs. Plastic Package
- Obsolescence Solutions by Increasing Inventory Selection of Potential Donor Stock (larger Package Selection Possibilities of Desired Component
- Available Die Inventory for Multi-Chip Modules or Prototype Requirements

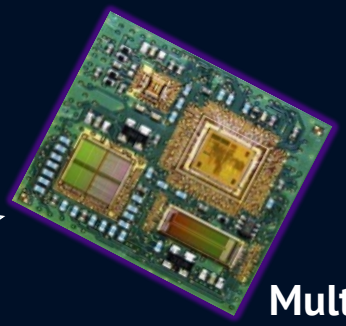
DER™: Die Extraction And Re-Assembly

If one Package Footprint is Obsolete, but the Die can still be Located in Another Package Footprint, or the Die is in an Undesirable Package, the Die can be Extracted and Re-assembled into the Desired Footprint (*DER*™)

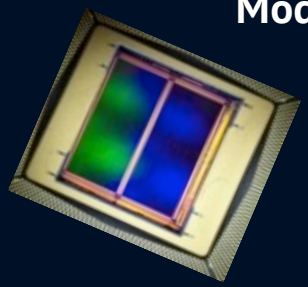


Donor IC Device

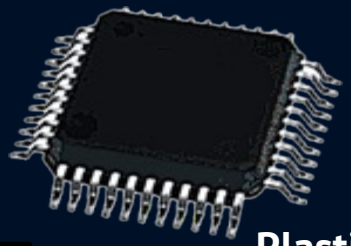
Extracted Die



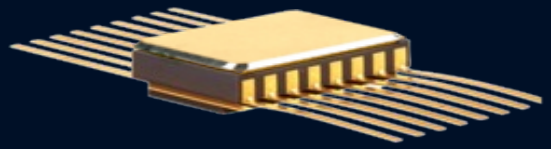
Multi-Chip Module



Ceramic CQFP



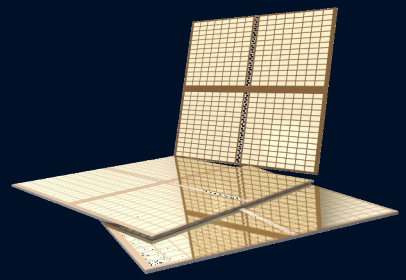
Plastic PQFP



Ceramic Flatpack

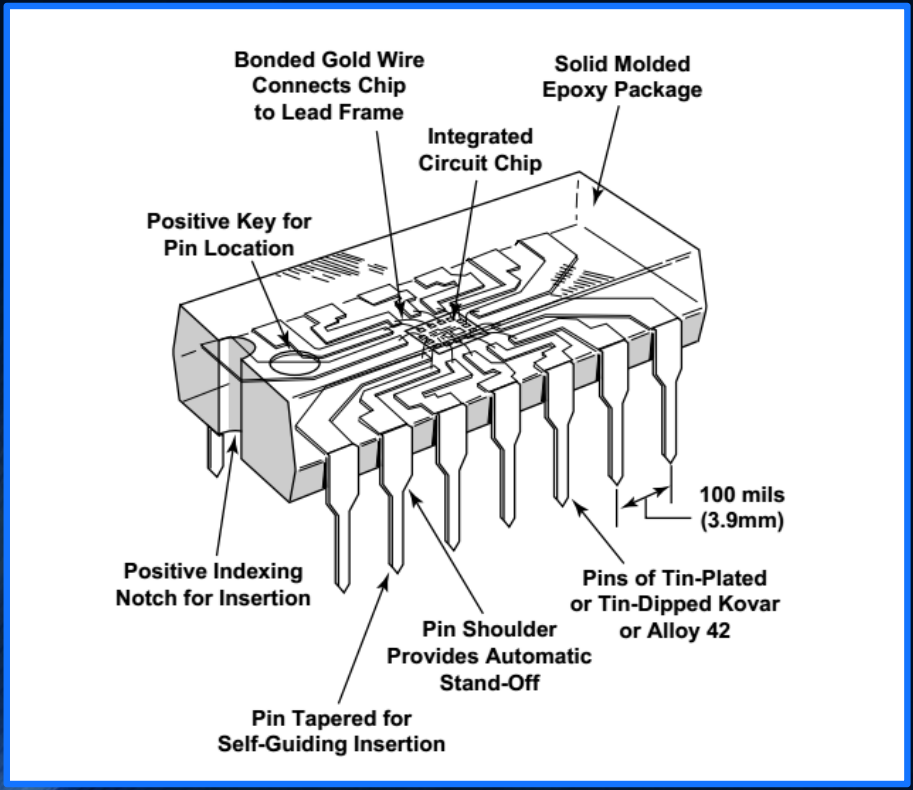
Ceramic DIP Sidebraze

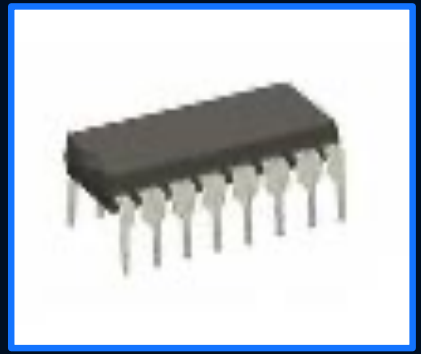
Or the *DER*™ Process Can be Used to Inventory Functional Die



Typical Integrated Circuit (IC) Architecture

The Various Elements of a Plastic Packaged IC Include:
the Die, Leadframe, Leads, and Plastic Encapsulation





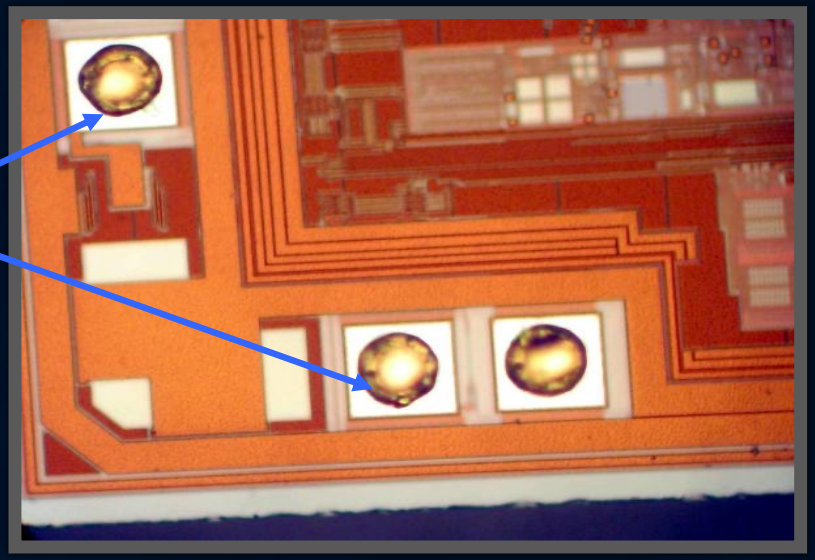
GCI's *DER*™ Technology Up Close

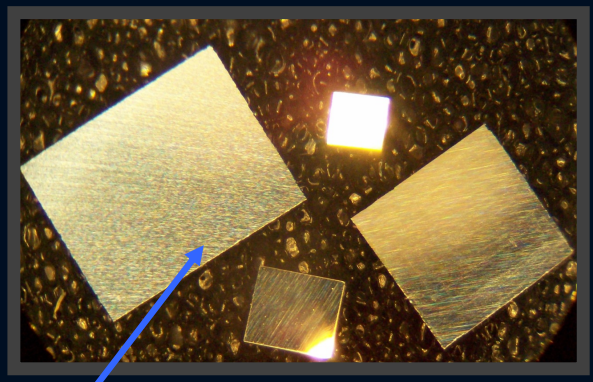
GCI's Extraction Technology Provides Very Clean Front-Side and Back-Side Surfaces

DER™ Relies on Chemical and Mechanical Processes Which Are No More Aggressive Than Those Used During Wafer Fabrication

No Inadvertent Etching of Bond Pads

Die Surface Free of Contaminants





Die Back-Side Surface Free of Contaminants and Returned to Original Mirror Finish

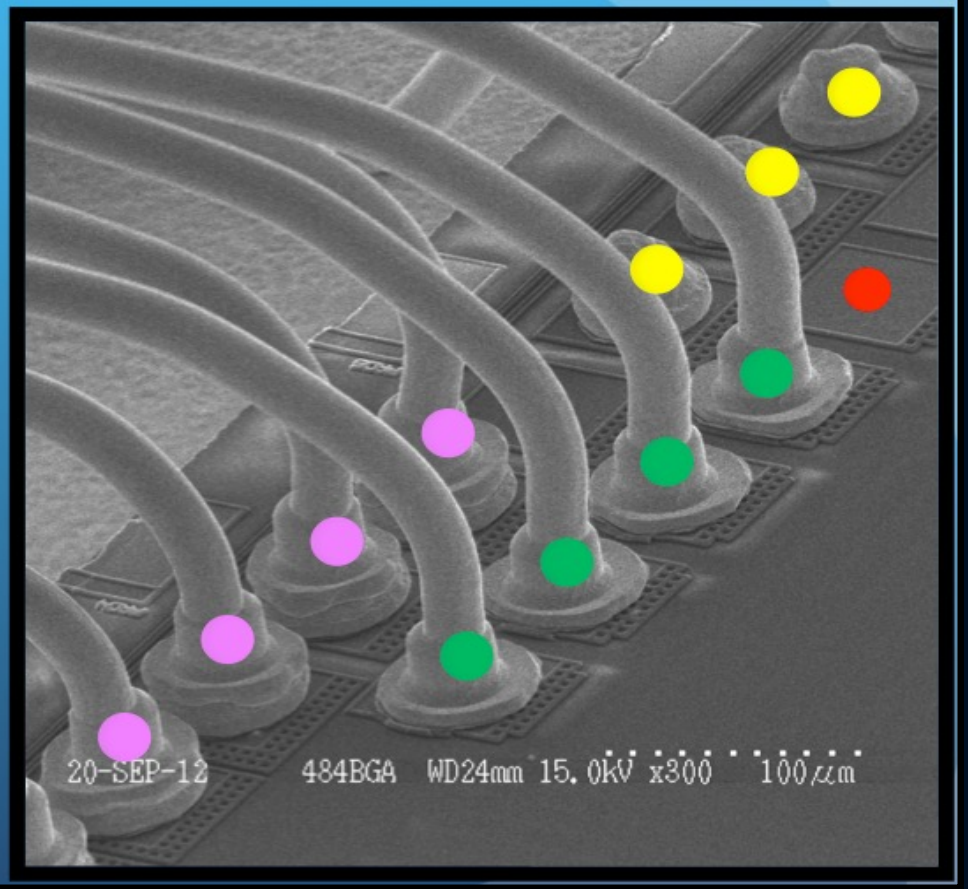
SEM Image of Compound Single Bonds

New Bond Mapping Options Available for Same Die

Multiple Chip Configurations for the Same Die Can be Achieved with Optional Bondouts

Note Four (4) Bond Options:

- Originally Non-Bonded Pad Still Not Bonded
- Originally Non-Bonded Pad Now Bonded
- Previously Bonded Pad Now Not Bonded
- Previously Bonded Pad With a New Compound Bond



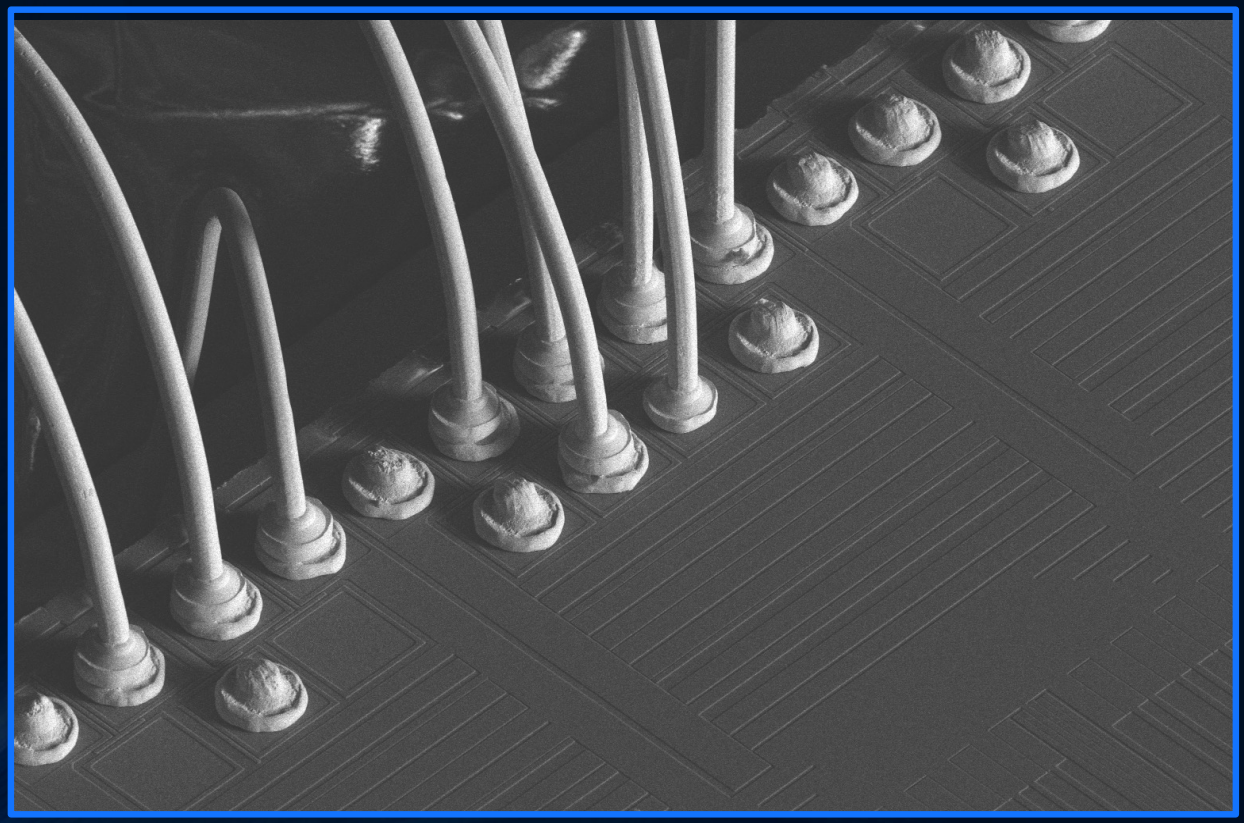
GCI's MIL-STD-883 Qualification

F-16 P/N (GEN#)	Original Package	New Package	Counterfeit Analysis	Variability Analysis	Reliability Study	DER	HERM ASSY	SMD Military 3-T Electrical	100% Screen/ Group A	QCI Group B	QCI Group C 1K Hour Life	QCI Group D	Ext. 2K Hour Life
AT28C64B *Memory Device*	*28-pin SOIC Plastic*	*Ceramic-28 Pin Sidebraze*	Authorized Distributor - Franchised	PASS	PASS	100%	100%	PASS	PASS	PASS	PASS	PASS	PASS
XC4013XL *Field Programmable Gate Array*	*160-pin TQFP Plastic*	*Ceramic-144 CQFP*	Authorized Distributor - Franchised	PASS	PASS	100%	100%	PASS	PASS	PASS	PASS	N/A	PASS

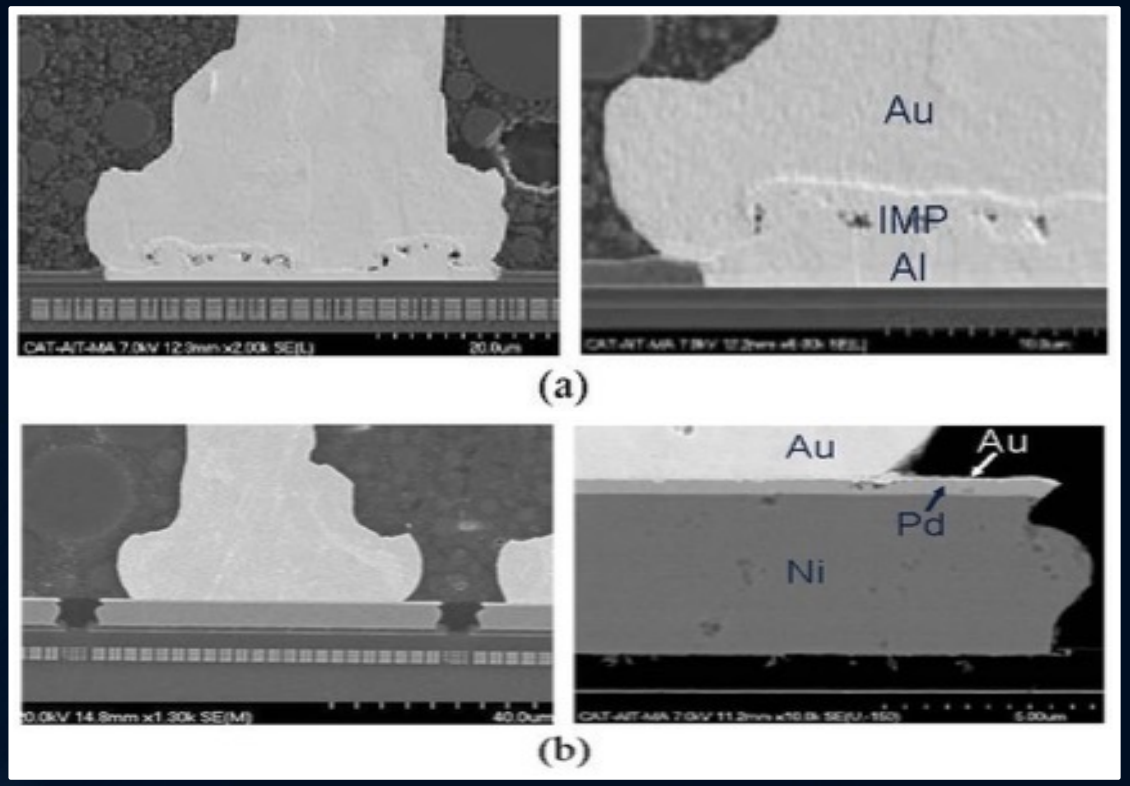
- GCI's *DER*™ Process passed "V" Level Testing per MIL-PRF-38535 and MIL-STD-883 TM 5005 QCI
- QCI Lifetest Extended from 1,000 hours Beyond 4,000 hours
- Results Demonstrate GCI's *DER*™ Process is Highly Reliable in Accordance with MIL-PRF-3853 and MIL-STD-883 Test Method 5005
- U.S. Department of Defense (DoD) MIL-STD 883 Testing
  - Nominal MIL-STD-883 Life Test Requirement of 1000 hours extended to 4000 hours at 125°C
  - IC Burn-In and Life Test Boards Designed for Maximum I/O Signal Level, I/O Loads and VDD Supply Voltage
- *XC4013XL FPGA: Solder Seal Solution with Brazed Sealing Ring Superior to Low-Temperature or High-Temperature Sealing Glass (for Hermetic Lid Sealing)

GCI's *DER*™ Technology Up Close - ReBonding

DER™ - Conventional Process Leaves Gold Ball Remnant in Place for Subsequent Compound Bonding



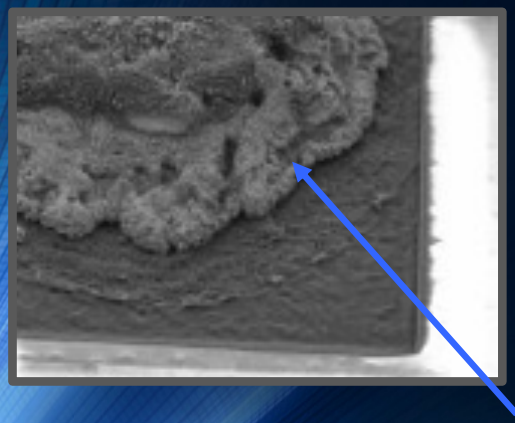
DEER™ Bond Intermetallic Formation



(a) Gold Ball Bond on an Aluminum Pad showing Undesired Inter-metallics.
(b) Gold Ball Bond on an ENEPIG Pad showing no Inter-metallics.

GCI's ***DEER***™ Process Development

- Pad Re-Conditioning Using Gold Ball Removal Followed by ***ENEPIG*** (*Electroless Nickel, Electroless Palladium, Immersion Gold*) Plating
  - Potential Original Poor Ball Bond Quality/Reliability is Removed
  - Subsequent Bonding is Non-Compound with Highly Consistent and Reliable Bond Pull Strength
  - New Bond Pad Surface ***Eliminates*** Possibility of Kirkendall Voiding with Gold Bond Wire at Operating Temperatures Above 150°C



General Appearance of Kirkendall or Horsting Voiding at Bond Pad Location

Specifically, at Gold Ball to Aluminum Bond Pad Interface, the following Undesired Intermetallic Compounds can be formed:

Au_5Al_2, Au_4Al, Au_2Al, $AuAl_2$

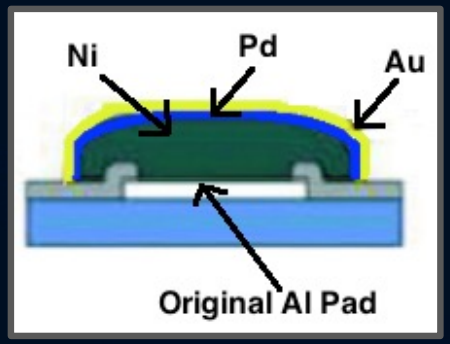
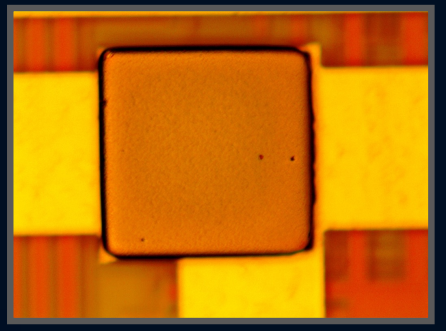
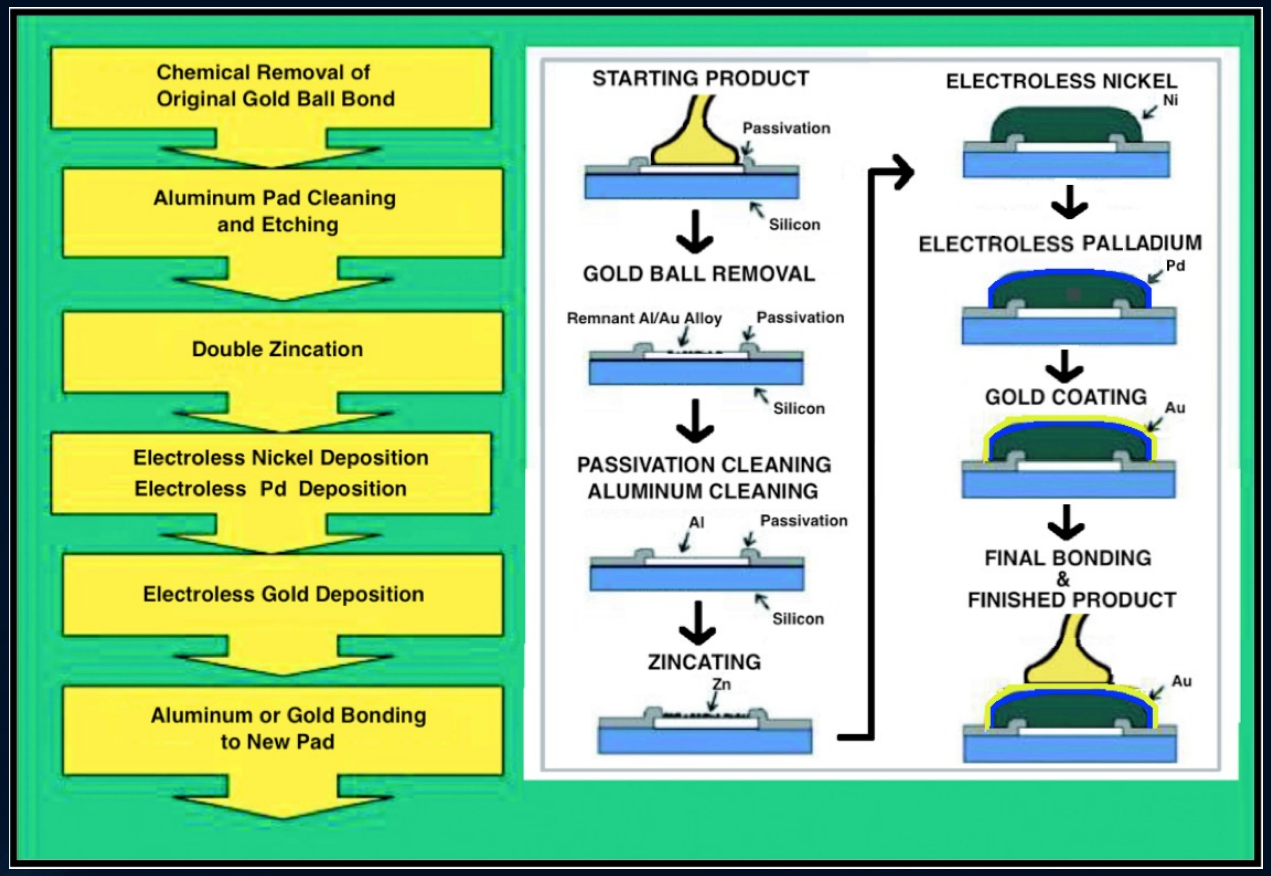


Illustration of *ENEPIG* Pad Plating



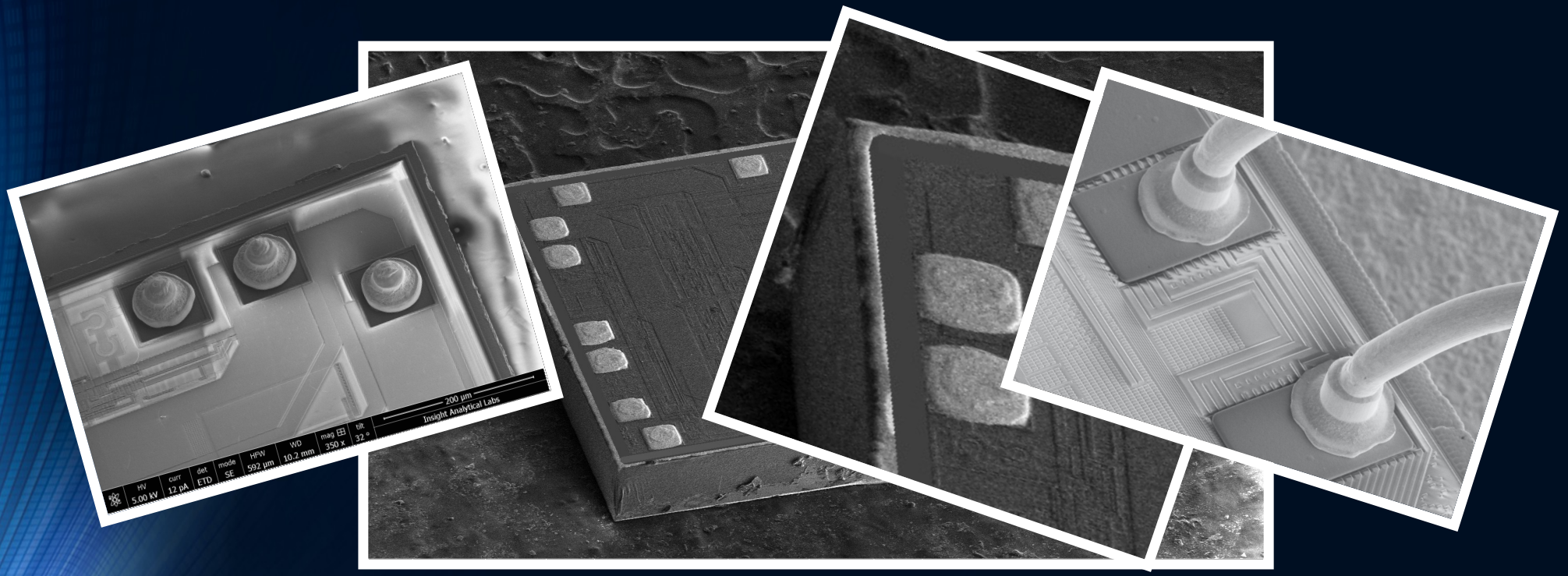
Optical Photo of Actual *ENEPIG* Plated Die Pad

Pad Re-Plating (*DEER™*) – High-Temperature Applications



Process Flow for Pad Re-Conditioning Following Extraction
Targeted Thicknesses: 4 µm Ni, 0.25 µm Pd, 0.04 µm Au

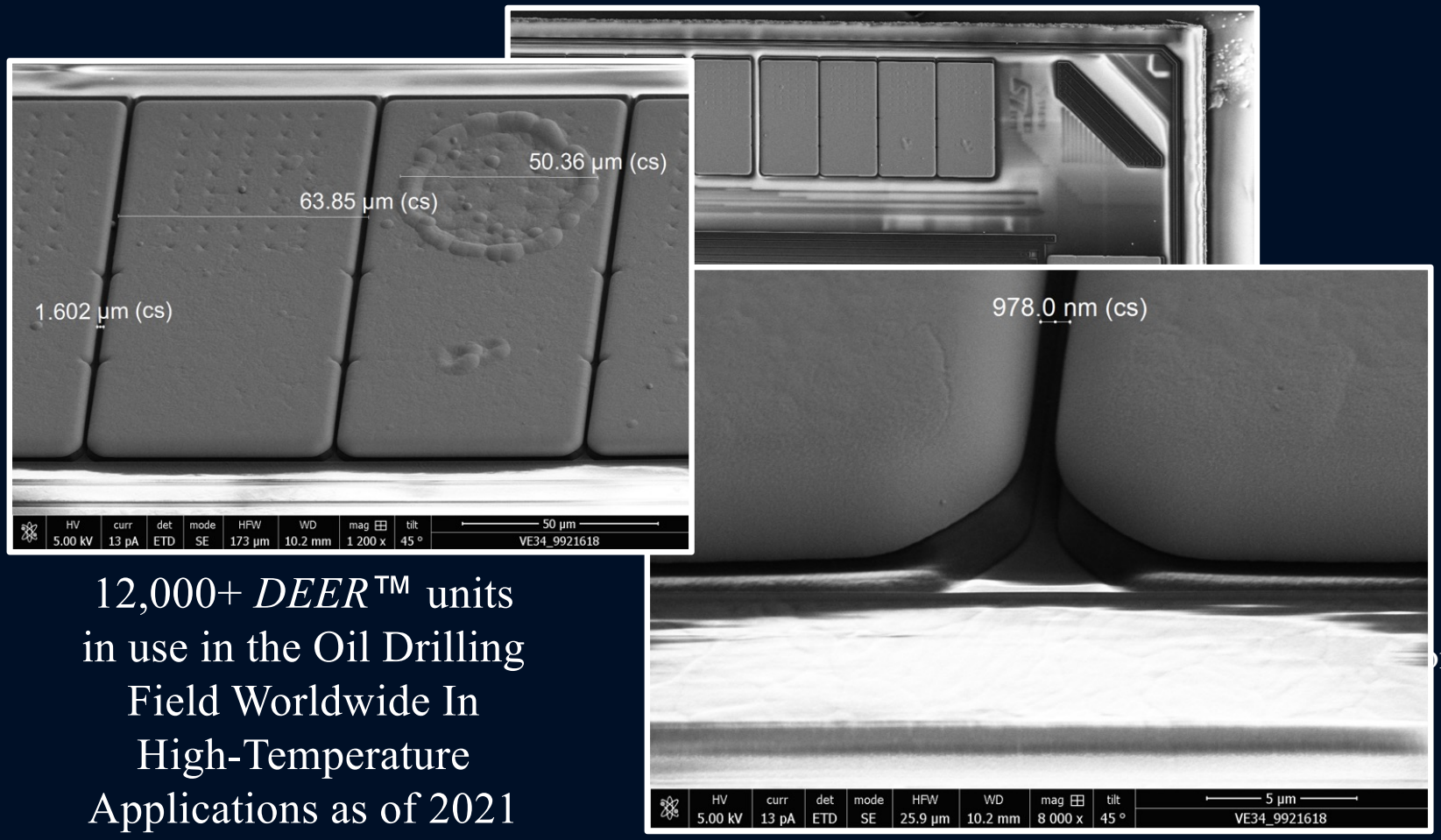
DEER™ Gold Ball Removal, Pad Re-Plating with Electroless Ni/Pd/Au Process (***ENEPIG***)



Aluminum Pad Reconditioning for an Extracted Die

(Target Total Plate Up is 4 – 5 µm)

DEER™ Gold Ball Removal, with *ENEPIG* Pad Re-Plating

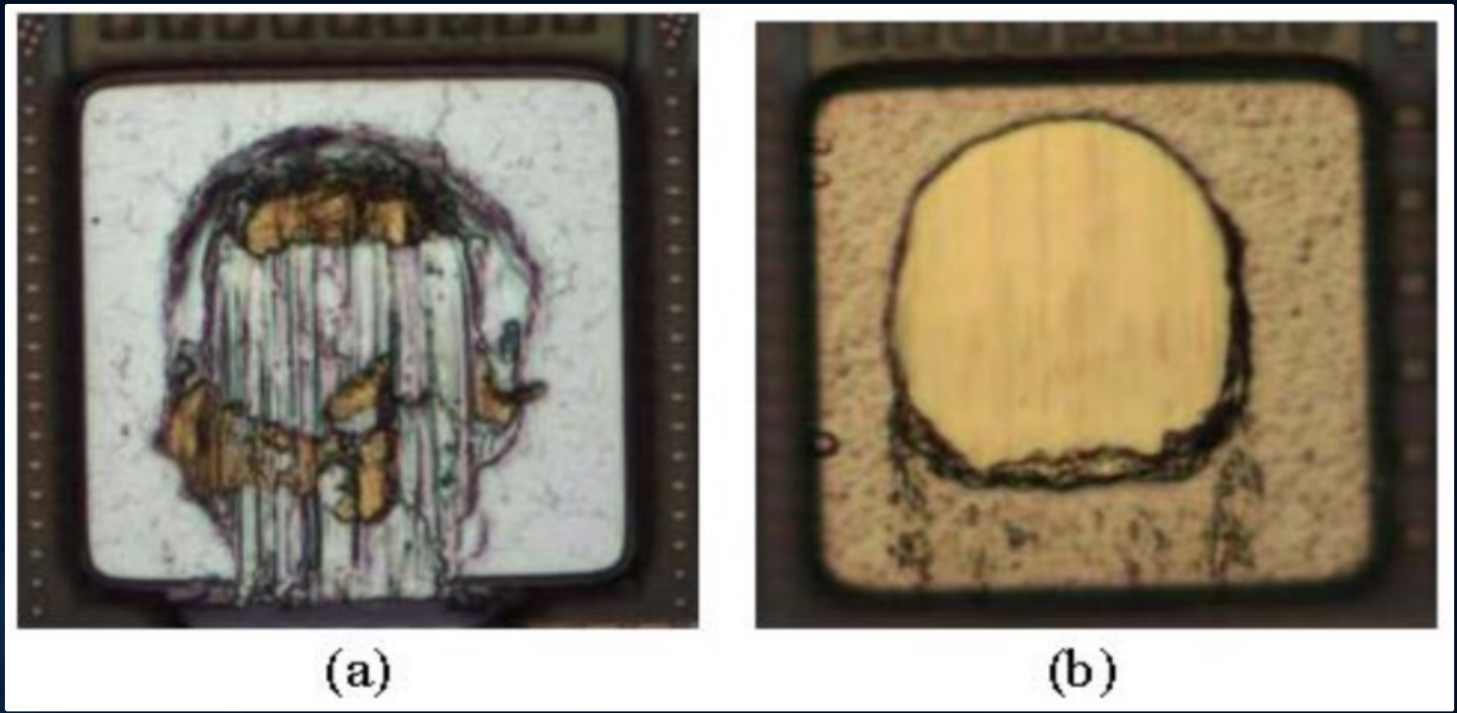


12,000+ *DEER*™ units in use in the Oil Drilling Field Worldwide In High-Temperature Applications as of 2021

DEER™ Gold Ball Removal, with *ENEPIG* Pad Re-Plating

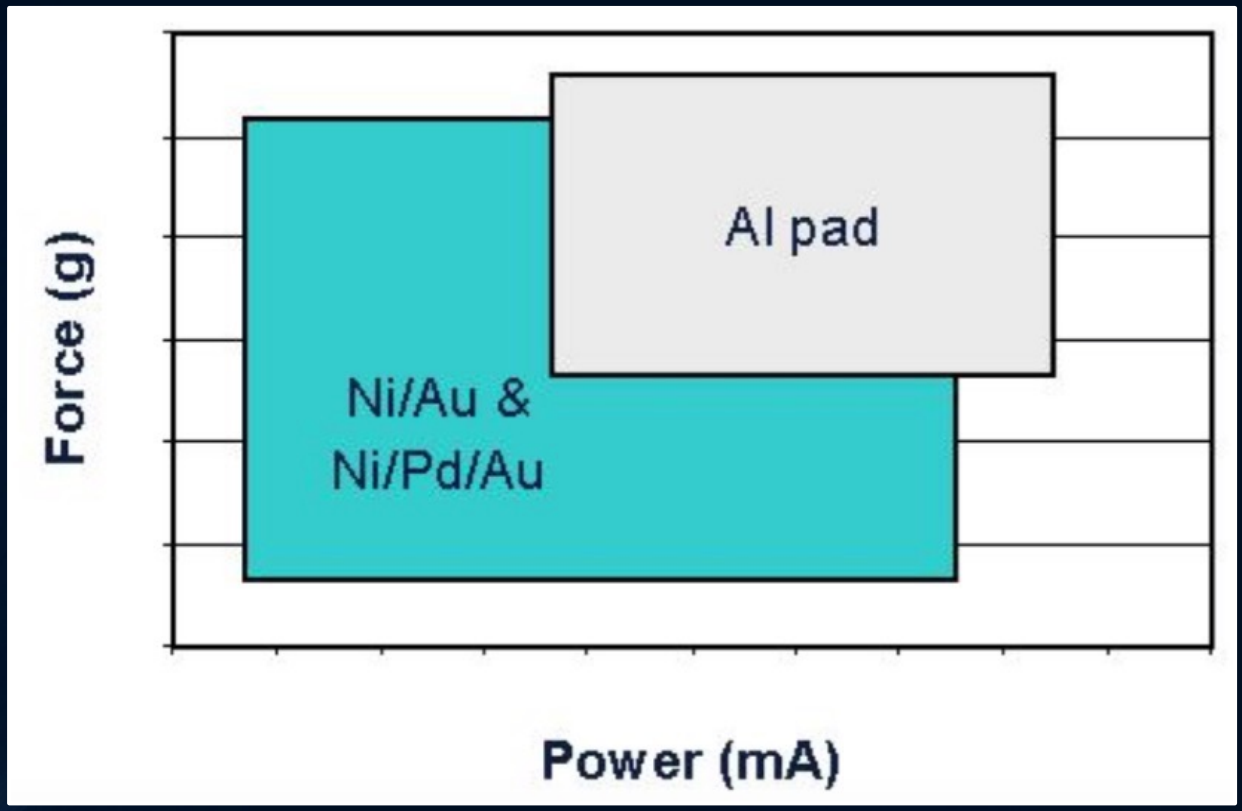
Extraction Lab and Automated ENEPIG Plating Process

DEER™ Bond Shear Results



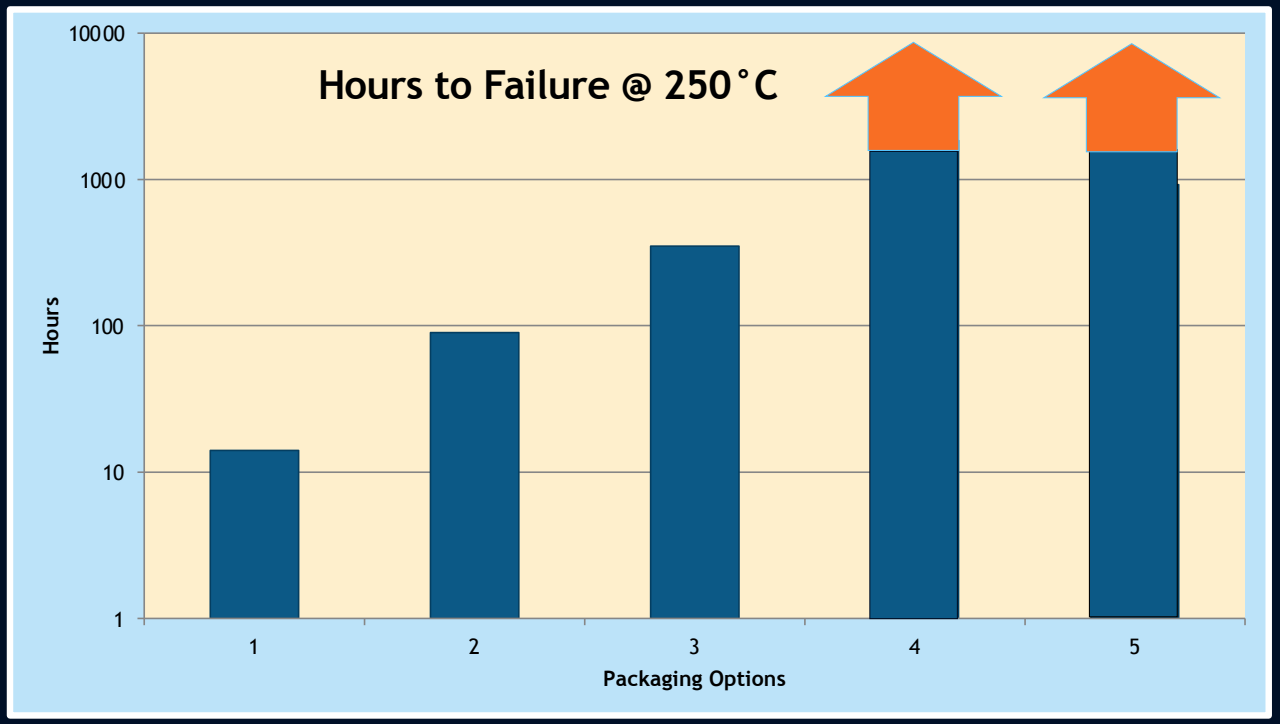
(a) Aluminum Bond Pad after Gold Ball Bonding and Shear Test
(b) ENEPIG Plated Bond Pad after Gold Ball Bonding and Shear Test.

DEER™ Bond Process Window Results



Additional Benefit of ***DEER***™ Technology - Comparison of Wire Bond Process Parameters for Aluminum and ENEPIG Pads.

Ni/Pd/Au Pad *DEER*™ Re-Plating Performance at +250°C



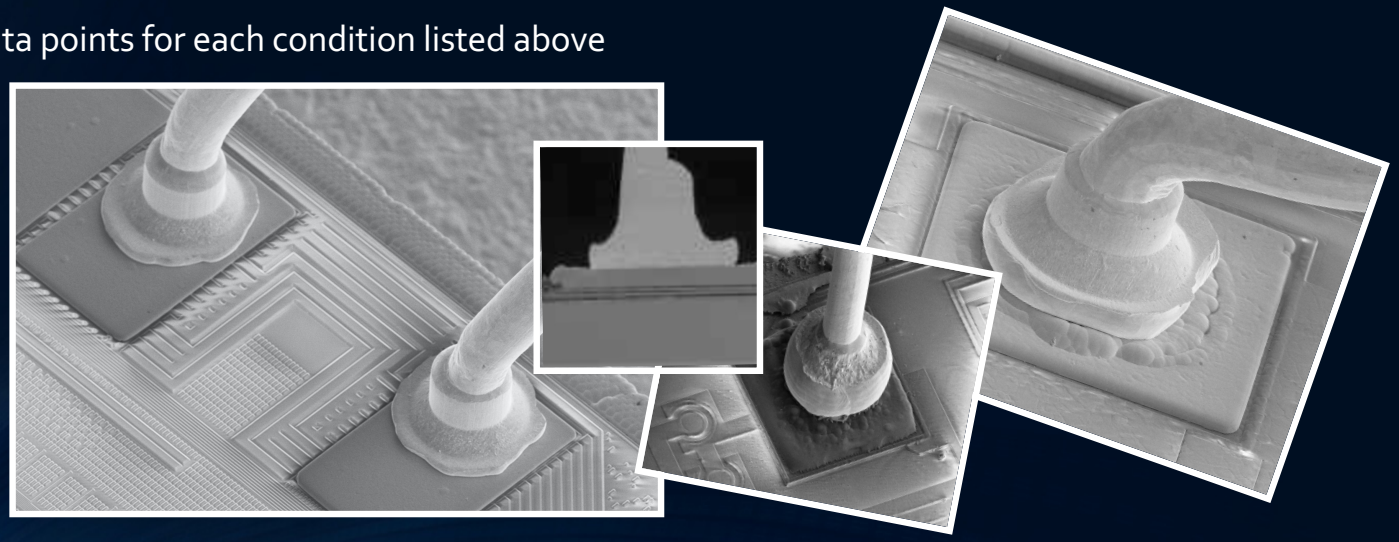
Packaging Option Key:

1 – Standard Plastic (25hr)
2 – Extraction, Standard Ceramic Assembly (*DER*™) (95hr)
3 – Extraction, Hi-Temp Ceramic Assembly (*DER*™) (600hr)
4 – Extraction, Ni/Pd/Au Process, Standard Ceramic Assembly (*DEER*™) (+2500hr)
5 – Extraction, Ni/Pd/Au Process, Hi-Temp Ceramic Assembly (*DEER*™) (+6000hr)

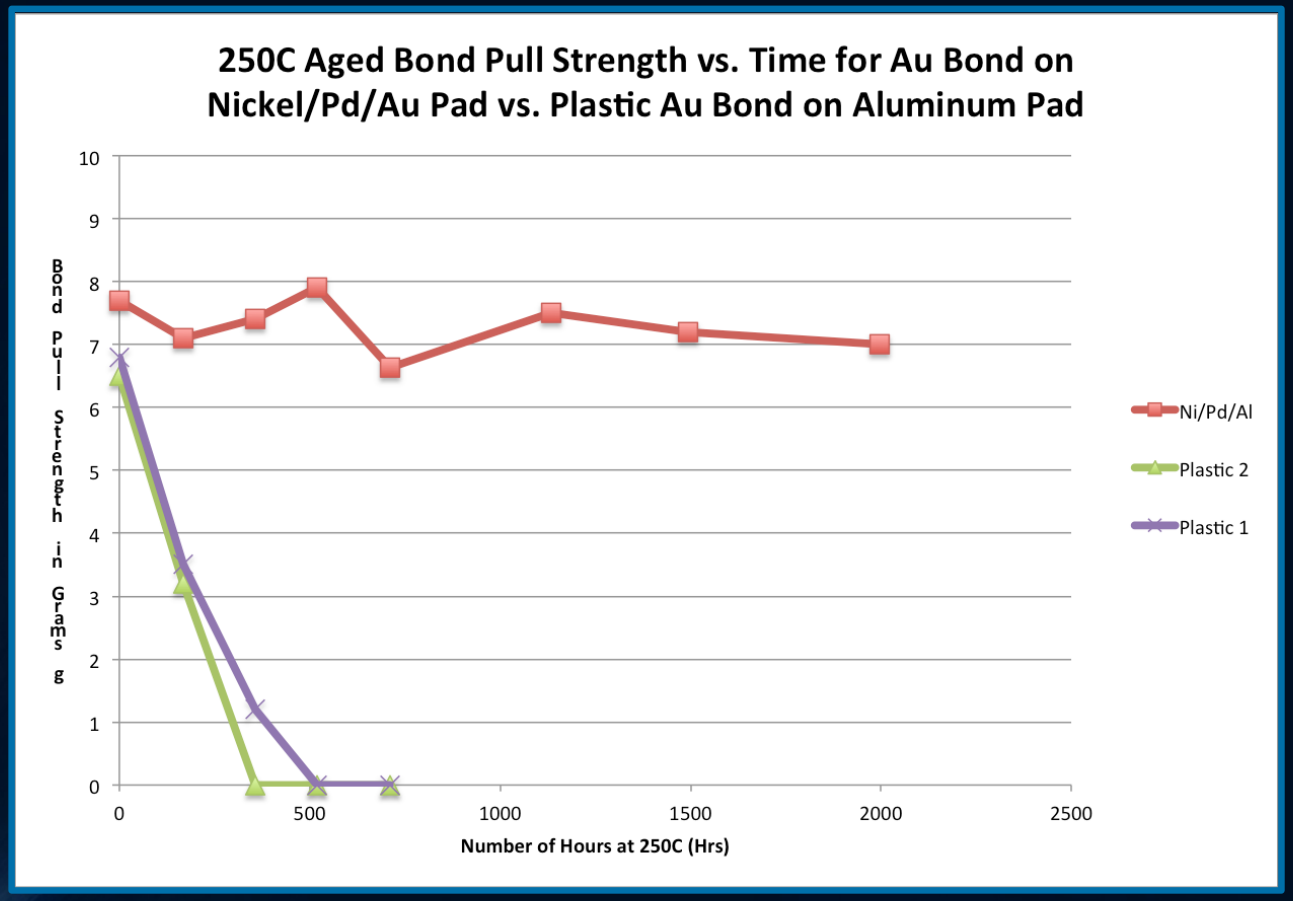
Ni/Pd/Au Pad ***DEER***™ Performance at 250°C

	Avg. Bond Pull Strength	Std. Dev.	Mean-3 SD	Original Plastic Control Unit
Device as Received:	7.154g	1.03g	4.06g	Mean:
Device After Pad Re-Conditioning:				
T= 0 Hr	13.302g	1.52g	8.74g	6.8g
T= 168 Hr (250°C)	12.650g	1.26g	8.89g	3.2g
T= 1000 Hr (250°C)	11.540g	0.90g	8.50g	1.0g
T= 2000 Hr (250°C)	10.913g	0.76g	8.65g	0.0g

Data reflects 16 data points for each condition listed above



GCI's Ni/Pd/Au Pad ***DEER***™ Re-Plating Performance at 250°C



Bond Pull Strength vs. Time at 250°C for ***ENEPIG*** Pad Plating

Contact Information

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