A How-To Guide on Addressing and Resolving IC Obsolescence

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Global Circuit Innovations – Booth 911

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Introduction to Global Circuit Innovations (GCI)

- Founded in 2006 in Colorado Springs, CO
- GCI is an Integrated Circuit (IC) manufacturer specializing in providing IC obsolescence solutions as well as high-temperature, highly rugged, environmentally hardened ICs
- GCI's staff averages over 25 years of semiconductor experience that includes Process Development, IC Design, Assembly, Test, Failure Analysis, Fab Operations, Program Management and Marketing
- GCI has 5 patents issued to date with 10 additional patents pending in our area of IC expertise

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Addressing IC Obsolescence

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Global Circuit Innovations Obsolescence RIF

- In July 2017, GCI was awarded a Rapid Innovation Fund (RIF) contract for $2.75 million from the Office of Secretary of Defense (OSD) to identify, manufacture, test and qualify 20+ IC obsolescence solutions across DoD using GCI's Die Extraction and Reassembly (*DER™*) technology
- In support of this project, GCI engaged in discussions with various USAF depots to identify potential IC obsolescence candidates
- GCI was provided with lists of obsolete ICs across various Bills of Material (BOMs)
- We were surprised to find that 85% to 90% of all obsolete ICs had existing solutions and that only 10% to 15% required *DER™* solutions

Actual IC Obsolescence BOM Review

GCI recently addressed three BOMs on a DoD system containing 58 obsolete ICs:

BOM 1 of 3

- 3 of 3 ICs identified as discontinued by Original Component Manufacturers (OCMs) but are still inventoried at select franchised distributors

BOM 2 of 3

- 19 of 28 ICs identified as discontinued by OCMs but are still inventoried at select franchised distributors
- 5 of 28 ICs have alternate Form-Fit-Function (F3) replacement ICs available at franchised distributors
- 4 of 28 ICs identified as GCI Die Extraction & Reassembly or *DER™* Candidates
  - 3 each 512x8 - OTP ROM
  - 1 each CT3231 - Line Driver/Receiver

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Actual IC Obsolescence BOM Review – (cont.)

BOM 3 of 3

- 15 of 27 ICs identified as discontinued by OCM but are still inventoried at select franchised distributors
- 8 of 27 ICs require additional information from customer to determine best approach
- 3 of 27 ICs have alternate Form-Fit-Function (F3) replacement ICs available at franchised distributors
- 1 of 27 ICs identified as GCI *DER*™ Candidate
    - 1 each DM2816A-250/B - 2Kx8 EEPROM

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Actual IC Obsolescence BOM Review – (cont.)

Summary

37 of 58 – 64% - ICs identified as Obsolete, but are still available
8 of 58 – 14% - ICs F3 replacement ICs are available at franchised distributor
8 of 58 – 14% - ICs in process of acquiring additional information
5 of 58 – 9% - ICs identified as GCI *DER*™ Candidates
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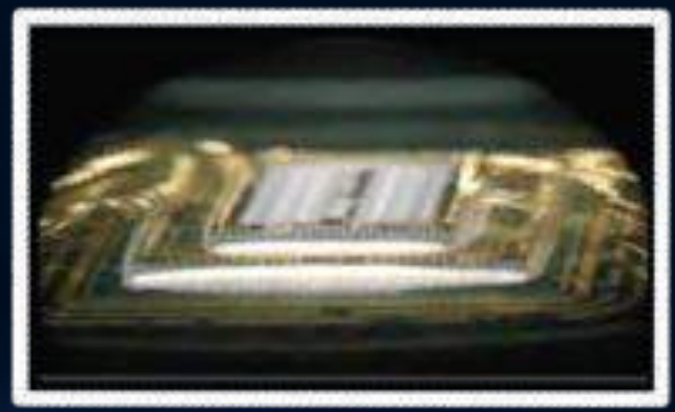
58 of 58 – 100% - Total



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IC Obsolescence – Useful Resources

- We first check SiliconExpert (SiliconExpert.com). We have found this to be an excellent software tool for locating hard-to-find ICs and predicting future obsolescence

- SiliconExpert references multiple electronic component databases with over 1 billion components from over 15,000 suppliers

- SiliconExpert (now owned by Arrow) has an annual subscription fee for use

IC Obsolescence – Useful Resources

- Rochester Electronics (RocElec.com) specializes in obsolete components and is another excellent resource

- Rochester is authorized and licensed by over 70 leading semiconductor manufacturers and purchases obsolete inventory
- Rochester handles franchised distribution of over 200,000 part numbers in stock with 15 billion finished devices in stock
- Rochester manufactures authorized, traceable, certified and guaranteed end-of-life products with over 12 billion die in stock

IC Obsolescence – Useful Resources

- Lansdale Electronics (Lansdale.com) is also a manufacturer of obsolete ICs

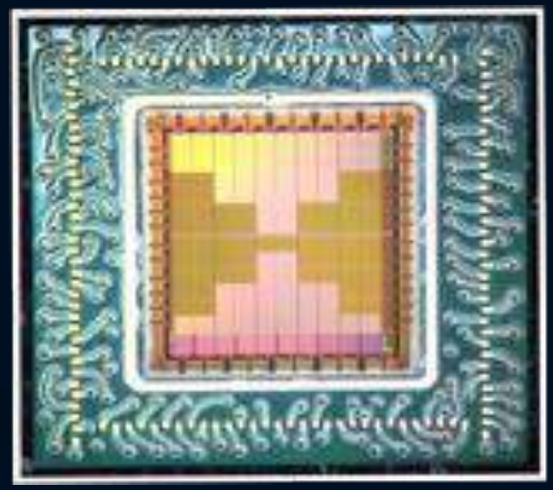
- Lansdale purchases the rights from various OCMs to continue manufacturing IC products that would otherwise be discontinued
- Lansdale was founded in 1964 and is located in Phoenix, AZ
- Lansdale Semiconductor is certified and approved by the Defense Supply Center Columbus (DSCC) as a Qualified Manufacturer (QM) of electronic military components under the MIL-PRF-38535 Qualified Manufacturing List (QML), as well as being an ISO 9001-2008 qualified supplier

IC Obsolescence - Scenarios

We routinely encounter the following scenarios with obsolete ICs on BOM**s:**

1. Obsolete – IC is officially "obsolete" and unavailable at the OCM (e.g., Texas Instruments, Microchip, Xilinx, Micron, etc.), and most distributors (e.g., Arrow, Avnet, Digi-Key, etc.). In many cases, SiliconExpert will recommend qualified franchised sources for these obsolete ICs (e.g., Rochester or Lansdale)

2. Speed Grad**e** – For example, memory with 250ns access time was originally used, but is no longer available. However, an identical IC with 200ns, 150nS or 120ns access time may be available as a valid F3 equivalent drop-in replacement IC. These speed-grades typically use identical die



IC Obsolescence – Scenarios (cont.)

Speed Grade – same memory often offered in multiple speed grades

ATMEL

64K (8K x 8)
Parallel
EEPROMs

AT28C64

Description

The AT28C64 is a low-power, high-performance 8,192 words by 8-bit nonvolatile electrically erasable and programmable read only memory with popular, easy-to-use features. The device is manufactured with Atmel's reliable nonvolatile technology.

AC Read Characteristics

Symbol	Parameter	AT28C64-12		AT28C64-15		AT28C64-20		AT28C64-25		Units
		Min	Max	Min	Max	Min	Max	Min	Max	
t_{ACC}	Address to Output Delay		120		150		200		250	ns
t_{CE} (1)	$\overline{CE}$ to Output Delay		120		150		200		250	ns

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IC Obsolescence – Scenarios (cont.)

Speed Grade – same memory often offered in multiple speed grades

AT28C64 Ordering Information

t_{ACC} (ns)	I_{CC} (mA)		Ordering Code	Package	Operation Range
	Active	Standby			
120	30	0.1	AT28C64-12JC AT28C64-12PC AT28C64-12SC AT28C64-12TC	32J 28P6 28S 28T	Commercial (0°C to 70°C)
	45	0.1	AT28C64-12J AT28C64-12P AT28C64-12S AT28C64-12TI	32J 28P6 28S 28T	Industrial (-40°C to 85°C)
150	30	0.1	AT28C64-15JC AT28C64-15PC AT28C64-15SC AT28C64-15TC	32J 28P6 28S 28T	Commercial (0°C to 70°C)
	45	0.1	AT28C64-15J AT28C64-15P AT28C64-15S AT28C64-15TI	32J 28P6 28S 28T	Industrial (-40°C to 85°C)

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IC Obsolescence – Scenarios (cont.)

Speed Grade – same memory often offered in multiple speed grades

200	30	0.1	AT28C64-20JC AT28C64-20PC AT28C64-20SC AT28C64-20TC	32J 28P6 28S 28T	Commercial (0°C to 70°C)
	45	0.1	AT28C64-20JI AT28C64-20PI AT28C64-20SI AT28C64-20TI	32J 28P6 28S 28T	Industrial (-40°C to 85°C)
250	30	0.1	AT28C64-25JC AT28C64-25PC AT28C64-25SC AT28C64-25TC	32J 28P6 28S 28T	Commercial (0°C to 70°C)
	45	0.1	AT28C64-25JI AT28C64-25PI AT28C64-25SI AT28C64-25TI	32J 28P6 28S 28T	Industrial (-40°C to 85°C)

IC Obsolescence – Scenarios (cont.)

Package and Endurance Options
Memory often offered in multiple options

Package Type	
32J	32-lead, Plastic J-leaded Chip Carrier (PLCC)
28P6	28-lead, 0.600" Wide, Plastic Dull Inline Package (PDIP)
28S	28-lead, 0.300" Wide, Plastic Gull Wing, Small Outline (SOIC)
28T	28-lead, Plastic Thin Small Outline Package (TSOP)
Options	
Blank	Standard Device: Endurance = 10K Write Cycles; Write Time = 1 ms
E	High Endurance Option: Endurance = 100K Write Cycles; Write Time = 200 µs

IC Obsolescence – Scenarios (cont.)

Additional scenarios with obsolete ICs on a BOM:

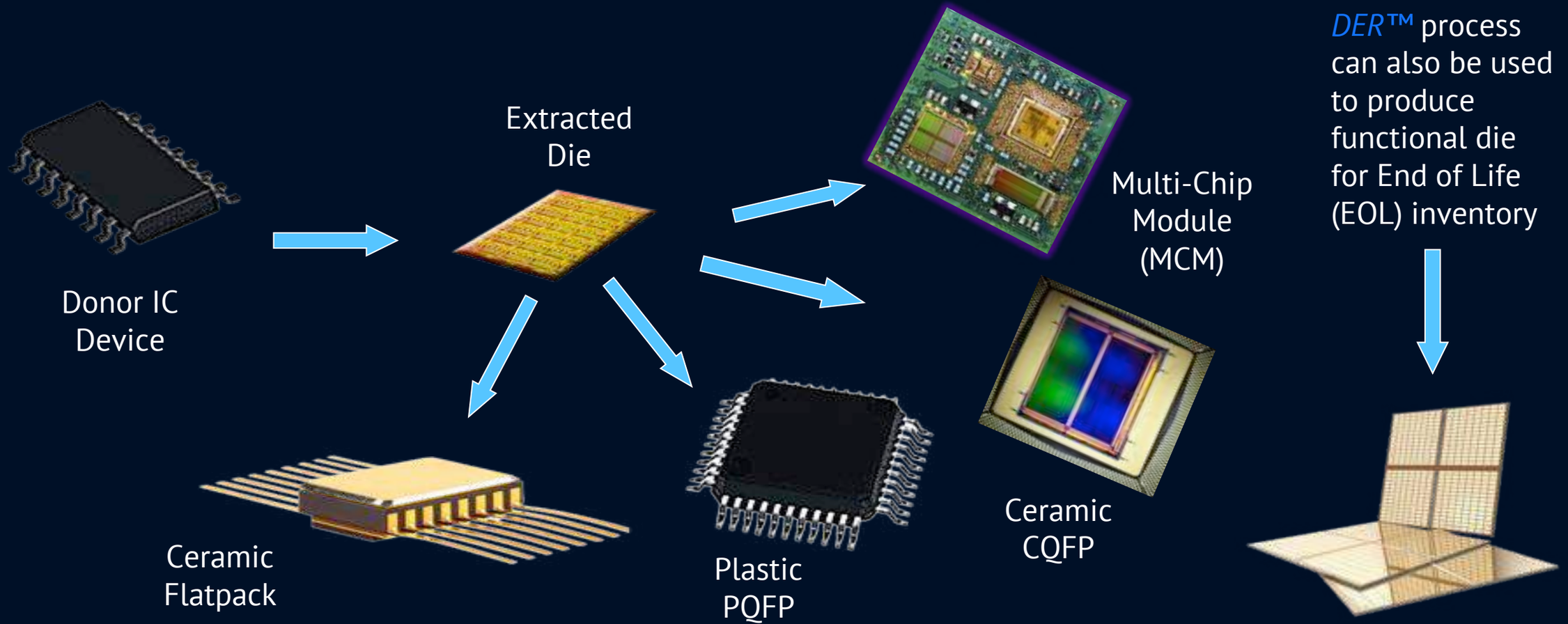
3. RoHS vs. non-RoHS – It is not unusual that a Restriction of Hazardous Substances or RoHS (RoHS1 went into effect 2006) version of an IC is available, when a DoD application requires non-RoHS. RoHS ICs can fairly easily be reworked to remove unleaded solder plating or solder balls and replaced with leaded solder plating or solder balls by many vendors (including GCI)

4. Custom IC at time that DoD specification was creat**ed** – Some ICs were fully custom when DoD requirement was created but there is now a commercially available product with identical or better specifications. GCI recently located a commercially available 500 MHz RF Amplifier that is a F3 replacement for an obsolete custom DoD IC. This was found with an internet search followed by a specification comparison

IC Obsolescence – Scenarios (cont.)

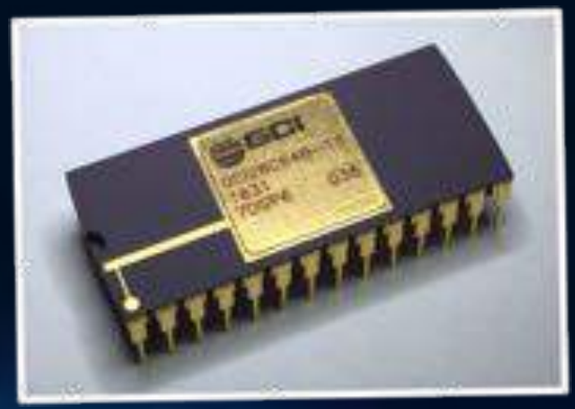
5. Die Extraction and Reassembly (*DER™*)

- Extract die from undesired package and re-assemble into the desired package



IC Obsolescence – Scenarios (cont.)

- GCI's *DER™* provides a *game-changing* solution using franchised donor ICs to resolve the last 10% to 15% of IC obsolescence issues:
  - GCI has provided *DER™* solutions for many DoD customers and, in each case, the final IC has passed full MIL-STD-883 QCI testing
  - Since 2009, GCI has been using our *DER™* technology as a solution for dozens of various ICs (130K units to date) used in production downhole (oil well drilling) applications at 185+° C operating in extreme shock and vibration environments



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IC Obsolescence – Scenarios (cont.)

We encounter the following common *DER™* scenarios with obsolete ICs:

5A. IC is available … BUT ONLY … in the incorrect package

This is the most frequent *DER™* scenario. The solution is to remove the donor die and reassemble it into a different package with the correct footprint

Examples of this are shown on the following slides:

IC Obsolescence – Scenarios (cont.)

Commercial PAL → MIL-STD PAL

OBSOLETE IC

- 5962-8605302KA
- 24 pin plastic SOIC

DONOR IC

- PAL22V10-15PC
- 24 pin PDIP – 300 mil wide
- Purchased from franchised distributor

GCI *DER*™ MANUFACTURED IC

- GCIPAL22V10BA
- 24 pin Hermetic SOIC
- Qualified IAW 5962-8605302KA

IC Obsolescence – Scenarios (cont.)

Commercial Asynchronous FIFO → MIL-STD Asynchronous FIFO

OBSOLETE IC

- IDT7201LA50XEB
- 24 Pin CERDIP – 600 mil wide

DONOR IC

- IDT7201LA50P
- 24 Pin PDIP – 300 mil wide
- Purchased from franchised distributor

GCI *DER*™ MANUFACTURED IC

- GCI7201LA50XEB
- 24 Pin Sidebraze DIP – 600 mil wide
- Qualified IAW IDTLA50XEB

IC Obsolescence – NSWC *DER™*

NSWC Decision Flow Chart to Replace a Needed IC

- **DLA**
  - Zero stock on hand, Terminal Acquisition Advice Code "Y"
- **Distribution Chain**
  - Parts are available but due to no traceability they cannot be utilized
- **FFF Replacement**
  - None found
- **GEM (DLA's General Emulation of Microcircuits Program)**
  - Not an option
    - Electrical reprogramming required
    - Even for 1-time programing, the DIP-8 package is too small for existing memory arrays
- ***DER™* (GCI's Die Extraction & Reassembly Process)**
  - Quick reaction and low cost
  - Aftermarket franchise die/parts available
    - Xicor, Fairchild, Atmel
- **CCA Redesign**
  - Last resort - Schedule and cost prohibitive

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IC Obsolescence – NSWC *DER™*

NSWC Empirical Experience with CCA Average Redesign Cost

NHA Redesign Average Cost $1,112,528 (per SD-22)

- Purchase of engineering, design, or technical data
- Qualification of new items
- Revision of test procedures
- Software changes
- Start-up costs (after-market, etc.)
- Testing
- Tooling, equipment, test equipment, or software
- Computer programs/documentation
- Interim support
- Supply/provisioning data
- Support/test equipment
- Technical manuals
- Training/trainers
- Item cost
- Spares

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IC Obsolescence – NSWC *DER™*

8-lead Hermetic Sidebraze DIP Package

NM24C04

Donor Device Package

SCD 80202739004

Target Device Package

- GCI Die Removal from Donor Plastic Package
- GCI Reassembly into Hermetic Package
- Donor Electrical Variability Analysis
- Reliability Temperature Stress Cycling
- MIL-PRF-38535 Appendix B (V Level)
- 100% Screening to MIL-STD-883/5004
- QCI Per MIL-STD-883/5005 including 1000 Hour Life Test @ 125°C

IC Obsolescence – NSWC *DER*™

- NSWC Crane (Navy) has been performing AN/ALQ-99 Tactical Jamming System (TJS) Acquisition, In-Service Engineering, Logistic, and Depot Sustainment for approximately 40 years
- NSWC Crane was experiencing a Mission Impaired Capability Awaiting Parts (**MICAP)** event on the EA-6B and EA-18G ALQ-99 TJS Pod
- DLA had zero stock, no distribution chain, no F3 replacement. Circuit Card Assembly (CCA) Re-design lead time was excessive and cost prohibitive at $1,112,528 average cost

Solution Schedule:

- April 2016, GCI evaluation ***DER***™ parts tested successfully at Crane
- July 2016, GCI production ***DER***™ parts tested successfully at QTSL Lab
- September 2016, Crane Purchase Order to GCI with RDD 02-15-17 350 units

Total *DER*™ Solution Cost: $81,875:

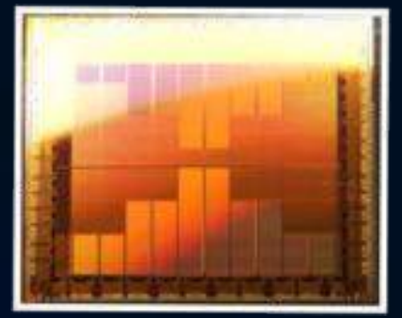
- Prototype procurement and NHA functional testing: $1500
- Prototype Group A testing at hot/cold temperature: $2500
- Production purchase order total price: $77,875
  - Qualification testing NSWC Crane SCD 802027393004: $40,323
  - Production qty 350 with screening NSWC Crane SCD 802027393004: $37,450

Cost Avoidance of *DER*™ vs. Re-design: $1,030,600 (93% cost savings)

IC Obsolescence – Scenarios (cont.)

5B. Different size memory – Larger memory die within the same technology generally can be substituted in the same package footprint. When removing a die from one package and reassembling it into another package, GCI can easily modify the die bonding

For example, GCI can often substitute a larger memory from the same family (2X, 4X, 8X or 16X larger than the original) and configure the memory appropriately to create an F3 equivalent drop in replacement



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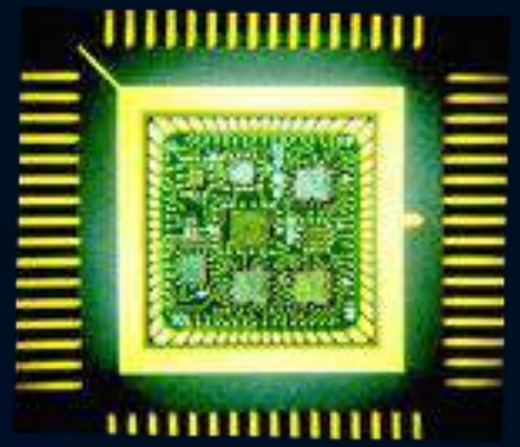
IC Obsolescence – Scenarios (cont.)

5C. Much more complex options are also possible:

For example, an obsolete 1800-gate bipolar gate array designed more than 30 years ago requiring a 5V supply voltage can be replaced by a Multi Chip Module (MCM) containing a modern Complex Programmable Logic Device (CPLD) with a voltage regulator and I/O level shifters to provide the specified output drive with an identical footprint of the original, now obsolete, bipolar IC

The solution options are nearly endless …



IC Obsolescence – USAF *DER*™

Potential Scenario Decision Flow Chart to Replace needed IC

A. USAF Tech troubleshooting radar system board finds bad IC ("chip")
B. Tech pulls bad chip. Goes to parts bin.
C. Finds that chip's part bin empty. Tech calls for supply refill.
D. Supply tech looks for supply of that chip – part discontinued.
E. OEM for that chip quit making them 2 years ago.
F. No chips to replace the bad chip are available.
G. Program/Sustainment Office called in to fix chip problem.
H. PO counts good radar spares—determines only 98 days remain!
I. USAF only needs 427 chips to keep radar going to end of system life.

IC Obsolescence – USAF *DER*™

Potential Scenario Decision Flow Chart to Replace needed IC

- COA 1 – Scour the earth to find that chip in that 'package'. Found chips coming out of a broker in Far East. High Counterfeiting and Malware risk!
- COA 2 – Reverse engineer that chip; build/burn new ones. Will take roughly 18 months & $3M. May/may not work—trial & error.
- COA 3 – Redesign the board with alternate electronics design. Will take 2 years, cost ~$7M ($20M plus for some). OFP software recoding required with full regression testing, etc.
- COA 4 – Emulate IC functionality. Will take 2.5 yrs., cost ~$8M – OFP S/W coding req'd w/ full regression testing, etc.
- COA 5 – Replace bad chip w/ more rugged *DER*™ chip. Total cost is $150K per tested *DER*™ solution. Two to six months for first *DER*™ chips delivery; only weeks for follow-on orders.

GLOBAL CIRCUIT INNOVATIONS®

DEER™

Die Extraction with ENEPIG processing and Reassembly

Improved *DER*™ for High-Temperature or High-Reliability Applications

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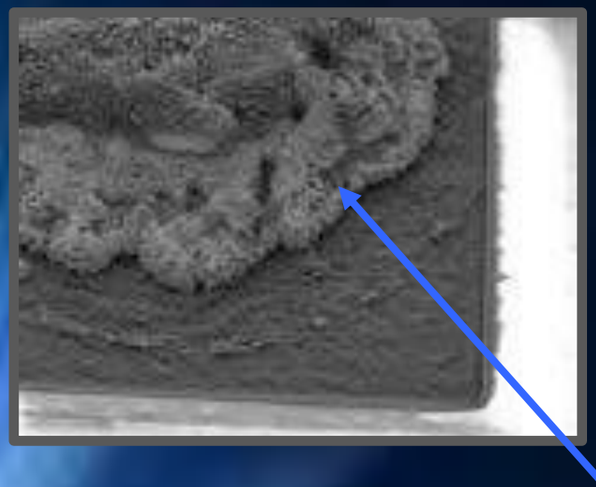
DEER™ Pad Re-Plating in High-Reliability Applications

- 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 Reliable Bond Pull Strength
  - New Bond Pad Surface Eliminates Possibility of Kirkendall Voiding (Purple Plague) with Gold Bond Wire at Operating Temperatures up to 250°C



General Appearance of Kirkendall or Horsting Voiding at Bond Pad Location

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

Au_5Al_2, Au_4Al, Au_2Al, $AuAl_2$

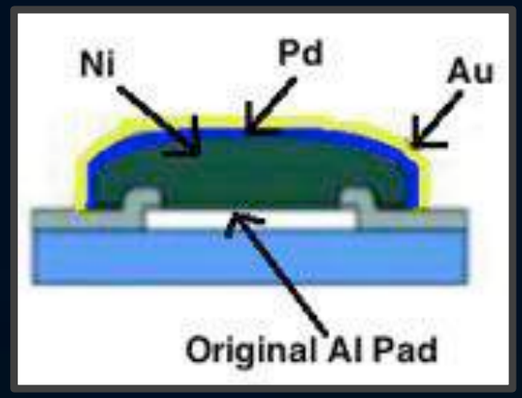
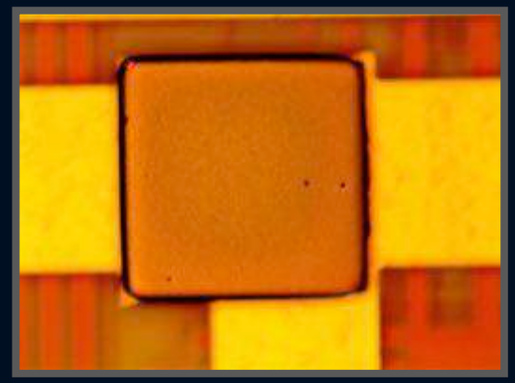


Illustration of **ENEPIG** Pad Plating



Optical Photo of Actual **ENEPIG** Plated Die Pad

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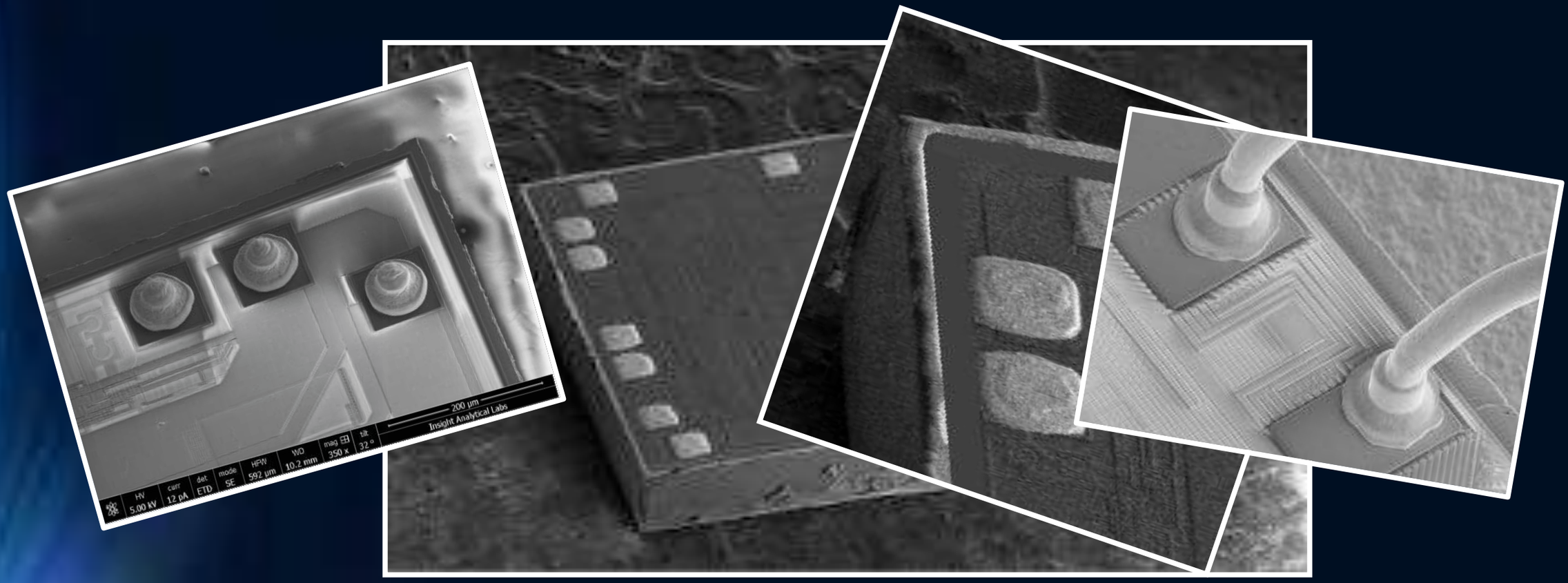
Gold Ball Removal, Pad Re-Plating with Electroless Ni/Pd/Au of *DEER*™ Process



Aluminum Pad Reconditioning for an Extracted Die (Total Target Plate-Up is 4 to 5 µm)

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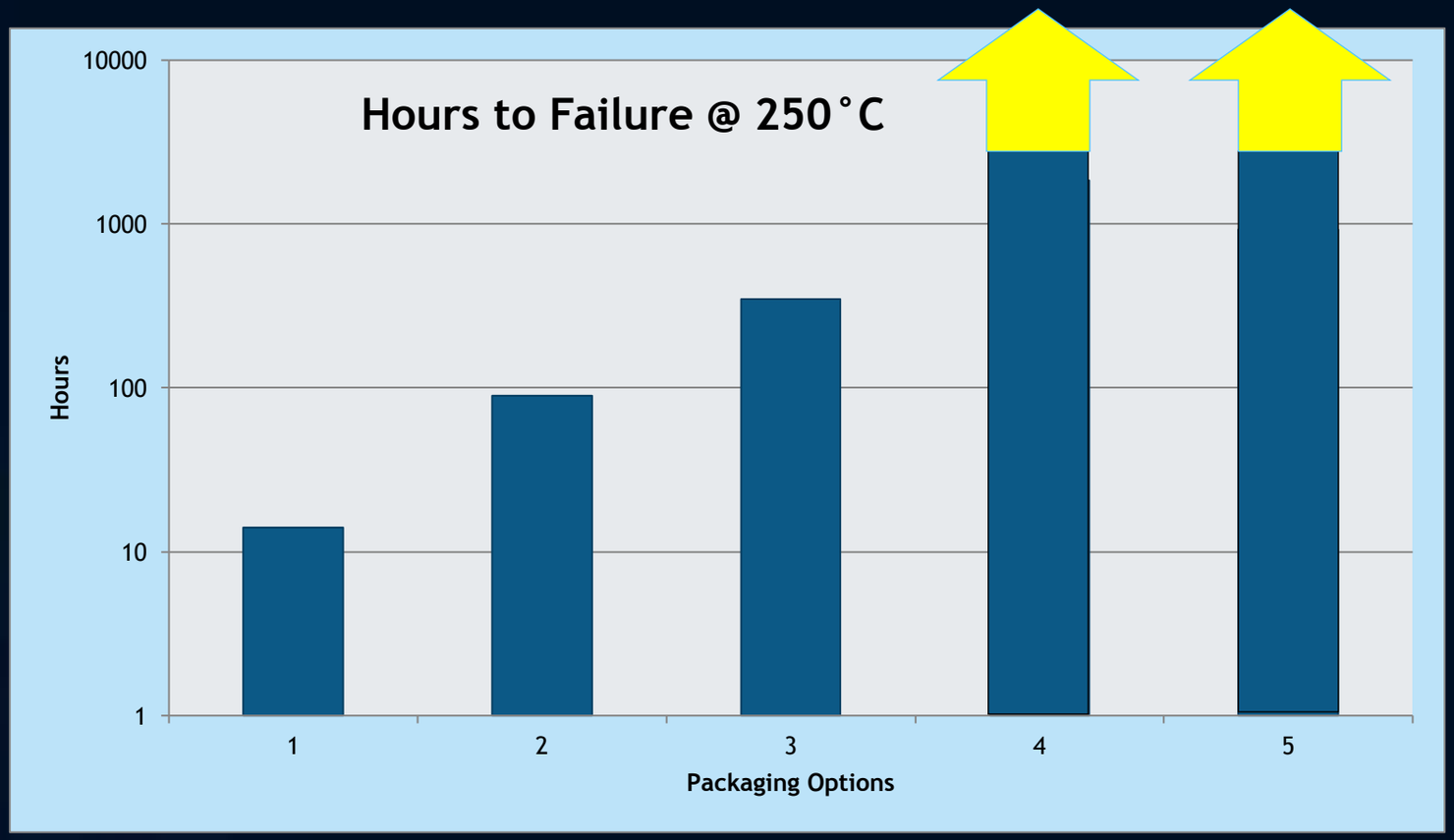
250°C Lifetest Performance



Packaging Option Key:

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

Contact Information

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