Future of QML Hermetic ICs

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Historical Perspective

- From the start, Military and Aerospace could drive the semiconductor industry. How? $$$
- First Integrated Circuits (ICs)
  - Slower than discrete solutions / low integration
  - Expensive (3-input NOR gate $30 each) [1960s $]
- Aerospace & Military Systems
  - Reduced power consumption
  - Smaller size
- Commercial World
  - Used discretes and/or tubes
  - Digital not important
Semiconductor Market

- QML Hermetic ICs (Integrated Circuits) occupy a unique initial cost point in the $350 billion semiconductor market

- Cost always a concern. What drives that cost?
  - Low Volumes (<1%)
  - Stringent Quality Requirements
  - Sporadic Purchasing Patterns

- Approaches to reducing costs include:
  - Commercial Off-The-Shelf (COTS)
  - Upscreened Parts
Qualified Manufacturing Line (QML)

- Reliability Driven
  - Defines levels of expectations
  - Standardize test methods
  - Helps control cost through competition
  - Pedigree traceability

- Qualification Testing
  - Specific failure mechanisms
  - Mechanical
  - Environmental

Image courtesy of JHUAPL/SwRI
Today’s Market Forces

- Commercial
  - Cost driven
  - Economies of scale
  - Moore’s Law + Rock’s Law = Need to Feed Fab
  - Innovation – “The Next Big Thing”

- Aerospace & Military Systems
  - Reliability
  - Traceability
  - Obsolescence concerns
  - Counterfeit devices
IC Designs and Longevity

- Aerospace & Military no longer “Wag the Dog”
- New Designs follow the commercial world
  - Wheel reinvention not cost effective
  - Market-drive advanced devices not typically offered in hermetic packaging include:
    - Networking controllers, transceivers
    - Multimedia audio/video processors
- Die and/or Wafers often available for purchase
- QML Manufacturers aren’t driven directly by the commercial world
- Device longevity a prime consideration
Packaging and Screening

- Plastic Encapsulated Microcircuits (PEMs)
  - When mass produced, initial cost advantage
  - Non-hermetic
    - Board assembly concerns
      - Moisture absorption
      - Delamination
      - Cracking
    - Contaminant ingress
    - Long term reliability issues
      - Harsh environments
      - Spares storage

Credit: Sonoscan
Packaging and Screening

- COTS and Upscreening
  - Parts require additional testing
    - Parametric values over temperature/voltage
    - Mechanical testing
    - Environmental testing
  - Limited (if any) lot/wafer traceability
  - Die not inspected to military screening levels
- No control over fabrication changes or stock rotations
- PEM disadvantages remain
Packaging and Screening

- QML Hermetic Integrated Circuits
  - Long Term Reliability
    - PEMs “breathe”
    - Hermetic parts don’t
  - The Aerospace community considers hermeticity key for higher reliability
  - Pushed JEDEC/DLA for tighter leak rates during seal testing
    - Already a hybrid requirement
    - Monolithics to follow
Packaging and Screening

- QML Hermetic Integrated Circuits
  - Thermal Characteristics
    - Lower Thermal Resistance
    - Key to performance at high temperatures
    - Improved life expectancy (MTBF)
  - $T_J \text{ v. } T_C \text{ v. } T_A$
  - Minor AC Timing Derating
- Traceable Inline Screening
- Lot Homogeneity
  - Failure Analysis
  - Lot Risk/Containment
PEM / COTS / Upscreen Savings?

- Total Costs must be considered
- Costs Adders for PEMs/COTS/Upscreens include:
  - Design effort for thermal considerations (NRE)
  - Documentation for complete traceability (???)
  - Additional environmental testing (HAST, Autoclave)
  - Additional electrical testing (extended ranges)
  - Post assembly inspections (CSAM)
  - Reliability of spares (long term storage)
- Total life cycle cost could exceed Hermetic QML ICs
- Trading Quality for Initial Cost — False Savings?
Qualified Manufacturing Lines

- Defense Logistic Agency (DLA) certified
  QML Manufacturers:
  - Forty-one (41) MIL-PRF-38535 (Monolithic)
  - Thirty-three (33) MIL-PRF-38534 (Hybrid)
- QML Hermetic Products
  - SMD Program, M-38510 Slash Sheets, QML Data Book products
- Device/Package Configurations
  - 38535: 19,000 part types
  - 38534: 1,300 part types
Qualified Manufacturing Lines

- Currently Seven (7) QML Assembly Facilities
  - Assembly process from wafers/dice to qualified units
  - Build QML product not offered by the OCM
  - Full Military Screening throughout the assembly process
    - Optical inspections, die shear, bond strength
  - Inline quality monitoring
  - Traceability to the wafer level
  - End-of-Life options
    - Fully assembled or store in wafer/die form
Conclusion

- Over the decades, the death knell for QML Hermetic ICs has rung many times
- Still, QML Hermetic ICs are alive and well
  - Committed Manufacturing Base
  - Package Characteristic Advantages
  - Package Assembly Advantages
  - Standardization
  - Set Expectations
  - Pedigree Traceability
  - Addresses Obsolescence