Future of QML Hermetic ICs

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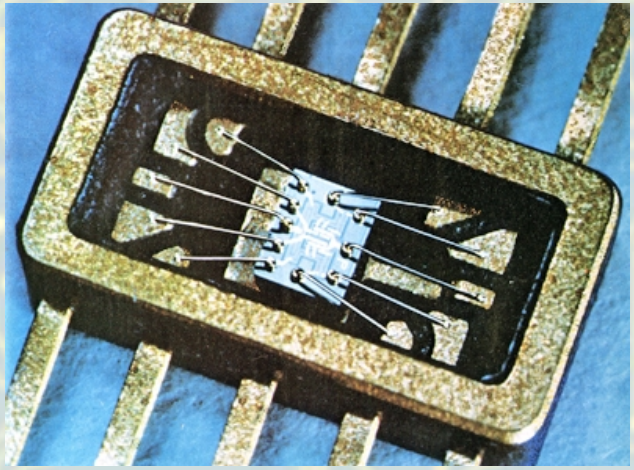
Historical Perspective

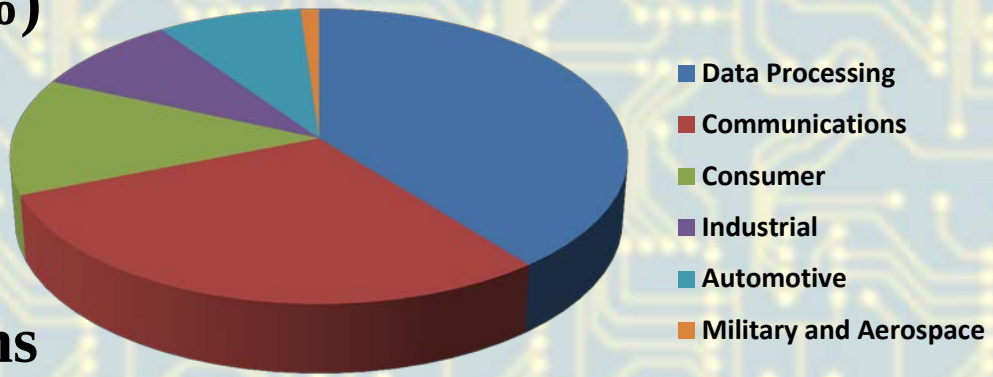
- **From the start, Military and Aerospace could drive the semiconductor industry. How? $$$**
- **First Integrated Circuits (ICs)**
  - **Slower than discrete solutions / low integration**
  - **Expensive (3-input NOR gate $30 each) [1960s $]**
- **Aerospace & Military Systems**
  - **Reduced power consumption**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



Credit: Philco-Ford Microelectronics

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**

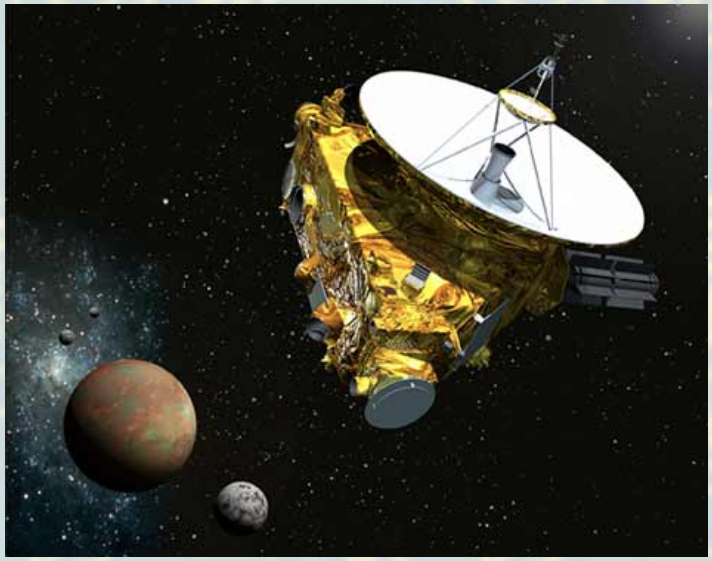


Image courtesy of JHUAPL/SwRI

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"**

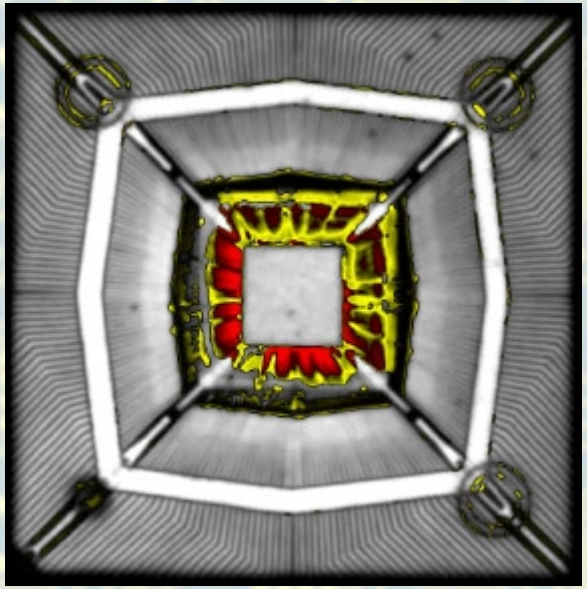
- **Aerospace & Military Systems**
  - **Reliability**
  - **Traceability**
  - **Obsolescence concerns**
  - **Counterfeit devices**

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**



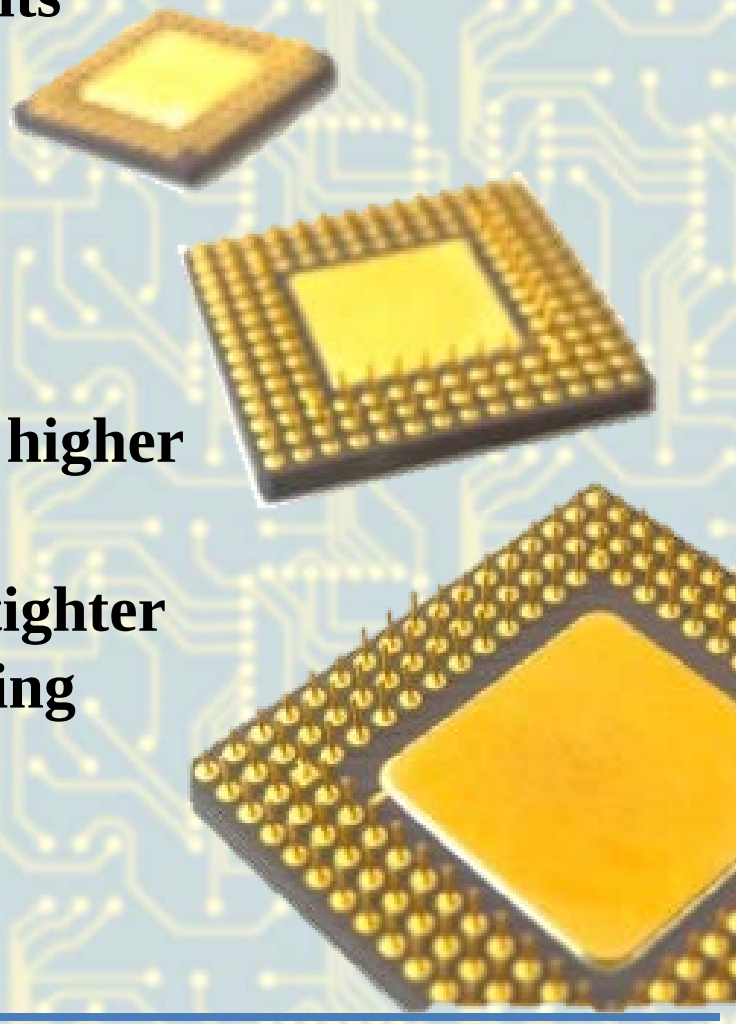
Credit: Sonoscan

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**

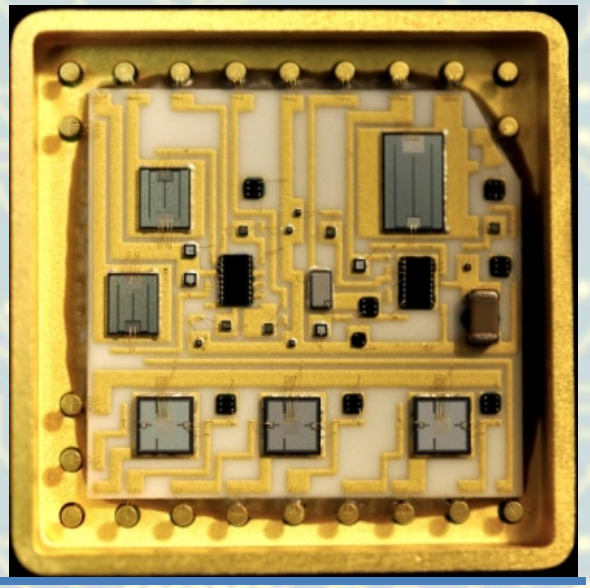
Packaging and Screening

- **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 v. T_C v. T_A**
    - **Minor AC Timing Derating**
  - **Traceable Inline Screening**
  - **Lot Homogeneity**
    - **Failure Analysis**
    - **Lot Risk/Containment**



PEM / COTS / Upscreen Savings?

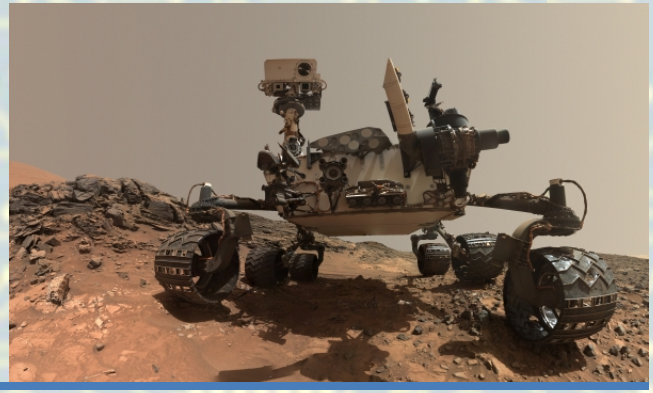
- **Total Costs must be considered**
- **Costs Adders for PEMs/COTS/Upscreens include:**
  - **Design effort for thermal considerations (NRE)**
  - **Documentation for complete traceability (???)**
  - **Additional environmental testing (HAST, Autoclave)**
  - **Additional electrical testing (extended 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**