Electronic Parts Evaluation Activities

at

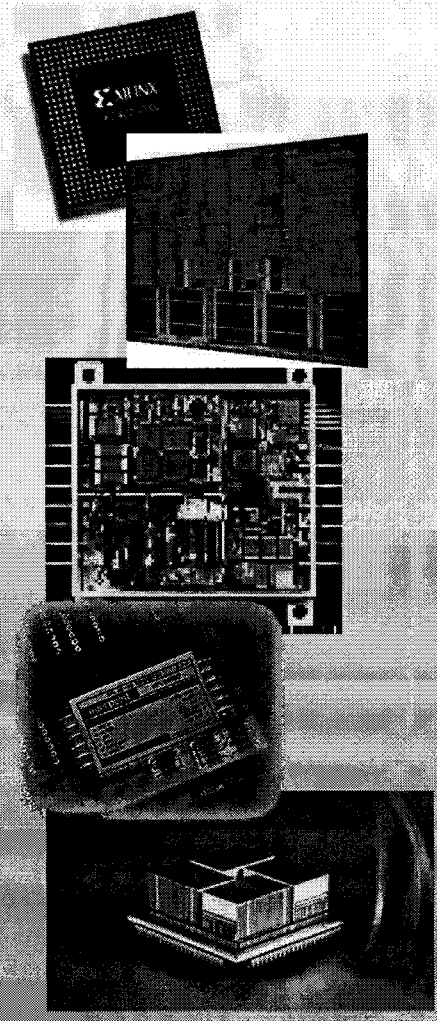
JPL

4/26/2000

Sammy Kayali
Manager
Electronic Parts Engineering Office
Jet Propulsion Laboratory
California Institute of Technology
Tel. (818) 354-6830
Email:Sammy.A.Kayali@jpl.nasa.gov

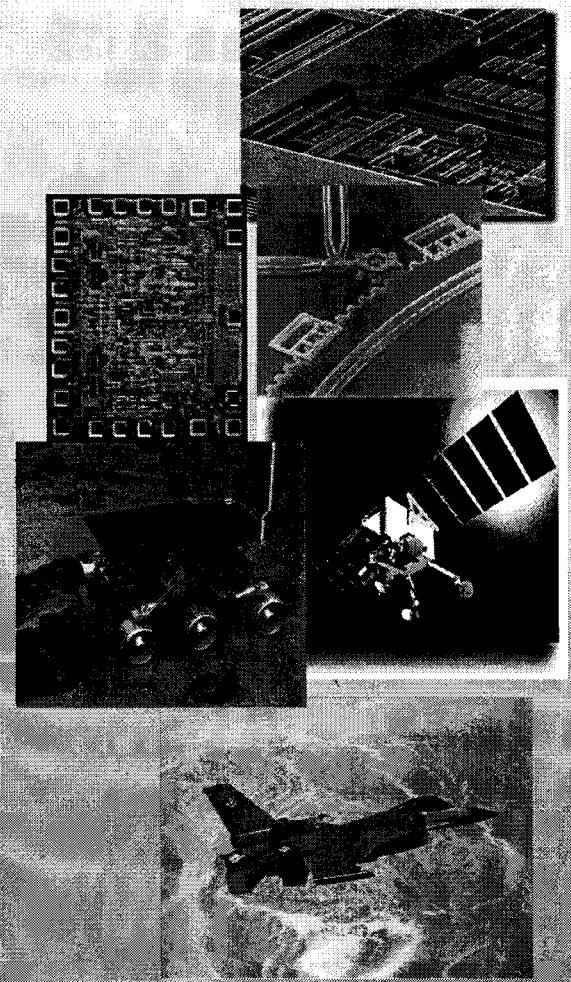
Overview

- ***Evaluate and assess new and advanced microelectronics device technologies for application in high reliability systems***
  - ***Identify common failure modes and mechanisms of new technologies***
  - ***Evaluation and characterization of new device Technologies***
  - ***Provide an infusion path for advanced technologies***
  - ***Develop innovative and cost effective reliability and qualification methods***
- ***Develop a new strategic alliances with industry, academia, and other government agencies for evaluation activities***



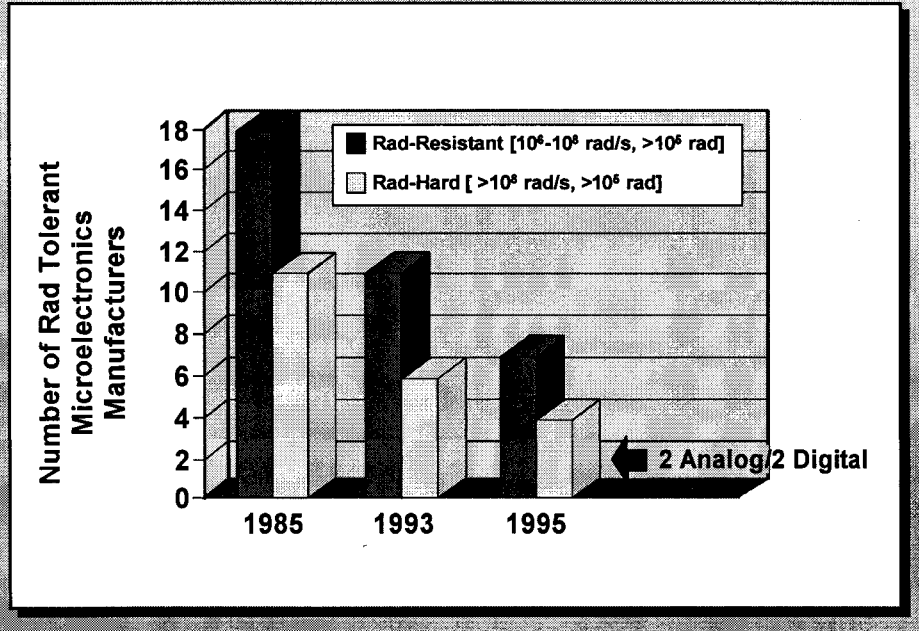
Parts Challenges

- *Technical challenges*
  - *Smaller feature sizes and miniaturization*
  - *Low power devices and processes*
  - *Device complexity*
  - *Radiation Tolerance of commercial Processes*
- *Environmental challenges*
  - *Operation at extreme temperatures*
  - *Reduction in mass and volume*
  - *New radiation effects and high radiation environments*
- *Programmatic challenges*
  - *Fast, better, cheaper missions*
  - *1/2 the cycle time, 2/3 the cost*
- *Industry challenges*
  - *Diminishing Hi-Rel suppliers*
  - *No supporting military infrastructure and standards*
  - *No procurements for small volume*



Diminishing Hi-Rel Suppliers

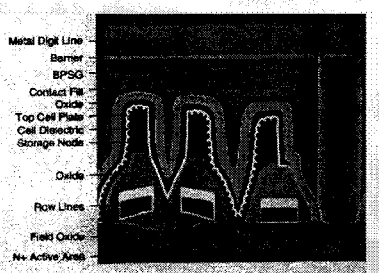
- *Military/space market represents too small a customer to drive new technology development*
- *Diminishing Hi-Rel suppliers means*
  - *No high-performance and high-reliability parts*
  - *No standard on screening/qualification*
  - *No rad-hard parts/processes*
- *Focus on assessing new technologies and electronic parts to understand the following for Hi-Rel applications*
  - *More electrical characterizations*
  - *Upscreening and qualification tests*
  - *Identification of dominant failure modes for various requirements*
  - *Radiation characterization tests*
  - *Material characteristics*
  - *Reliability of advanced technology devices for extreme environments*
  - *Reliability and quality assurance standards for highly reliable parts*

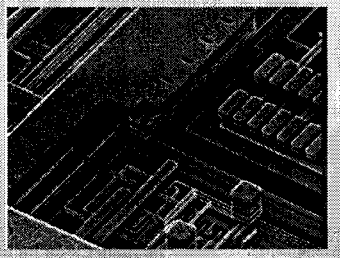


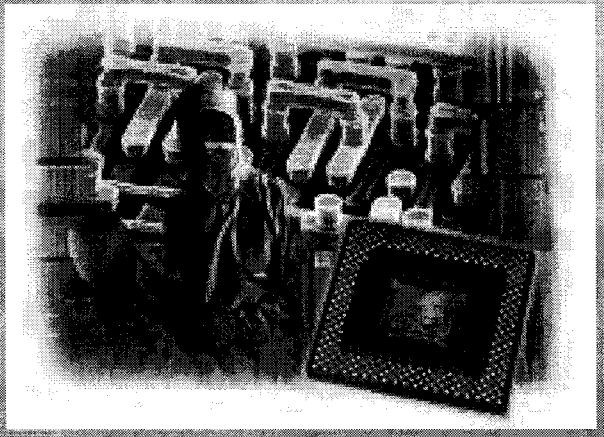
COTS Evaluations

- *The miniaturization and commercialization trends are the driving force for usage of COTS for space flight projects*

- *The challenge is to use COTS in high radiation and reliability requirements*
  - *Identify the reliability and validate COTS for flight projects*
    - *Evaluation of SDRAMs, EEPROMs, Flash Memories for high temperature and high radiation environments*
    - *Evaluation of various discretes, passives, linear devices*
  - *Provide upscreening options for projects with a variety of risk levels for using COTS devices*
  - *Provide KGD requirements for insuring reliability of COTS devices for fight projects*







COTS Evaluations (cont.)

- *PEMS*
  - *Establish validation methods for plastic (PEM) parts*
  - *Develop tailored upscreen procedure for insuring reliable PEMs in JPL Flight projects*
  - *Develop a baseline approach for reliability assurance for space flight applications*
  - *Enable flight projects to use state-of-the-art devices not otherwise available*

- *Need to develop of new strategic alliances with industry, academia, and other government agencies to leverage resources for COTS reliability/qualification evaluations*

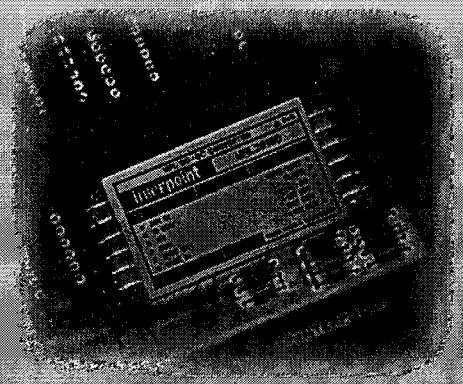
http://cots.jpl.nasa.gov/

DC/DC Converters

- *Objective*
  - *Identify and publish a list of preferred DC/DC converter suppliers and technologies for space application*
  - *Evaluate reliability of DC/DC converters and publish reliability assurance guidelines*

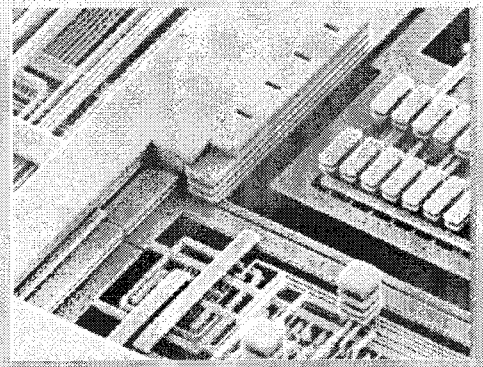
- *Status*
  - *Completed evaluation reports from on-site supplier line evaluations, DPA, and other environmental testing*
  - *Produced summary matrix for DC/DC converter selection criteria*

- *Plan*
  - *Generate listing of preferred/qualified suppliers*



Reliability of Cu-Based Microelectronic Metallization Systems

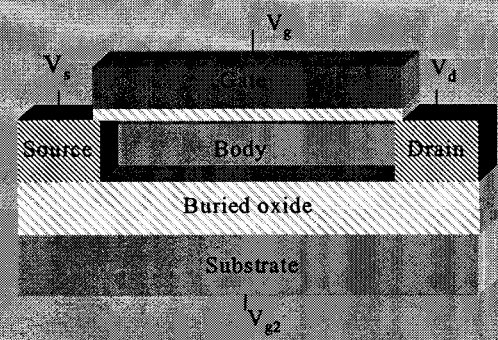
- *Objective*
  - *Evaluate reliability of Cu-based microelectronic metalization systems*
- *Status*
  - *Engineering studies of Cu/low-k systems*
    - *Expected failure mechanisms identified*
    - *Variability due to process seen as major issue*
    - *Critical reliability detractors found*
    - *Experiments identified*
  - *Presented several papers in various conferences*



- *Plan*
  - *Publish a report on expected failure modes and mechanisms for Cu/low-k interconnect systems*
  - *Provide recommendations for use and application of these materials in high reliability space flight systems*

SOI Reliability

- ***Objective***
  - ***Perform a comprehensive technology characterization of SOI Mixed Signal ASIC processes in partnership with industry, academia, and government-sponsored laboratories***
  - ***Provide critical information for design engineers and circuit designers relating to the characteristics and limitations of this new technology for high reliability applications (in an extended temperature range down to -150°C)***
- ***Status***
  - ***Completed low temperature evaluation of DC characteristics (300K to 77K) for 0.25-um FD-SOI transistors.***
  - ***Obtained preliminary proton radiation test results.***
- ***Plan***
  - ***Evaluate 0.18-um fully-depleted and 0.8-um partially-depleted devices for mixed-signal applications.***
  - ***Modify device parameters using simulation tools and, based on simulation results, fabricate devices with better performance in harsh environments.***

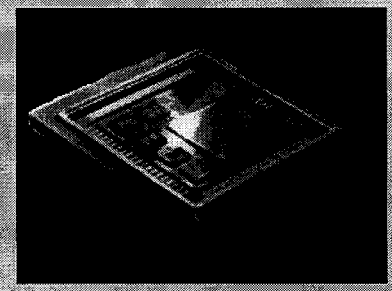


Non-Volatile Memory (NVM) Evaluation

- *Objective*
  - *Develop a test methodology for determination of non-volatile memory (NVM) reliability and radiation effects and construction of a test structure for characterization.*
- *Status*
  - *Characterization of all major NVM types:*
    - *Floating gate technology: including PROM, UVPROM, EEPROM, PLED, and flash technologies*
    - *Ferroelectric technology: including GMRAM, FeRAM, Spin Valve, and PZT technologies*
    - *Phase Change Materials Technology: including Chalcogenide and Antifuse technologies*
- *Plan*
  - *Develop test structures and methodology for testing of NVM:*
    - *Reliability and operational liability of NVM*
    - *Radiation effects and mitigation strategies*
    - *Develop NVM characterization test database from existing data and test matrix required for complete characterization*

KGD for Space Applications

- *Objective*
  - *Establish all requirements for semiconductor KGD which are purchased by JPL or its subcontractors for use in JPL flight projects*
- *Status*
  - *Developed guidelines for insuring two level KGD in JPL flight hardware and an operating procedure for die storage and handling*
  - *Collected and reviewed KGD test methods, KGD vendor programs, KGD test options, and risk associated with KGD screens/options*
- *Plan*
  - *Facilitate future die procurements, infusion, and usage*



Electronics For Extreme Environments

- *Objective*
  - *Develop reliability assessments of electronic parts at extreme environments and identify failure mechanisms to support future JPL/NASA flight projects*
- *Status*
  - *Conducted characterization tests on a number of parts in support of JPL flight projects at low temperature (-170 C)*
  - *Report "Failure Mechanisms In Electronic Devices At Low Temperatures Part I: Electrically Induced Failures"*
  - *Report on Failure Mechanisms In Electronic Devices At Low Temperatures, Part II: Mechanically Induced Failures: "Thermo-Mechanical Stress Induced Failures in Die Metallization Lines – an Overview"*
  - *Report "Die Attachment For -120 C To +20 C Thermal Cycling Of Microelectronics For Future Mars Rovers - An Overview"*
- *Plan*
  - *Support the Mars Program in test and characterization of commercial encoder boards for low temperature applications*

Other Parts Evaluation Activities

- *Radiation Effects*
- *MEMS Reliability*
- *Compound Semiconductor Reliability*
- *SiGe Reliability*
- *Optoelectronic And Photonic Devices*
- *InP Reliability Characterization*
- *TEM as a Reliability Tool*
- *Specific parts Evaluations*

Summary

- *COTS insertion into high reliability space systems requires detailed knowledge of the performance and characteristics of these components in a space environment*
- *A systematic approach to the "qualification" of COTS components is a must*
- *Understanding the technology and the intended application are essential first steps of qualification*
- *There is a clear need to leverage resources and develop strategic alliances for the evaluation and characterization of COTS components for high reliability applications.*

Acknowledgement

- ***The work described in this presentation was conducted at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration.***