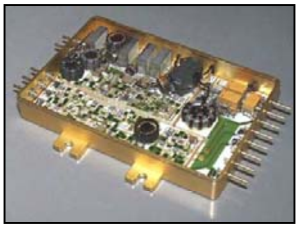

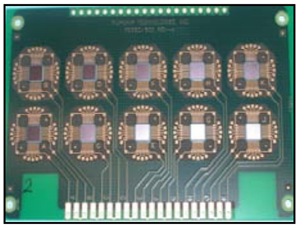

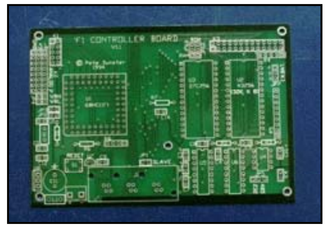

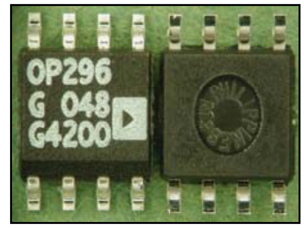

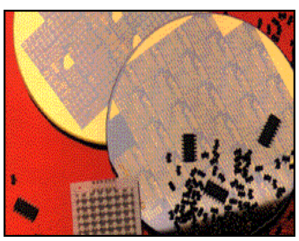

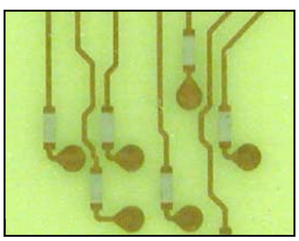

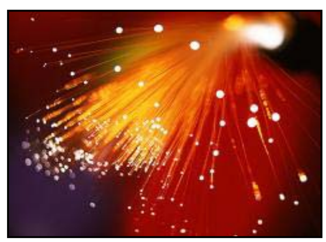

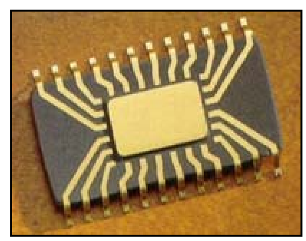

Code 562 / Parts, Packaging, and Assembly Technologies Office

2004 Annual Report

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I. Introduction

Dear Project Managers and Systems Designers,

Code 562 thanks you for your continued support over the past 3 years, during which we have had a dramatic increase in projects requesting parts engineering and testing services. Our experience has shown that early interaction between Code 562 and GSFC systems is key to reducing problems encountered with parts. For example, recent team efforts to overcome obstacles on the SWIFT BAT project proved advantageous in enabling the craft's successful launch. Our goal is to continue improving that model as we move forward into the future.

This Annual Report summarizes some of the technical highlights in 2004 and focuses on the people working with Code 562. The far-reaching scope of these ventures affects projects across GSFC in several capacities such as testing and analysis, research in new technology, and support of older systems. The technical highlights are organized topically by project support; parts screening, qualification, and failure analysis; advanced technology and manufacturing; electrostatic discharge control; knowledge exchange; and plans for 2005, as well as a feature on Code 562's Chief Engineer and integral resource, Dr. Henning Leidecker.

We remain committed to assisting you in flying systems that exceed NASA mission goals.

Very Respectfully,

Darryl D. Lakins
Head, Code 562/Parts, Packaging, and Assembly Technologies Office

II. 2004 Technical Highlights

Project Support

PARTS ENGINEERING

Kusum Sahu

The Code 562 parts engineering team supports the development of space hardware within GSFC, either by out-of-house developers at universities or by aerospace contractors and their subcontractors. For hardware built at GSFC, the parts engineers support GSFC designers in components selection, procurement, screening, and qualification, and resolve parts issues as they arise. For hardware built outside GSFC, parts engineers assess the parts programs established by the developers and contractors, oversee the implementation of these programs to enforce compliance, and report any delinquencies to the project office. In either instance, this is primarily accomplished by participating in Parts Control Board (PCB) meetings with the developers and contractors to evaluate the suitability of each part intended for space flight applications. The flow chart on page 5 illustrates the updated parts management process being used by parts engineers in supporting GSFC projects.

In 2004, the parts engineering staff supported more than 20 projects under various NASA programs such as Explorer, EOS, ESSP, SEC, JWST, SDO, HST, RLEP, and the Space Shuttle Return to Flight. Two of them, SWIFT and EOS Aura, were launched in 2004 and are operating successfully. CALIPSO and Astro-E2 are nearing completion and scheduled for launch in early 2005.

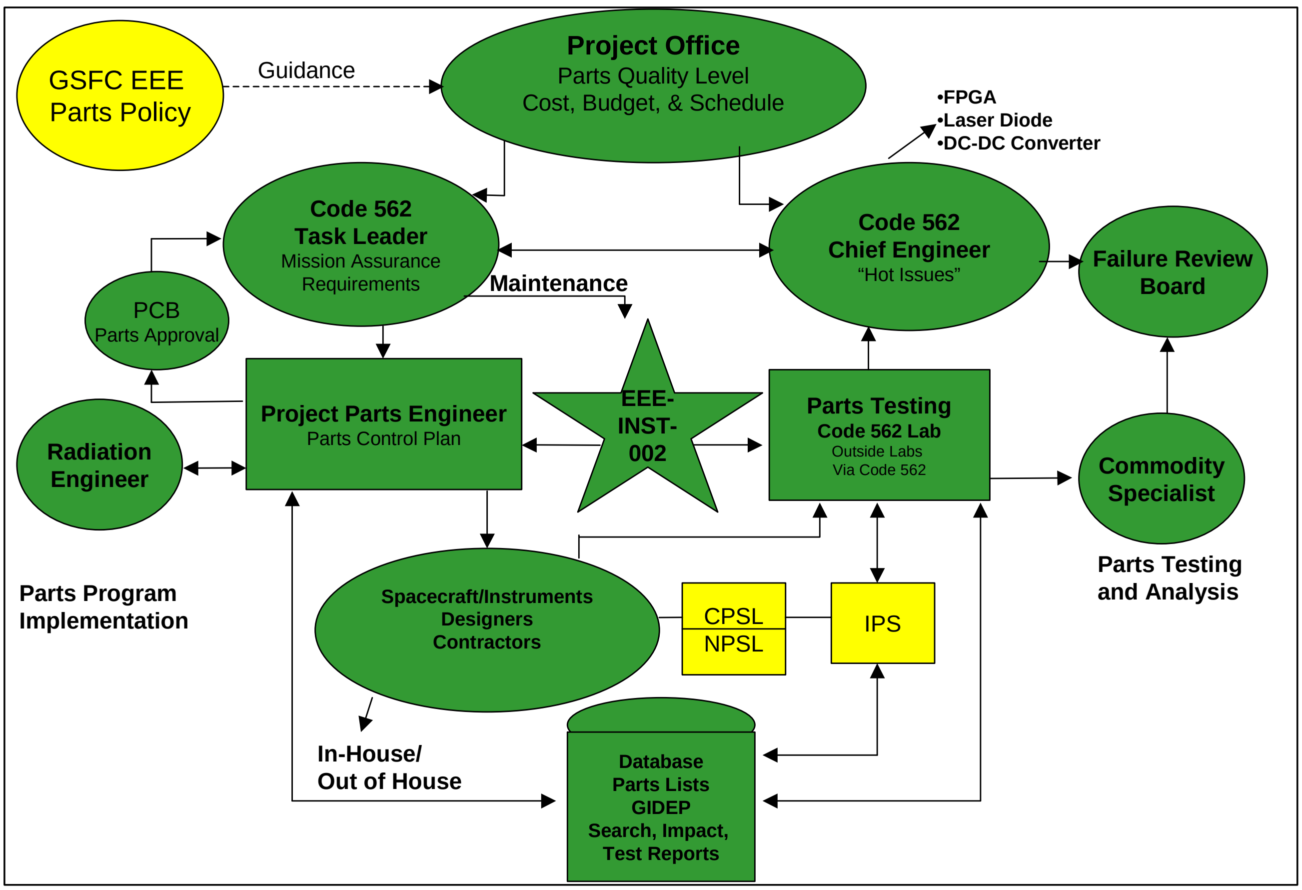
To ensure that high-reliability parts are used in space flight hardware, parts engineers work closely with various prime contractors like Boeing, Ball, Lockheed-Martin, ITT, Northrop-Grumman, and Spectrum-Astro; a large number of subcontractors including Panametrics, Raytheon, Rockwell, and Litton; and universities such as MIT, University of Colorado, University of Arizona, Stanford University, Penn State, and The Johns Hopkins Applied Physics Lab. They also work with many international partners like ESA, JAXA, and CSA. Parts engineers have been working with projects throughout 2004 to resolve a number of key parts issues involving Actel FPGAs, Hitachi EEPROMs, cPCI connectors, and various DC-DC converters. Some highlights from the year follow on the next page.

- For Actel FPGAs, Dr. Kusum Sahu issued a guideline paper for GSFC parts engineers and the space community summarizing current information related to Actel MEC/UMC parts. The paper provided specific testing and application recommendations for all GSFC projects.
- In the spirit of One NASA, a GSFC parts engineer partnered with Johnson Space Center parts engineering activities to support Return to Flight activities for the Space Shuttle. The parts engineer worked as an integral part of both Centers' engineering teams as well as the CSA team, and resided at JSC for 1 week each month.
- cPCI connectors are new to space applications. Currently, projects are using commercial cPCI connectors. PPEs are supporting the qualification and evaluation of risk associated with the use of commercial connectors from AMP and ERNI for the STEREO and GLAST projects, respectively. The SDO PPE has done extensive work with Hypertronics to design and build space-quality cPCI connectors. Hypertronics is being qualified for SDO and all new projects, including JWST, with support from the SDO PPE.
- The SDO PPE was instrumental in pushing IR to develop the new LS series of miniaturized DC-DC converters to meet project size constraints. The new converters, which also contain an integral filter, still meet project radiation requirements—a critical factor in the design of new DC-DC converters.
- The JWST PE worked closely with several vendors to get space-qualified state-of-the-art parts that are currently available only as commercial parts; e.g., 16-bit A-to-D converters, Gigabit memories, and high-density FPGAs. Work is in progress with Linear Technologies to produce a space-level commercial version of the 16-bit A-to-D converter, the LTC1604. Maxwell Technologies is producing a 2-Gbit stacked SDRAM part that they have designed and are qualifying based largely on JWST requirements. Close interaction and follow-up is being maintained with Actel to enable the usage of Actel's latest RTAX series of FPGAs with 2 million gates.
- The THEMIS PPE engineered the screening and qualification of the first 16-bit A-to-D converter for space flight, while the GLAST PPE supported the screening and qualification of nine types of ASICs (a total of 14,000) that will be flown by GLAST.

Many of the parts engineers also play the role of specialist for the various EEE part commodities. These commodity specialists are responsible for updating the GSFC parts document, EEE-INST-002, which provides guidelines for parts selection, screening, qualification, and derating. They also work with various manufacturers on transferring their new technology devices from commercial to space-quality products. A highlight in 2004 was working with Gore in developing and implementing qualification of Space Wire cable assemblies for use as communication data bus on JWST and SDO.

Commodity specialists participated in auditing manufacturers' facilities including Gore, Micropak, and Maxwell to ensure space-quality fabrication processes. Commodity specialists within the department also updated the Qualified Products Directory List (QPLD) and issued new parts procurement specifications for thermostats and electromagnetic devices. Commodity specialists also worked toward resolving the parts issues that arose during space flight integrations and operations. A parts engineer commodity specialist investigated an on-orbit anomaly on the Landsat 5 spacecraft involving a relay that failed to provide charge current to one of the batteries when engaged. As a result, new guidelines were issued to Landsat 5 for future operation of charge relays to ensure continued success of the mission.

Parts engineers also made significant efforts in locating needed parts from the inventories of previous projects to keep the current projects on schedule and to reduce cost. To make this more effective, the SWIFT PPE spearheaded an effort to establish a centralized inventory of commonly used EEE parts based on inputs from projects, test results, and other sources. This effort is nearing completion and will streamline the EEE parts procurement process for future projects.



In the above flow chart representing Code 562's parts management process, items highlighted in green have been implemented, while items highlighted in yellow are still in progress.

PLASTIC PARTS IMPLEMENTATION FOR THE SWIFT BAT INSTRUMENT

Bruce Meinhold

SWIFT launched successfully on November 20, 2004. As the primary instrument, all BAT subsystem parts were reviewed for quality/reliability compliance on an equal footing with all other parts on the spacecraft. Specific test requirements were tailored for each individual device, depending on the manufacturer's guaranteed datasheet parameters and operational temperature range. The basic flow for the development of a test plan for each part is as follows.

Parts lists were reviewed for compliance with the project-specified quality and performance requirements. Many of the detector module and block control data handling parts selected were commercial-grade PEMs, which created a very large block of parts requiring extensive screening and technology characterization testing. Because of concurrent engineering model and flight design, completed parts lists were not released until flight assembly was started; consequently, parts reviews were performed as designers added new parts to the system.

Alternate parts better suited to the project-specified quality level, and to the 3-year mission life/5-year goal requirements, were recommended to the designers/project team. Most recommendations for preferred higher reliability components were rejected due to size and power considerations. The instrument team supported the design engineer's choices in nearly all cases, and those parts required extensive testing.

Where the initial parts were considered non-compliant or unacceptable and the alternate parts were rejected by the designers, screening, qualification, radiation characterization, and technology characterization (PEMs only) flows were developed, with the assistance of Code 561 (Radiation Effects and Analysis Group) and Code 562 (Parts, Packaging, and Assembly Technologies Office) specialists. There were initially 48 different part types requiring extensive testing regimens. Compromises were necessary in the required testing flows, since many of the selected components were not able to operate over the full -55 °C to +125 °C military temperature operating range, and the equivalent burn-in times exceeded the time necessary to meet launch schedules.

Parts were bought at the highest quality level possible. Vendors were requested to complete as much of the additional required testing as possible (via purchase order requirements). This placed lot jeopardy with the manufacturers should a lot failure occur. This plan was successful with passive device vendors, who were also qualified manufacturers list/qualified product list suppliers for similar parts.

Parts requiring additional evaluation, beyond that performed by the vendor, were shipped from GSFC to the selected test facility. All DPA was performed onsite at GSFC, so that was begun as soon as the flight lots were received. Other testing was started as flight part deliveries were completed (some quantities required multiple shipments), and contracts were set in place at the testing facilities.

Testing was monitored via Supplier Audit Contract representatives, as well as the PPE and project team. Test results from the various test sources were reviewed to verify that each part complied with the project parts requirements. Parts problems were handled via electronic review and/or facility trips. The final stage of review was the Parts Control Board and/or Failure Review Board, who convened to discuss the results of noncompliant parts, reasons for noncompliance, project risk assessment, and final parts disposition.

The quantity of parts that required additional screening and qualification and technology characterization testing was small (50 part types) when compared to the total of more than 300 part types used in this instrument. However, quantities were large compared to space mission standards, causing significant costs to be incurred in fixturing and testing. The quantity of parts requiring testing also posed a challenge to all of the test facilities in providing the amount of labor required to manage and handle the large numbers of parts. To date, all parts on the instrument are working as planned, which can be attributed to the team's process and test flow efforts to qualify parts to operate in space.

The BAT instrument integrated on the SWIFT spacecraft.

EOS AURA

Terry King

The Earth Observing System's Aura satellite was successfully launched on July 15, 2004. Parts engineering was active up to launch investigating EEE part concerns. Among the items of interest were MicroSemi military-grade transistors with potential for nickel flaking inside the metallic lid and lead whisker concerns with FTS Datum ultra-stable oscillators. Code 562 participated in investigations for these, performed calculations to estimate risk of failure, and determined that the risk of these items was minimal. Reports were issued by Code 562 with recommendations to fly as installed and tested.

Parts engineering was also involved in lengthy investigations that included reliability concerns due to internal corrosion of Semicoa military transistors, Betatronix potentiometer noise in SADA telemetry, and potential for failure of commercial TRW HBTs and EEPROMs with Hitachi die. For Semicoa transistors, in order to assess risk residual transistors from the flight lots were re-screened and others were obtained by Code 562 for DPAs to be inspected for internal corrosion. No problems were found, and a report was written recommending that the project fly as is. Code 562 was involved in evaluating a backup SADA telemetry sensor that was added on Aura, and also monitored JPL's investigations of HBT use on the MLS instrument. JPL predictions concluded that science obligations could be met, and the decision was made to fly as tested. Contingency workarounds for Hitachi EEPROMs were developed by the project. Aura was not affected by Actel FPGA developments. Parts lists (PAPLs) for the observatory bus and all four instruments (HIRDLS, TES, MLS, and OMI) were continuously monitored for impact of GIDEP alerts and NASA advisories up to launch.

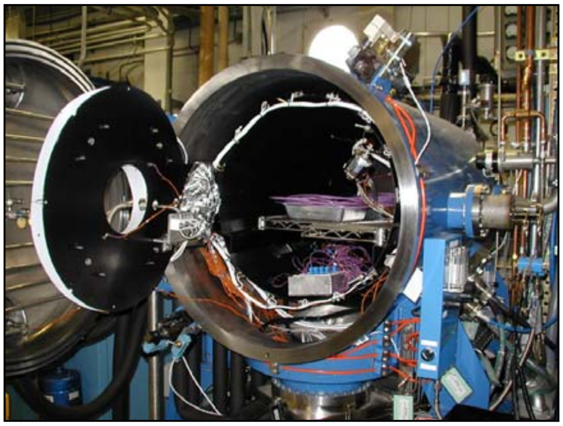
EOS Aura during final testing.

Aura satellite launches at Vandenberg AFB.

MANUFACTURING OF CUSTOM OPTICAL FIBER ASSEMBLIES FOR THE SPACE SHUTTLE

Melanie Ott

To support the development and fabrication of the Laser Camera System (LCS), Code 562 performed development, manufacturing, and consulting for the laser diode and the collimator assemblies. Both the laser diodes and the collimators were supplied as fiber pigtailed components with some unknown materials used for the component side strain relief. These components were analyzed for nonmetallic materials, and when it was possible these materials were preprocessed to ensure better reliability and to meet outgassing criteria. The preprocessing of materials was used for the collimator assemblies where Hytrel tubing was used as strain relief for the connection of the fiber to the collimator cylinder. However, for the laser diode assemblies, a post-fabrication decontamination vacuum exposure was necessary to perform the upjacketed and terminated assemblies (see the figure below). The assemblies were terminated with a Diamond AVIMS connector.



Laser diode assemblies in the vacuum chamber for final decontamination.

Photonics laboratory assembly area.

LASER DIODE PACKAGING INVESTIGATION FOR GLAS AND CALIPSO

Melanie Ott

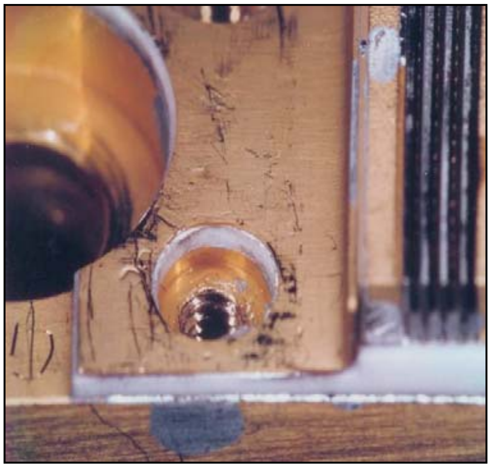
Full qualification is not feasible for commercial photonic parts as defined by the military specification system in the past. Due to changes in the photonic components industry and the military specification system that NASA had relied upon so heavily, an approach to technology validation of commercial off-the-shelf parts had to be devised. This approach involves knowledge of system requirements, environmental requirements, and failure modes of the particular components under consideration. Synthesizing the criteria together with the major known failure modes to formulate a test plan is an effective way of establishing knowledge-based qualification. Although this does not provide the type of reliability assurance that the military specification system did, it is an approach that allows for increased risk mitigation.

This knowledge-based method for characterizing commercial photonic components to insure they will survive a space flight mission is called technology validation assurance. This method is used on commercial devices combining analysis of the materials and construction and design of a tailored test plan based on the known failure modes and vulnerabilities associated with each component. The most important elements of this procedure are materials and construction analysis, vibration, thermal and radiation characterization with data taken in situ where possible, and the parameters of the testing adjusted per the system requirements and the part vulnerabilities.

In order to assist with technology assessments of commercial photonic parts, the Code 562 photonics Web site is maintained to aid space flight engineers in design and development of systems that incorporate commercial parts. The site is located at http://misspiggy.gsfc.nasa.gov/photonics. New this year to the site was the creation of the laser diode reliability Web page. This page was created to aid space flight hardware design, packaging, and parts engineers who need to know about commercial laser diode reliability. Included in this site is information on packaging issues, test methods, data reports, publications, reliability guidelines, destructive physical analysis reports, and failure analysis reports. Access is direct through http://misspiggy.gsfc.nasa.gov/tva/meldoc/photonicsdocs/LDreliability.htm or through the main photonics Web site at http://misspiggy.gsfc.nasa.gov/photonics/.

Included in the laser diode reliability Web site is the work performed over the past year in Code 562 on the high-power laser diode arrays for GLAS and CALIPSO. The studies performed on these commercial laser diode devices are great examples to illustrate the importance of construction analysis as the first step in understanding a commercial part's failure modes and ability to survive and function in a space flight environment. During the studies on the high-power laser diode bar arrays used to pump the Nd:YAG 1064 nm solid-state lasers, several issues were noted as failure mechanisms to these devices including indium creep resulting in shorting, semiconductor cracking, diffusion layer pinholes, dendrite growth of tin/lead solder, contamination-related failure (hermetic packaging), and workmanship (application of indium solder). This year several of these issues were documented by Code 562.

Several of the important issues mentioned above became completely evident during construction analysis studies of the GLAS and CALIPSO laser diode arrays. The results of the DPA performed on the CALIPSO laser diodes are documented and available on the laser diode reliability Web site. There is a link from the laser diode reliability Web site to the report; the direct access location is http://misspiggy.gsfc.nasa.gov/tva/meldoc/photonicsdocs/calipsolaserdiode.pdf. This evaluation identified several major problems with the laser diode assembly, including massive gold-indium intermetallic found on gold wires on many bars, extruded indium found in mounting bar bolt holes, indium solder failing to bond any of the laser diode units to the substrate, and gold wedge bonds at the spacer exhibiting evidence of tool mark damage. Due to the extensive information that can be gathered as a result of a DPA, all projects are being requested to use this tool as a diagnostic for determining potential failure modes for all commercial laser diode devices being considered for space flight use. Additional information on the laser diode wire bond issues related to the GLAS devices can be found in summary at http://nepp.nasa.gov/wirebond/laser_diode_arrays.htm. For more information on the dendrite failure mode, see the Web site located at http://nepp.nasa.gov/whisker/reference/tech_papers/Leidecker2003-SnPb-whiskers-on-laser-diode-array.pdf. This page can also be reached through the laser diode reliability Web site.



Device short.

Indium creep into bolt holes.

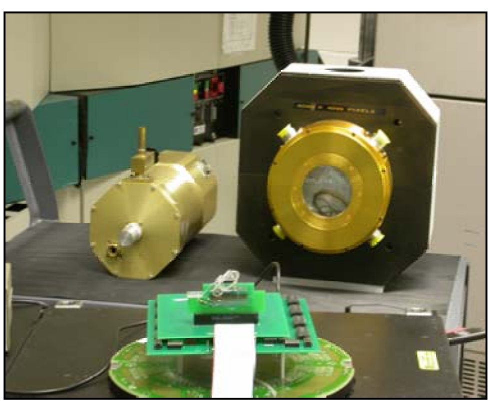
Parts Screening, Qualification, and Failure Analysis (FA)

PARTS TESTING AND ANALYSIS LAB

Ashok Sharma

Capabilities

The Code 562 parts testing and analysis lab provides component-level testing including screening, PVT, PIND, evaluation, qualification, DPA, and FA on all types of active and passive devices and electromechanical assemblies. The active devices include microcircuits, transistors, and diodes, whereas the passive devices include commodities such as cables, capacitors, connectors, fuses, inductors, resistors, relays, and switches. These lab facilities are in Building 22 of GSFC and include state-of-the-art test and environmental equipment including an X-ray, a PIND tester, thermal cycling chambers, burn-in ovens, a HAST chamber for PEMs, bench-top and automated test equipment (ATE) for electrical testing, an acoustic microscope, optical microscopes, a SEM, a liquid crystal setup, and an IR camera for hot-spot detection in semiconductor devices. A separate lab is dedicated to testing of fiber-optic and all types of optoelectronic components such as laser diodes, amplifiers, and modulators. Additional capabilities include a lab for hybrid device assembly that includes manual and automated wire bonders and destructive wire bond and dies shear test equipment. This lab is currently being used for flight assembly and testing of SSPAs for the RF transmitter used in the SDO project. A recent addition to the parts testing and analysis lab is the capability of testing at cryogenic temperatures (liquid nitrogen and helium based up to 30 °K). This testing is being done on micro-shutter array ASICs to support the JWST project. Below is depicted the cryogenic test setup including the dewar and ATE interface. Further details about cryogenic testing support can be found in Alexander Teverovsky's article on page 25, Degradation of SiGe Transistors at Cryogenic Temperatures.



Screening and Qualification

Screening is performed per project work request and specification for the part type tested. The purpose of this testing is to identify/detect workmanship, manufacturing process related defects, and infant mortality types of failures by subjecting the devices to electrical, thermo-mechanical, and burn-in stress testing.

The T&A lab received approximately 43 screening lots, out of which about 50% of the parts were active devices such as microcircuits, transistors, and diodes, whereas the remaining 50% of the devices were passive commodities (cables, capacitors, connectors, fuses, inductors, resistors, and switches).

Qualification is performed when requested and extends beyond screening to assess long-term reliability issues by subjecting the parts/commodities to more stringent testing including higher thermo-mechanical stresses, accelerated life testing, or longer duration of burn-in. Qualification is usually performed at the component level. However, for the GLAST project that used several types of complex application-specific integrated circuits, special board-level qualification testing was developed that involved building special fixtures for low- and high-temperature testing, generating software, monitoring critical device parameters while under testing, and establishing pass/fail criteria.

The T&A lab received roughly 40% active devices for qualification testing, and the remaining 60% were passive devices such as fuses, inductors, and resistors.

Destructive Physical Analysis (DPA) and Failure Analysis

DPA is performed on sample devices to examine design and workmanship-related issues that can affect device reliability and long-term operation. Failure analysis is performed on the devices that have failed during screening, qualification, or board-level/system-level testing. Failure analysis involves device electrical testing, X-ray, C-mode scanning acoustic microscopy (C-SAM), de-encapsulation, optical as well as scanning electron microscope (SEM) examination, cross-sectioning, and other advanced IR/thermal techniques to identify device failure mode and mechanism.

The T&A lab received about 140 DPA lots that included all types of active and passive devices. About 42 device types were received for failure analysis.

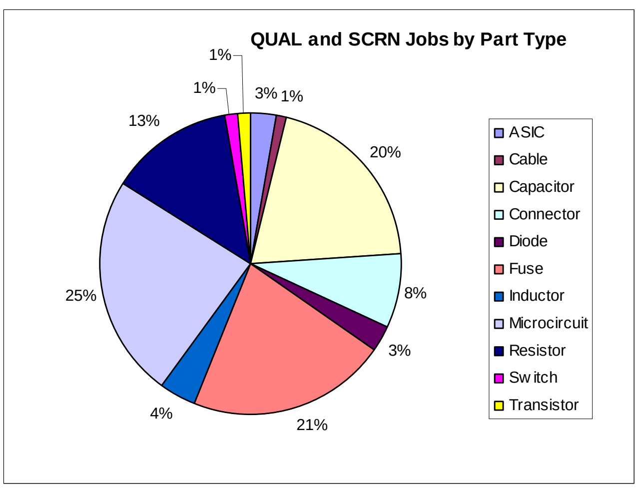
PVT and PIND Testing

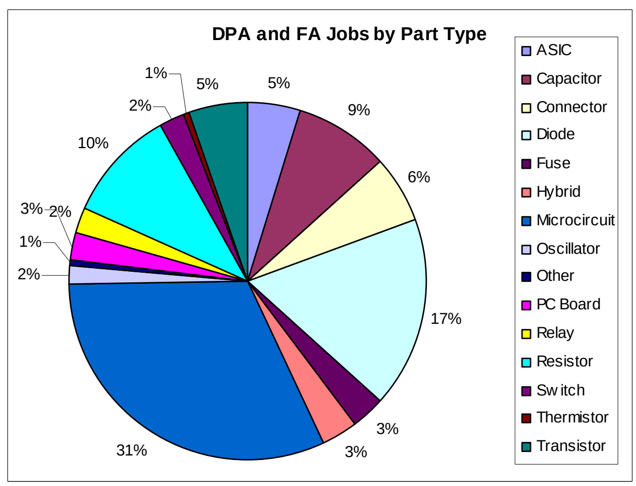
Procurement verification testing (PVT) is performed to identify workmanship types of visual, mechanical defects, and electrical rejects. Particle impact noise detection (PIND) testing is performed usually on active packaged devices that have a cavity inside to detect any loose particles or contaminants on the die surface that may cause device failure or performance degradation. The T&A lab is receiving many requests for PIND testing, since this is usually not performed by manufacturers.

Jobs by Part Type and Job Type

Below are the numbers of job lots per part type and job type defined by description of work.

Part Type	DPA	Evaluation	FA	PIND	PVT	Qualification	Screening	Other
ASIC	8	7	1	–	–	2	–	2
Cable	–	–	–	–	5	–	1	3
Capacitor	14	5	2	–	1	–	15	9
Connector	6	3	5	–	8	–	6	6
Diode	29	3	3	6	1	1	1	4
Fiber Optics	–	–	–	–	1	–	–	–
Fuse	6	–	–	–	–	6	10	–
Hybrid	4	4	2	1	4	–	–	3
Inductor	–	–	–	–	1	1	2	–
Microcircuit	41	13	18	59	3	6	12	23
Oscillator	2	–	1	1	–	–	–	–
Other	–	5	1	–	–	–	–	4
PC Board	4	–	1	–	1	–	–	1
Relay	–	1	4	1	–	–	–	–
Resistor	18	2	1	1	1	6	4	2
RF Detector	–	1	–	–	1	–	–	–
Switch	4	1	–	2	–	–	1	2
Thermistor	–	1	1	–	–	–	–	–
Transistor	8	1	2	13	–	–	1	1
Wire	–	7	–	–	–	–	–	–



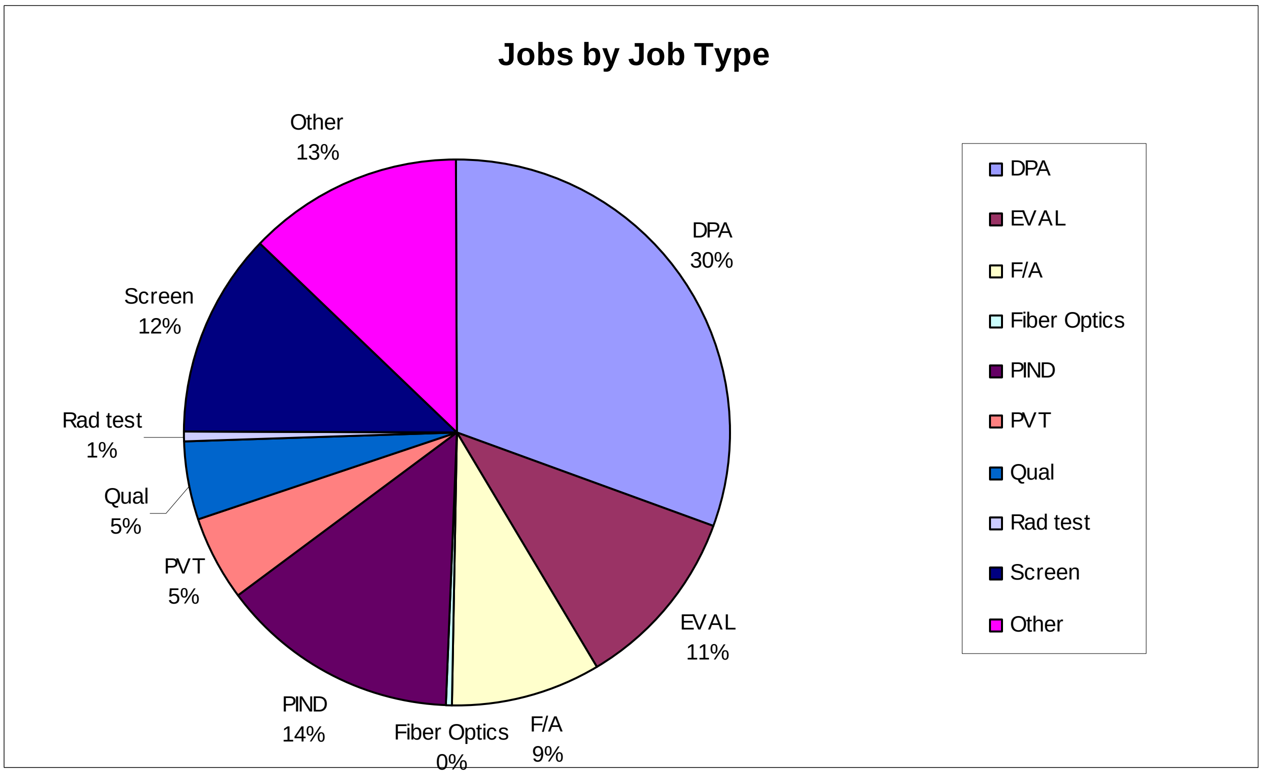


The qualification and screening pie chart (left) shows relative percentages for each part type versus total qualification and screening jobs performed, while the table shows commodity and part types versus various job types performed. The DPA and FA pie chart (right) shows relative percentages of each part type's total DPA and FA jobs performed, while the table shows various commodities and part types versus job types including DPA and FA performed.

Jobs per Project and Job Type

Below are the numbers of job lots per project and job type defined by project.

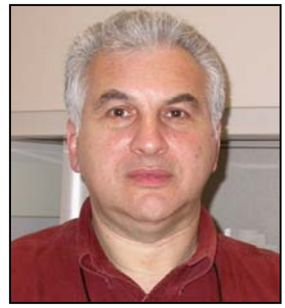
Project	DPA	Eval.	FA	PIND	PVT	Rad. Testing	Qual.	Screening	Other
Explorer	–	1	1	–	–	–	9	10	4
GLAST	54	6	7	16	8	1	13	19	33
GLORY	6	–	–	–	1	–	–	–	2
HST	37	3	3	20	7	–	–	4	1
JWST	2	2	–	–	1	–	–	–	–
Misc.	1	10	5	25	1	–	–	3	1
NPP	2	6	1	–	1	–	–	–	–
NSROC	–	–	4	–	–	–	–	–	1
SDO	4	–	3	–	–	–	–	4	5
Shuttle	–	1	–	–	3	–	–	–	–
ST-5	4	3	6	–	2	–	–	1	5
STEREO	33	18	6	4	11	–	–	3	4
SWIFT	1	2	6	2	–	2	–	2	3



The pie chart above illustrates distribution of overall jobs by job type, while the table breaks down that information for all projects listed.

SCREENING AND QUALIFICATION OF COMMERCIAL PEMs FOR SPACE APPLICATIONS

Alexander Teverovsky

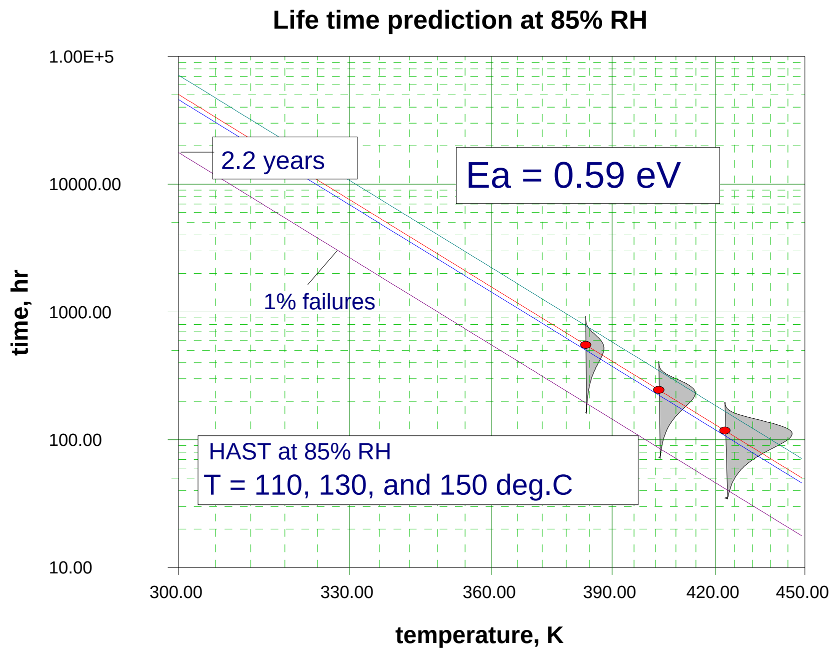


The benefits of using advanced technology and high-performance commercial off-the-shelf (COTS) plastic encapsulated microcircuits (PEMs) have come to the military and aerospace equipment manufacturer community, along with the task of evaluating and qualifying the devices to the level required for high-reliability applications. The philosophy and practice of commercial manufacturers differs dramatically from the methodology used to manufacture and test military components; some techniques that were proved effective for military-grade parts cannot be used for commercial PEMs. This requires development of new approaches for reliability evaluation and quality assurance.

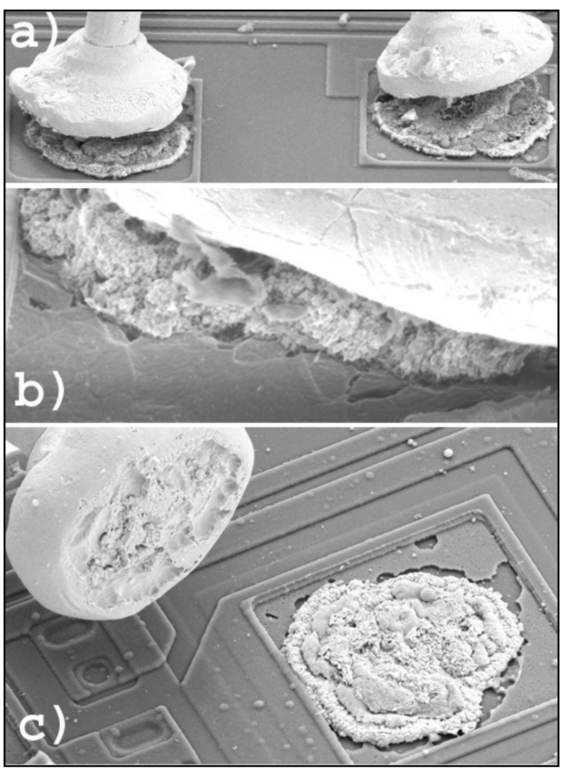
Based on experience acquired by the parts engineering community in the process of working with commercial parts, practices, and guidelines established by high-reliability electronics original equipment manufacturers (OEMs), and the existing qualification system for military and aerospace components, Code 562 of NASA Goddard Space Flight Center (GSFC) developed and released in August 2002 Instructions for PEMs Selection, Screening, and Qualification, 311-INST-001, Revision A. Major elements of this document were used in Instructions for Electrical, Electronic, and Electromechanical (EEE) Parts Selection, Screening, Qualification, and Derating, EEE-INST-002, released in May 2003, which is used as a guideline across all NASA Centers and internationally. This document describes GSFC's policy on PEMs applications, establishes a system of quality assurance for PEMs, and provides detailed guidelines for three major elements of the quality assurance system: screening, qualification, and destructive physical analysis. It also contains requirements for derating and handling of PEMs and recommendations for additional design evaluation and assessment of part history.

Rapid changes in the design and technology of microcircuits might make current guidelines obsolete in the near future. To keep pace with technology changes, a lessons-learned feedback system to improve PEM screening and qualification guidelines was implemented by Code 562 at GSFC. The core of the system is based on thorough analysis of all screening and qualification (S&Q) results generated by GSFC projects, follow-up investigation of revealed problems, accumulation of test and analysis results in a PEMs database, and dissemination of this information through the NASA parts engineering community.

This system allows optimization of test plans, stress test conditions, and evaluation of the effectiveness of different techniques. Using this system, necessary corrections in the qualification and screening test flows are currently being made to reduce cost and improve the quality assurance system of PEMs for space applications.



An example of risk evaluation for the plastic encapsulated parts, which had failures during highly accelerated stress testing (HAST).



Example of degraded bonds.

Dr. Henning Leidecker: Code 562's Chief Engineer

Dr. Henning Leidecker attended The Catholic University of America, graduating with a B.A. in 1963 (Physics Major; Philosophy Minor, Sigma Xi) and a Ph.D. in Physics in 1968. He was a professor of physics at The American University from 1967 to 1985, where he graduated 10 Ph.D. students and several Masters students. Dr. Leidecker taught courses in Thermodynamics, Statistical Mechanics, Classical Mechanics, Quantum Mechanics, Electricity and Magnetism, Solid-State Physics, and Methods of Mathematical Physics, among others. He was a Member of Technical Staff at Bell Telephone Laboratories during the summer of 1969. He worked at Goddard Space Flight Center in the Materials Branch from 1985 to 1996, in the Assurance Technologies Division from 1996 until the GSFC reorganization, and in Code 562 from then until now. He is currently the Chief Engineer for Code 562.

Dr. Leidecker has received a number of awards while at Goddard, including the QASAR Award for Safety and Mission Assurance for contributions to the safety of NASA programs for 1999 and again for 2000. He received the Robert C. Baumann Memorial Award For Contributions to Mission Success for 2000, and a Flight Awareness Award 2001. In 2003, Dr. Leidecker was awarded a NASA Medal for Exceptional Service, and in 2004 he received a NASA Award of Merit, NASA Medal for Outstanding Leadership, ICESat GSFC Certificate of Recognition, and numerous Group Achievement Awards and Groups, Special Acts, and Accommodations Awards.

Below is a list of some of Dr. Leidecker's publications.

1. Probability of Success of Interpoint MTR28xxd Converters Used in Image
2. Video: Known Problems With the Use of Pure Tin Coatings – Questions
3. Response of a FM08-Style Fuse to a Pulse of Current: Memo to XTE Project
4. Notes on the Reliability of the HST Gyros
5. A Comparison of Moisture Resistance With Different Types of End-Terminations In Ceramic Capacitors
6. Video: Known Problems With the Use of Pure Tin Coatings – Part 1
7. Vibration-induced Fatigue Failures in Bonding Wires Used in Stacked Chip Modules
8. COTS PEMs Procurement/Acquisition Concerns and Issues
9. Video: Known Problems with the Use of Pure Tin Coatings – Part 2
10. Executive Summary CVD Diamond Film Project WPI Major Qualifying Project

THE "ASK HENNING" WEB SITE

One of NASA GSFC's significant intellectual assets is Dr. Henning Leidecker, Chief Engineer of Code 562 and a man of great knowledge and experience at NASA GSFC. His advice is sought time and again by various individuals and projects for guidance on reliability and quality issues pertaining to electronic parts and materials that, in time, may be flown in space. Many GSFC engineers line up outside of his door to get answers to questions regarding their electronic parts. For this reason, the "Ask Henning" Web page was developed essentially to digitally archive Dr. Leidecker's knowledge.

The Web site is at http://128.183.52.249/askhenning/. The site was developed with the goals of helping GSFC better utilize intellectual capital, providing a focal point for engineers to ask EEE parts-related questions, establishing a learning organization approach within the parts organization, and enabling parts organization to support projects in meeting NASA's new vision for space exploration. The site includes search capabilities, frequently asked questions, background, a reading list, problem-solving approaches, and experiences (papers, e-mails, and analysis).

THE EFFECT OF SCREENING ON RELIABILITY WITH APPLICATION TO ACTEL FPGAs

Henning Leidecker

In general literature, reliability equates with dependability. But in engineering literature, this term has come to mean something more specific and quantitative: It is the probability that a system will satisfactorily perform its intended function for the mission time when operated in the mission environment. Parts are often screened in the hope that this will improve their reliability.

One kind of screen—a functional screen—examines whether the parts perform their intended function when operated in the mission environment for a particular “screening time,” and parts that do not are rejected. The expectation is that surviving parts are more reliable for the subject mission, and the more so, the longer the screening time. We show how to compute the change in reliability achieved by this kind of screen, provided we know the probability of correct functioning in this environment as a function of time.

Another kind of screen—a parametric screen—attends to the dynamics of the performance-affecting parameters of the parts as they carry out their intended functions in the specified environment. There are situations in which one can use the parameter-change information gained during the screening time to predict later functional failures, even though the functional failures are not visible during that time. In these situations, a parametric screen can produce better reliability gains than a functional screen.

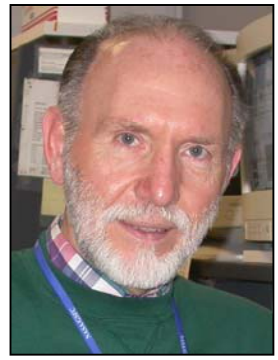
Both kinds of screens can be carried out in an environment that is more stressful than the mission environment. This is called an accelerated screen, sometimes only out of hope; acceleration is not discussed in this report. The full-length paper addresses general rules, functional screening, parametric shifts and functional failures, and combining functional and parametric screening for Actel field programmable gate arrays (FPGAs). When we know the reliability of individual devices, then we can design systems that attain the required reliability for space flight use.

Example of an Actel FPGA.

Advanced Technology and Manufacturing

GSFC SPACE HARDWARE PACKAGING AND ASSEMBLY GROUP

Larry Pack



Code 562's Space Hardware Packaging and Assembly Group has been serving GSFC since 1989. This organization understands NASA's issues, costs, schedules, and plans; all work is performed onsite to NASA standards and is essential for projects to accomplish build requirements on time and within budget. The group operates two assembly labs and a PWB layout lab, and products range from ground-support equipment development and test hardware to complete flight packages. Examples of projects the group has supported are CIRS, GLAS, GLAST, GPM, IRAC, JWST, Living With a Star, MAP, MLA, MOLA I and II, SDO, ST-5, and SWIFT BAT. The group's chief objective is to employ standardized processes and procedures for all NASA projects to ensure high-quality products and mitigate risks effectively. The group's technical capabilities save projects money and resources while providing experienced flight- and ISO 9001-certified personnel who understand today's complex, sophisticated parts and the dynamics of launch and orbit. Services offered include the following:

- Project planning and management; task setup, management, and tracking; and SOW development.
- Cost and schedule development and tracking support, and detailed cost and status reporting.
- Mechanical and thermal packaging engineering, and analysis to the component level.
- Packaging, electrical, and enclosure design.
- Electronics packaging (complete engineering design and mechanical/thermal analysis).
- PWB fabrication, layout, and drawings.
- Electrical and electronic assembly and inspection (PWB, SMT, BGA, conventional, and cables and harnesses).

FIBER LASER DEVELOPMENT FOR SPACE FLIGHT ENVIRONMENTS

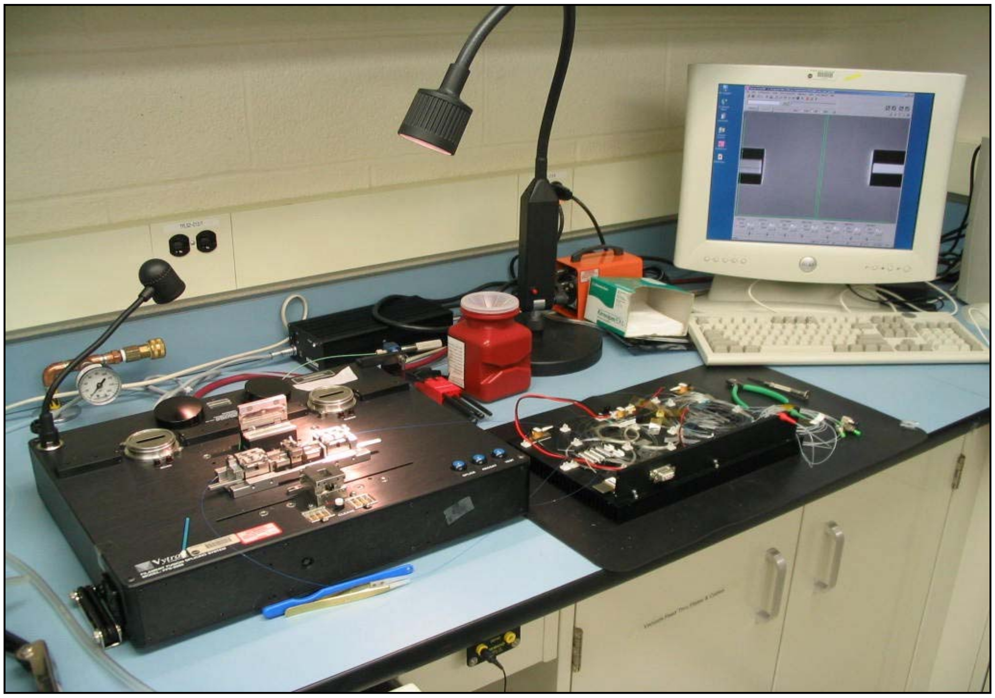
Melanie Ott

Fiber lasers are still considered an emerging technology because at the system level there exists no harsh environmental qualification data that is available to the public. Some vendors claim to have thermal and vibration data on their units, but NASA still needs to conduct validation analysis and testing to insure the technology will function as expected under harsh environmental conditions. In most cases, the known failure modes of these systems can be approached and validated in the way other COTS photonics devices have been validated in the past for reliable functionality. In general, fiber lasers are of great interest because they are primarily intrinsic systems in that the majority of components that compose a fiber amplifier system are linked with optical fiber. Typically these systems consist of rare earth doped amplifier fiber, pump diodes, Bragg gratings, isolators, thermal controllers, and a fiber coupling mechanism (packaging technique varies).

Many of the components that make up fiber laser systems have been used in telecommunications and other space-based systems for the past decade. However, as with any system based on commercial components, a knowledge-based approach for validation of each technology should be implemented to increase the technology readiness level (TRL) of this technology. Currently, fiber lasers and amplifiers are being developed for the Mars Laser Communications Demonstration (MLCD) and for usage as part of the Laser Interferometer Space Antenna (LISA), and they are being considered for Robotic 3D Vision for Moon and Mars Surface Rovers (Code T), imaging lidar for wide mapping of ice-sheet topography, future advanced implementation of the Laser Vegetation Imaging Sensor (LVIS), and a future implementation of GLAS. In order to best enable this technology, Code 562 has provided some preliminary reports on the technology readiness of these systems. Reports are being presented at http://misspiggy.gsfc.nasa.gov/photonics. In particular, a summary report on the radiation effects of fiber laser fiber available in published literature is located at http://misspiggy.gsfc.nasa.gov/tva/meldoc/fiberlaserradiationeffects.pdf.

One commonality among the published data is the conclusion that of all the components that make up typical fiber amplifier systems, the rare earth doped fiber is the most susceptible to radiation-induced darkening and is considered the first component necessary to test prior to assessment of the system performance as a whole. Mostly this is due to the long path lengths and the high dopant concentration. In answering the need for a small database of radiation data on these optical fibers for 1064 nm wavelength usage, Code 562 in cooperation with Code 561 will be performing radiation testing of several amplifier optical fiber candidates. In addition, a database of available commercial photonic components will be formulated that enable fiber laser designs and that are best suitable for space flight environments based on the testing and analysis available. Code 562 is currently working with several components vendors to bring this technology to a higher TRL.

In addition to consulting for design, development, testing, assessment, and reliability, the Code 562 photonics laboratory is supporting the fabrication of fiber laser prototypes with fusion-splicing and termination efforts. These missions are using 1064 nm for performing lidar-type science-based measurements. During 2004, the photonics lab supported the prototyping and studies for fiber amplifiers for lidar space missions, and in 2005 it will support development of fiber-amplifier activities to support the robotic laser vision system for the Code T Enterprise.



Manufacturing support for fiber amplifier development for lidar space missions.

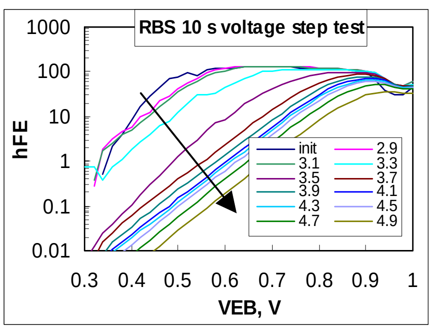
RELIABILITY EVALUATION OF SiGe TRANSISTORS

Alexander Teverovsky

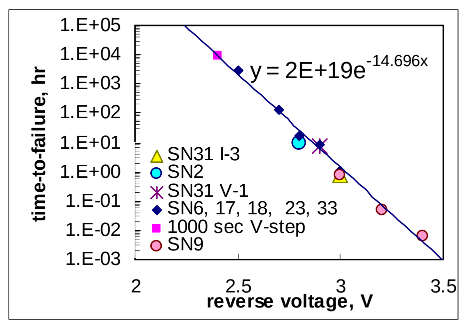
Exposure to reverse E-B voltages degrades low-current gain and increases noise in most bipolar junction transistors (BJTs) and in silicon-germanium (SiGe) technology transistors in particular. Reverse bias conditions occur during operation of devices manufactured by bipolar complementary metal oxide semiconductor (BiCMOS) technology and bipolar technology, e.g., op-amps and analog-to-digital converters (ADCs). The effect has been known for more than 35 years, but increases in importance for sub-micrometer-sized transistors. The level of degradation depends on design and materials and has to be evaluated for new technologies. The effect of environmental conditions on reverse bias degradation has not been investigated yet.

The purpose of reliability evaluation in this case was to accomplish the following:

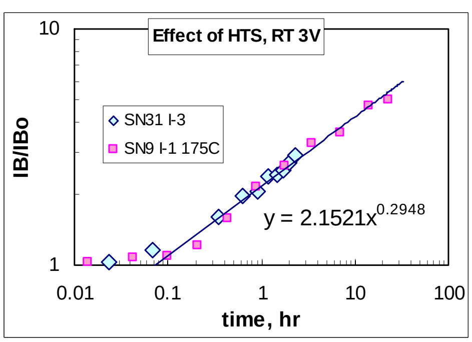
1. Estimate acceleration factors of reverse-bias-stress (RBS) degradation and long-term reliability of the SiGe transistors used in high-frequency ADCs.
2. Evaluate the effect of environmental stress testing on reverse-bias degradation.
3. Assess radiation tolerance and the effect of preconditioning on results of radiation testing (total ionization dose [TID]).

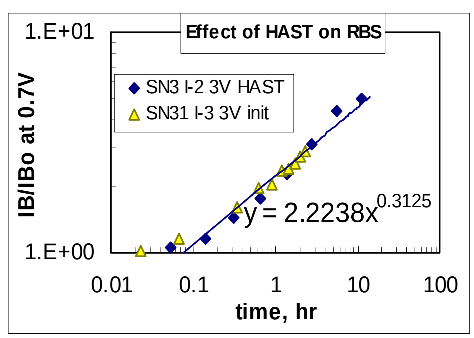


Typical gain degradation during RBS.



Accelerating factors of degradation.



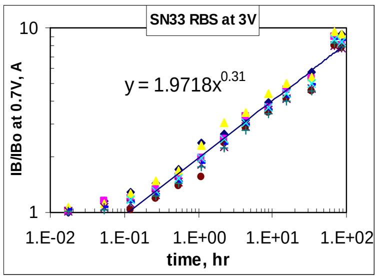


Environmental stress testing (HTS – right and HAST – left) does not affect RBS.

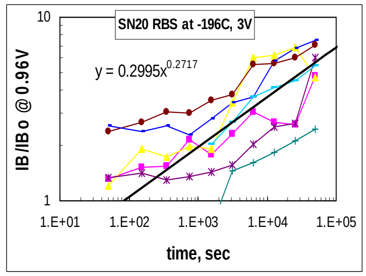
DEGRADATION OF SiGe TRANSISTORS AT CRYOGENIC TEMPERATURES

Alexander Teverovsky

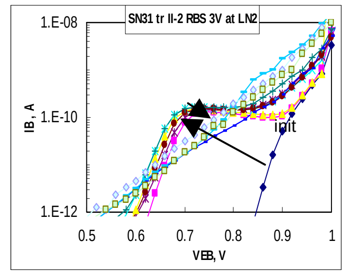
In a separate set of experiments, reverse bias degradation of SiGe transistors was investigated at a liquid nitrogen temperature of -196 ^{o}C. Below are some results of these tests.



1a) RBS at 3V and +25 ^{o}C.



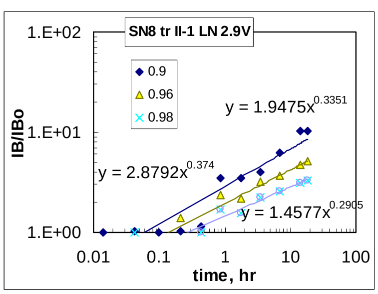
1b) RBS at 3V and -196 ^{o}C.



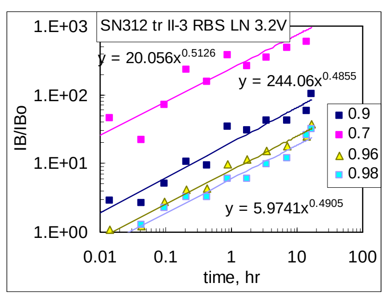
1c) Anomalous forward IV characteristics during RBS at LN.

Reverse bias testing at 3 V.

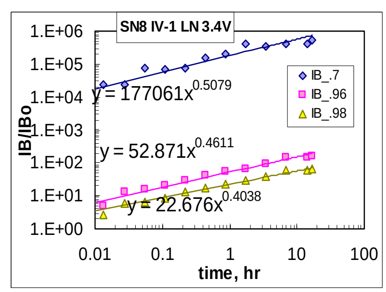
Reverse bias degradation at -196 ^{o}C is less reproducible than at room temperature (compare Figs. 1a and 1b). In some cases, anomalous behavior of forward I-V characteristics was observed (Fig. 1c). In these cases, base currents first increased sharply resulting in step-like I-V characteristics, and then the currents decreased resulting in "normal" IB currents, which exponentially increased with forward voltage.



2a) VRB=2.9 V.



2b) VRB=3.2 V.



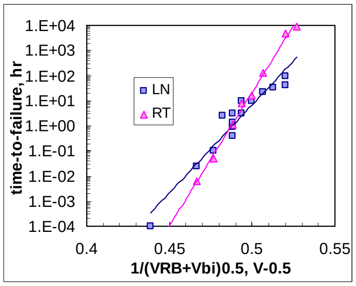
2c) VRB=3.4 V.

Variations of base currents with time during RB testing at -196 ^{o}C and different VRB.

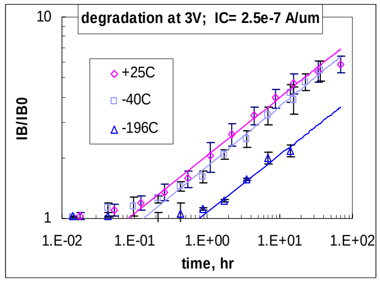
Similar to room-temperature conditions, RB degradation at -196 ^{o}C (see Fig. 2) can be described with a power function: IB/IBo ~ t^{β} at t > t_i(VF), where 0.6 < β < 0.3. Degradation time exponent, β, has a trend of increasing at lower VF and is somewhat larger than at RT ($\beta_{avr.}$~0.35 compared to 0.3 at room temperature).

Kinetics of RB currents at RT and LN conditions is similar. At low voltages (VRB < 3 V) currents first increase with time, and then decrease after reaching the maximum;

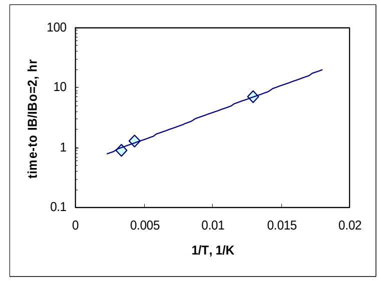
however, at VRB > 3.5 V currents decrease with time. Similar to what was observed at room temperature, at LN conditions the time-to-maximum reverse current decreases with voltage exponentially. Extremes in IRB -t curves might indicate a change in the degradation mechanism.



3a) Time-to-failure as a function of reverse EB bias at +25 °C and -196 °C.



3b) Reverse bias test at 3 V. Degradation is normalized to IC = 2.5×10-7 A/μm.



3c) Arrhenius plot of time-to-failure (IB/IBo = 2).

Effect of temperature and voltage during reverse bias stress testing.

Fig. 3 suggests that reverse bias degradation increases linearly with the tunnel component of reverse current, which prevails at room and low temperatures and is an exponential function of reverse electrical field [$E \sim (V+V_{bi})^{0.5}$], $I_{RB} = A\times\exp[B/(V_{RB}+V_{bi})^{0.5}]$, where B is constant (= 47.1); V_{bi} is the built-in EB voltage (=1.2 V).

A least-square fit (LSF) analysis has shown that experimental data on voltage dependence of time-to-failure, τ, at room temperature and -196 °C fit equally well to both approximations: the one, which is typically used in accelerated reliability testing, $\tau \sim \exp(-\alpha V_{RB})$, and the other, which is based on voltage dependence of reverse EB currents, $\tau \sim \exp[B/(V_{RB}+V_{bi})^{0.5}]$. This allows using a simple engineering model to describe acceleration factors of reverse bias degradation in SiGe transistors at 2.5 < VRB< 4 V and temperatures from +25 to –196 °C using the following equation:

$$IB/IB_0 = A \times t^{\beta} \times \exp(-\alpha \times V_{RB}), \quad t > ti(VF),$$

where $\beta \sim 0.3$, $\alpha \sim 4.4$ at RT and $\beta \sim 0.35$, $\alpha \sim 3.2$ at –196 °C; $t_i(VF)$ is the induction period, which depends on VF.

In a range from +25 °C to -196 °C, the time-to-failure due to reverse bias degradation has a weak temperature dependence with an apparent activation energy of Ea ~0.02 eV (see Fig. 3c). There is a trend of further decreasing Ea at low VRB down to ~ -0.04 eV at VRB=2.5 V.

MMIC PACKAGING AND SSPA ASSEMBLIES FOR THE SDO PROJECT

Jeannette Plante

A Ka-band transmitter is being designed and built for the Solar Dynamics Observatory (SDO) spacecraft and is part of the Ka communications system. The Ka-transmitter box contains three major sections:

1. The base plate with the power supply components and PC board assembly attached to it.
2. The main body with the interface board carrying packaged electronic parts and chip passives mounted to the underside; the RF circuitry in the form of alumina and aluminum nitride substrates and MMIC hybrids attached to the top side, within the RF cavity; connectors mounted to the side walls (which terminate either on a surface within the main body or terminate on the surface of the base plate/power supply); and capacitor feed-throughs that are installed in the main body and connect the interface board to the substrates in the RF cavity.
3. The lid and EMI gasket.

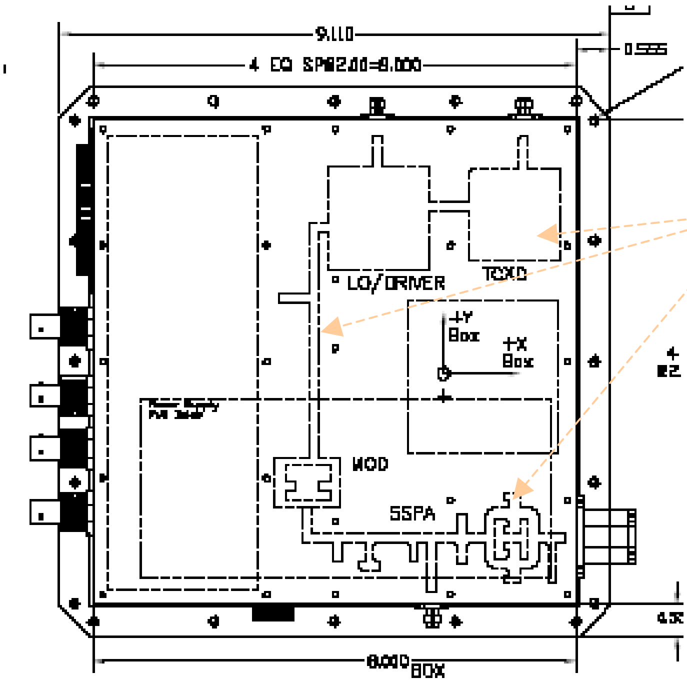
The power supply circuitry is being designed by Carl Kellenbenz of NASA GSFC Code 563. The circuitry in the main body section is being designed by Jeff Jaso of GSFC Code 567. The entire assembly has been prototyped in sections and is being built by NASA Code 562 using a combination of NASA GSFC and outside commercial facilities.

Code 562 is providing the advanced packaging processes development, including 1) MMIC hybrid assembly (die attach and wire bonding), 2) RF cavity chip on-board assembly (substrates and MMIC hybrids interconnected on the main housing with wire bonds), and 3) feed-through and connector installation.

These processes are specially designed and ordered to prevent damage to and contamination of the highly sensitive MMIC dies used in the RF cavity. Particular attention was paid to working in the tight spacings and recesses in the RF cavity that are needed to optimize the electrical performance of the system. An image of the RF cavity section called the SSPA (solid-state power amplifier) is shown below.

This job has enabled Code 562 to demonstrate the many capabilities of the hybrid manufacturing lab and has provided an opportunity to bring the new automatic wire bonder online. The automatic wire bonder in the Code 562 hybrid lab is West Bond Model 343637E. This system is capable of bonding using vertical-feed wedge-wedge boding on Au wire or ribbon, 45 degree feed wire bonding for Au or Al wire, and Au ball-crescent bonding. It has what is referred to as a flying head and allows for bonding over a 6” x 8” area. Additionally, these bond heads move in a pure vertical fashion, allowing for large step bonds to be optimized because the bonding toll remains vertical throughout its range of travel. Process development is being done as prototype units continue to be built in the lab. Procedure development is following in preparation for the engineering model (qualification unit) and flight model build.

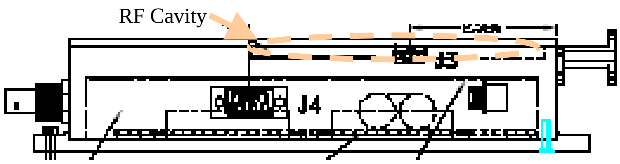
Top-down View of RF Cavity in the Main Body



Complex hog-outs and trenches are machined into the RF cavity floor to create distinct seats for the ceramic substrates and the MMIC hybrid assemblies.

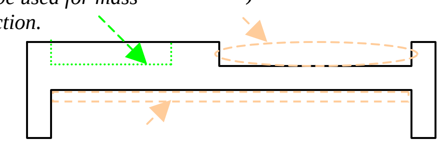
Side View of Lid, Main Body, and Base Plate/Power Supply

RF Cavity



Additional cutouts may be used for mass reduction.

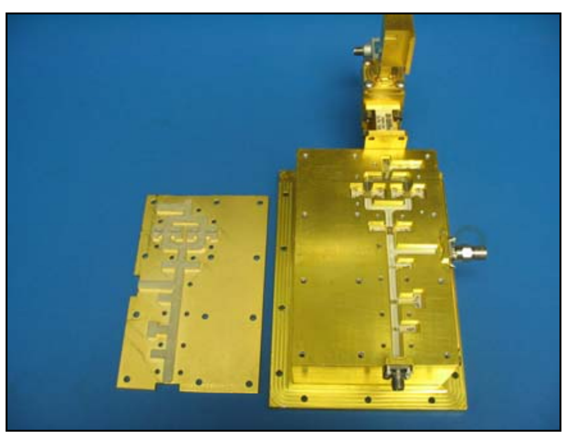
The RF cavity (runs full length of box but only a fraction of its width).



Simplified Side View of Main Body

The interface board is screw-mounted to the ceiling of lower cavity of the main body. This board spans the full length and width of the main body.

Ka-band transmitter box.



SSPA (RF cavity section).

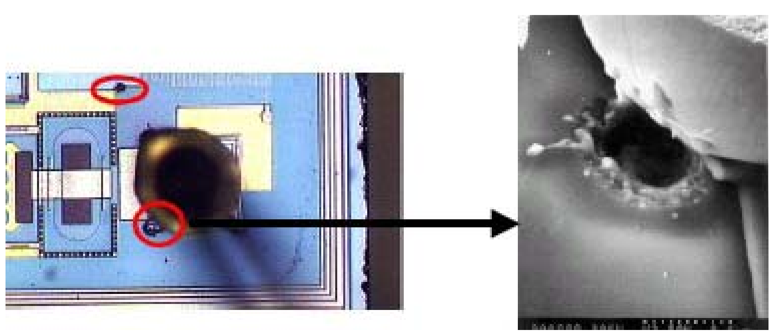
Electrostatic Discharge (ESD) Control

Marcellus Proctor

ESD to electronic devices can occur at any point in manufacturing, assembly, or installation into a spacecraft. Numerous published papers from industry, military, and aerospace organizations, as well as alerts from GIDEP, have expounded on the failures of electronic parts due to ESD. The cost of not implementing effective ESD controls can be substantial in terms of lost dollars for failed parts. Damage to an electrostatic discharge sensitive device by an ESD event is determined by the device's ability to dissipate the energy of the discharge or withstand the voltage levels involved, known as the device's ESD sensitivity. ESD damage is usually caused by direct ESD to the device, ESD from the device, or field-induced discharges.

Many advanced technologies, such as PEMs, are susceptible at less than 100 volts, and many disk-drive components have sensitivities below 10 volts. To put more circuitry into small packages, the spacing isolating circuitry has been reduced, making it more susceptible to ESD. A discharge of static electricity produces enough heat to burn through microelectronic architecture that is rated to withstand voltage in the order of volts. As a preventive measure, on-chip ESD protection mechanisms dissipate the large ESD current transient safely using a low-impedance discharging channel to prevent thermal damages in the silicon and/or metal interconnects, and to clamp any large ESD-induced voltage pulse to a safe level to avoid dielectric degradation or rupture. The complete ESD protection solution should be realized at the chip level, where the emphasis is creating a discharging channel from any pin to every other pin on a chip.

Any project at GSFC should evaluate ESD sensitivity levels for their parts. If the project deems that the ESDS parts are critical or necessary to the success of the mission requirements, then an ESD Control Plan must be written to ensure that ESDS parts are not exposed to ESD pulses from handling to installation. This plan requires the coordinated efforts of all levels of engineering, quality assurance, and project management to be effective and successful. For more information, see the ESD Web site located on the EED home page at http://eed.gsfc.nasa.gov/562/ESD_PreventionGSFCHWFrontpage.htm.



Visual ESD damage of a ball bond on a circuit board.

Knowledge Exchange

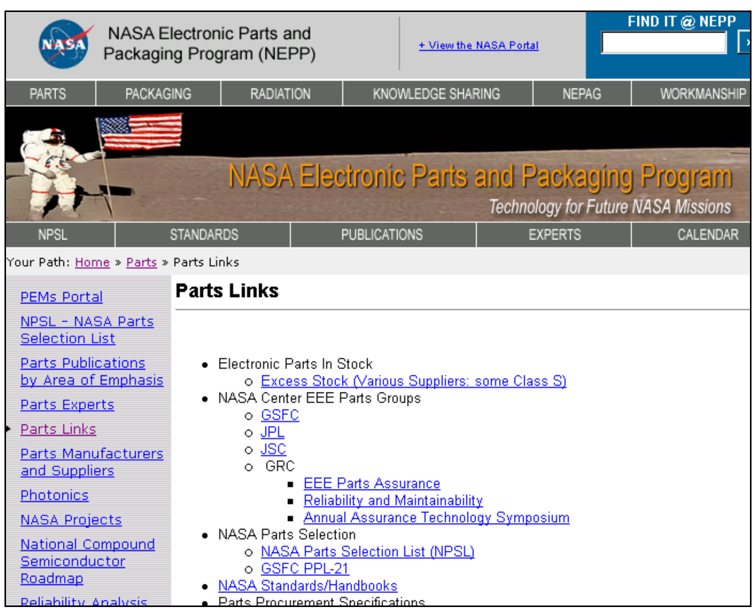
EEE-INST-002

Kusum Sahu

The purpose of EEE-INST-002, Instructions for EEE Parts Selection, Screening, Qualification, and Derating, is to establish baseline criteria for selection, screening, qualification, and derating of EEE parts for use on NASA GSFC space flight projects. It provides a mechanism to assure that appropriate parts are used in the fabrication of space hardware that will meet mission reliability objectives within budget constraints. It is updated as needed and used as a guideline across all NASA Centers and internationally.

This document provides instructions for meeting three reliability levels of EEE parts requirements based on mission needs. Level 1 is the highest reliability and level 3 the lowest. A level 1 part has the highest level of manufacturing control and testing per military or DSCC specifications. Level 2 parts have reduced manufacturing control and testing. Level 3 parts have no guaranteed reliability controls in the manufacturing process and no standardized testing requirements. The reliability of level 3 parts can vary significantly with each manufacturer and part type due to unreported and frequent changes in design, construction, and materials. GSFC projects and contractors are required to incorporate this guideline into their Project EEE Parts Program.

To download the document, go to http://nepp.nasa.gov and select Parts > Parts Links > Parts Applications > EEE-INST-002; scroll down and select the document, and complete the download page form to access the full version of the document.



DESIGN AND DEPLOYMENT OF PARTS ENGINEERING DATABASE II

Jeannette Plante

The second generation of Code 562's parts engineering database was brought online in 2004 to continue to increase connectivity among the many independently operating banks of data used by flight projects for selecting and managing their electronic parts. The basic infrastructure of the parts engineering database II (PdBII) includes the following features.

Project Formulation: Reference information for each project, including names and contact information for the project and project management, is recorded here. This data also includes fields for recording critical milestone dates (PDR, CDR, pre-ship review, etc.) so that standardized reports can be generated based on project status.

Project Requirement: Mission profile and environmental requirements information is recorded here. This provides background and insight about the basis upon which the electronic parts that are associated with a given project were selected and tested. Parts engineers can find projects that had similar (same or tougher) requirements and discover leveraging opportunities in the form of knowledge, data, purchases, or spare parts.

System Organization: The database provides a method for defining the structure of a project's subsystems so that the electronic parts lists can be associated correctly with spacecraft or instrument name, subsystem name, and board or module name. This enables the parts engineer to track and report parts information at any of these levels and enables the branch to assess and manage parts concerns based on how the parts are used.

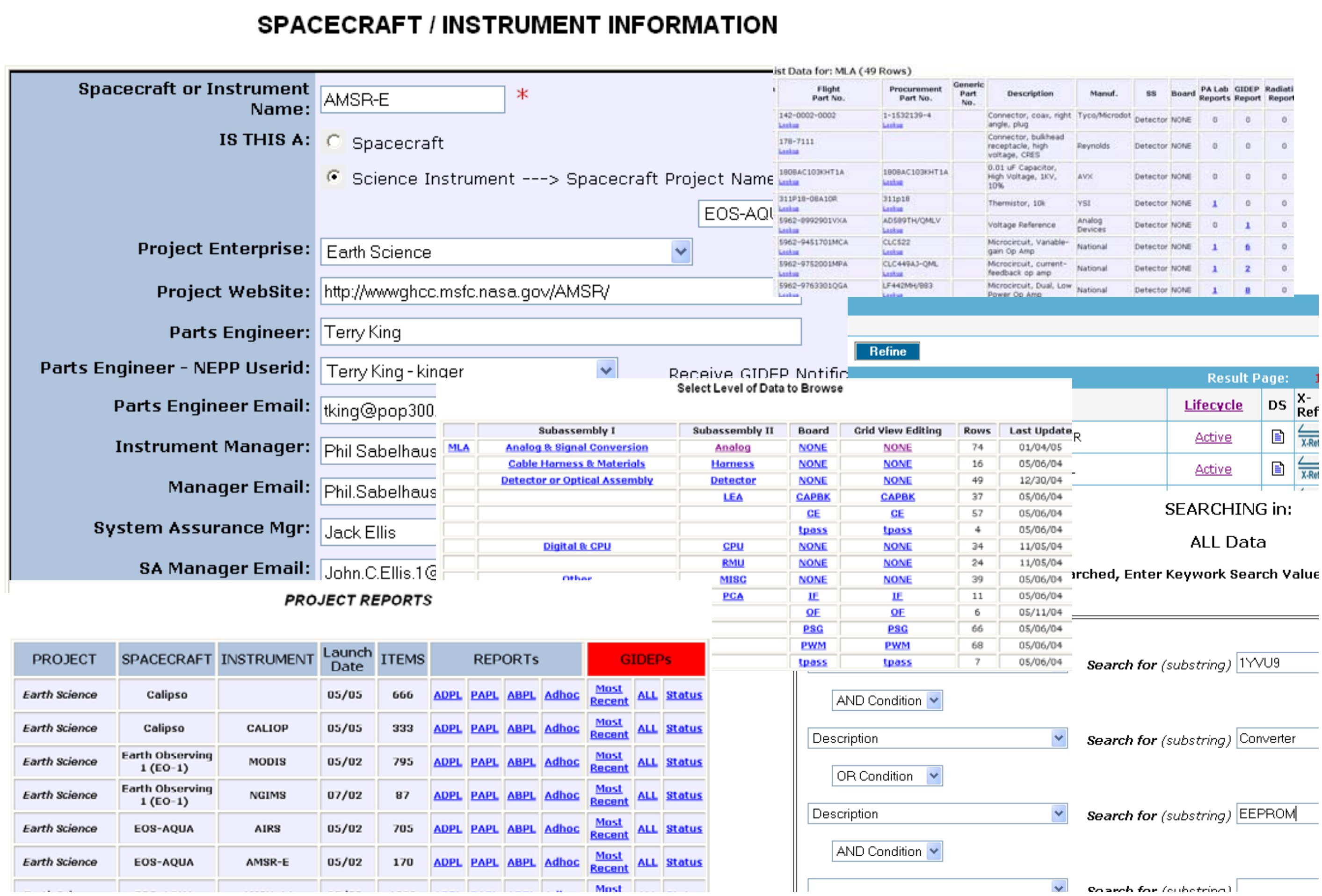
Formats: A tool is provided that allows the parts engineer to upload parts lists from a Microsoft Excel format regardless of the column arrangement. A minimal amount of data is required to upload a valid record so that projects from their earliest stages through launch can create records and continue adding to them throughout the project life cycle.

Maintenance and Reports: Tools are included to allow the parts engineers to update individual records as needed. They can define special reports or use tools that generate generic or "canned" reports such as an as-designed list, an as-built list, or a kit list. The maintenance capability has several entry ways to enable either editing field-by-field or by cutting and pasting from Excel lists or other tables into many fields simultaneously.

Searching: Built into PdBII is automatic connectivity among several information collections such as GIDEP, the Parts Analysis Test Lab Library, and the RadHome Library. All parts in PdBII are matched up with these libraries and matches are displayed. Not only can users see if a part on a list has GIDEPs or test reports associated with it, but also they can view these reports without leaving the system. This associating feature is used to keep the parts engineers notified when a new GIDEP has been issued that may impact a part on their list. Notification is "pushed" to the parts engineer automatically. Custom searches can also be done through the search feature, enabling the parts engineers to quickly identify the list(s) that include a type of part or a range of parts. Boolean operators and three instances of a variable are allowed. The variables are defined by the fields of the database.

Part Finder: PdBII includes connectivity with Silicon Expert, which is a commercial database of millions of valid part numbers. This connectivity allows parts engineers to find alternate part numbers or availability for line items that are still being defined. This feature is still being developed in order to support increased connectivity between the parts lists and the available stock at the manufacturers and distributors – an absolute necessity for the dominant just-in-time manufacturing environment of today.

While PdBII continues to be improved, such as the addition of a field to tag line items that are PEMs and need special handling and testing, Code 562 is broadening its scope of electronic parts knowledge assets and finding ways to connect them to PdBII. These include reports generated by Code 562 and Code 300 about supplier quality, manufacturer announcements about process changes and product line phase-outs, a newly launched automated candidate parts list (to replace any residual use of the obsolete PPL), and application notes. PdBII is also being designed for connectivity with electronic schematic and board layout tools. Contact the Code 562 Office Head for a demonstration of PdBII.



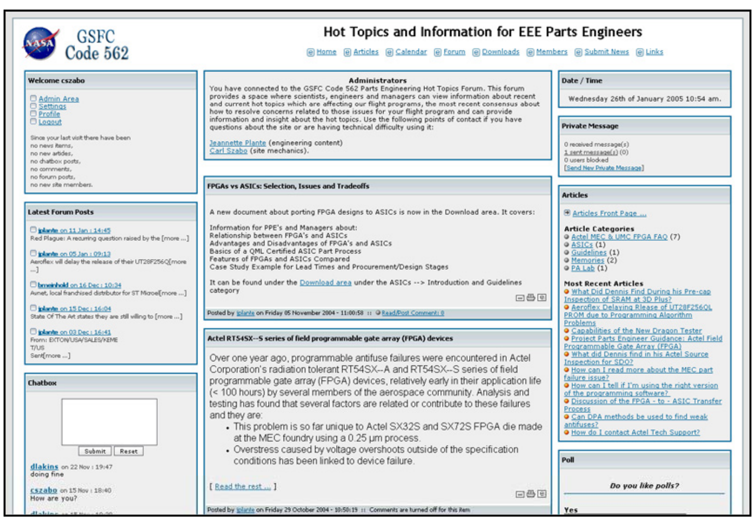
NEW ELECTRONIC PARTS KNOWLEDGE ASSETS BUILT BY CODE 562

Jeannette Plante

In the tradition of the project parts list (PPL), MIL-STD-975, and MIL-STD-978, Code 562 continues to generate important electronic parts knowledge assets that allow GSFC flight projects to select and apply heritage and new electronic parts in ways that will enable them to perform as needed over the life of the mission. These new assets are being designed and built to address current needs and to be compatible with the evolving database system PdBII. The newest tools of this type are the following; these new information sites join an already broad range of knowledge assets maintained by Code 562 including their flagship products about part screening and qualification, ESD, photonics, MEMs, carbon nanotubes, and metal whiskers. See http://eed.gsfc.nasa.gov/codes/code562.htm.

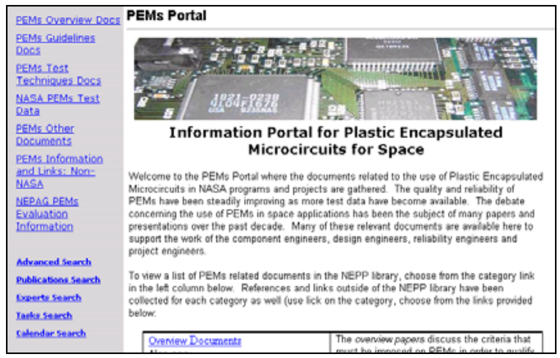
Candidate Parts Selection List (CPSL): This is a Web portal that hosts the current candidate parts list, which is a collection of part numbers that have been pre-approved for use by flight programs and can be bought from NASA-approved vendors and distributors. The tool resides within a forum Web site format so that late-breaking information about the CPSL can be disseminated and so that questions, comments, and lessons learned can be shared among the community. Contact Bruce Meinhold at bruce.meinhold@gsfc.nasa.gov for a demonstration.

Hot Topics and EEE Parts Engineering Forum: This is a Web portal for Code 562 parts engineers to share newly acquired information about part availability, issues, and needs. Draft positions and reports can be shared and issues discussed here prior to formal publication or reporting. This is a tool that provides the parts engineers with an informal chat space to post general parts engineering information that may not be related to a specific project. The Web site, available internally at GSFC, can be accessed at http://128.183.53.35. In order to participate, new users must follow the simple sign-up process and choose a login name and password.



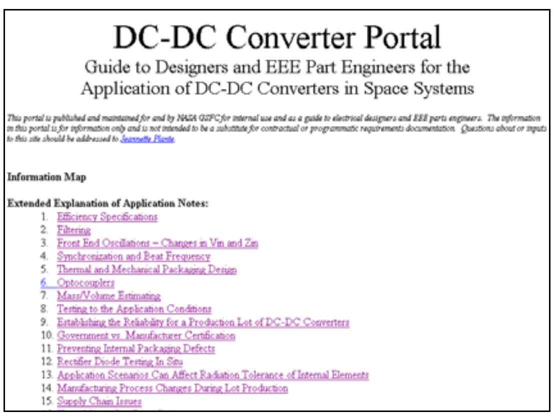
Wire Bond Web Site: This is a suite of Web pages that have been built to store general information about electronic wire bonds and recent lessons learned about wire bond failure modes. This is a public site and can be viewed at http://nepp.nasa.gov/wirebond.

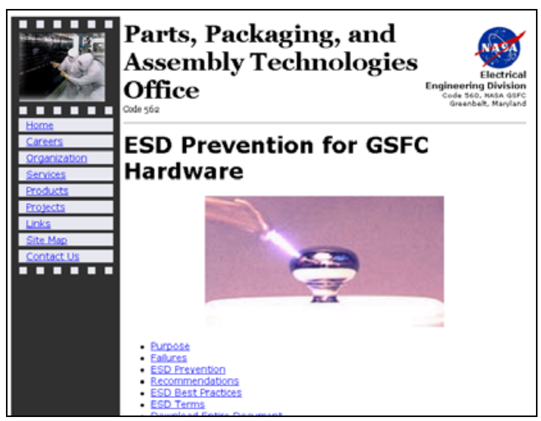
PEMs Portal: This is a suite of Web pages that provide policy positions about the use of PEMs in space hardware. It also pre-sorts the papers in the document library that relate to PEMs technology and reliability. This is a public site and can be viewed at http://nepp.nasa.gov/index_nasa.cfm/1026/.



DC/DC Converter Portal: This is a suite of Web pages that are being built to provide lessons learned and application notes about using hybridized DC/DC converters for space. This is a public site and can be viewed at http://nepp.nasa.gov/dcdc.

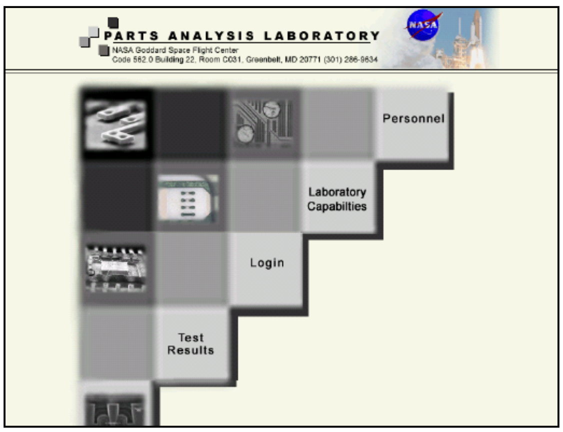
ESD Web Site: This site contains critical information on preventing ESD-related device damage and failure. Details address failures, ESD prevention, recommendations, best practices, and links to relevant documents. The ESD Web site resides on the EED home page at http://eed.gsfc.nasa.gov/562/ESD_PreventionGSFCHWFrontpage.htm.





Parts Analysis (PA) Laboratory Web Site: The Code 562 PA lab provides component testing, inspection, DPA, and failure analysis services on site at GSFC. Types of laboratory services include failure analyses of electrical and electromechanical parts and assemblies, destructive physical analyses, incoming test and inspection, screening/flight qualification, and evaluation. The lab publishes detailed reports of all test results and maintains active databases and historical data for traceability and potential trend analysis. See http://nepp.nasa.gov/palab.

Tin (and Other Metal) Whiskers Home Page: Tin whiskers are electrically conductive, crystalline structures of tin that sometimes grow from surfaces where tin (especially electroplated tin) is used as a final finish. Numerous electronic system failures have been attributed to short circuits caused by tin whiskers that bridge closely spaced circuit elements maintained at different electrical potentials. This site at http://nepp.nasa.gov/whisker/ covers basic information on metal whiskers, failures, FAQs, anecdotes, image galleries, experiments, and related links.



NEW WEB SITE FOR LASER DIODE RELIABILITY FOR SPACE

Melanie Ott

A Web site has been built to aid space flight hardware design, packaging, and parts engineers who need to know about laser diode reliability. It is called Reliability of Laser Diodes for Space Flight Application and is maintained by Melanie Ott at NASA GSFC. It covers packaging issues, test methods, data reports, publications, reliability guidelines, destructive physical analysis reports, and failure reliability reports. Access is direct through http://misspiggy.gsfc.nasa.gov/tva/meldoc/photonicsdocs/LDreliability.htm or through the main photonics Web site at http://misspiggy.gsfc.nasa.gov/photonics/.

III. Looking Ahead to 2005

Darryl Lakins

Code 562's shared vision for the future is to be the Center's focal point for EEE parts, parts engineering, and packaging technology development. This goal is being accomplished through the use of state-of-the-art test laboratories and advanced assembly facilities that will enable the reliable use of EEE parts on the Moon, Mars, and beyond.

Electronic parts are critical elements of NASA space systems. There can be as many as thousands of electronic parts from multiple manufacturers and suppliers that are used interchangeably by system designers and developers throughout the GSFC Enterprise. These EEE parts must withstand harsh environmental conditions while meeting mission reliability and performance requirements. The approach to selecting, procuring, and testing these parts poses a challenge to NASA because of unknown risks associated with newer technologies and the increasingly used integrated development approach to build the systems. We are also challenged by parts that are becoming smaller and more complex, as well as by assembly technologies that focus on miniaturization. Nonetheless, we maintain our position as leaders in the EEE parts community through our vast EEE parts experience and capabilities and our ability to decrease the size of designs. We are unique in that we enable the use of parts that can survive the rigors of space flight.

The GSFC projects, their designers, and the EEE parts suppliers are stakeholders in our efforts. We want to work more closely with projects and part manufacturers as early as possible in the project life cycle. The value that we must continue to bring to the table is our commodity knowledge, parts engineering experience, testing capacities, and advanced fabrication techniques. We remain competitive by functioning as a learning organization and enhancing our interaction with projects, designers, and manufacturers by focusing on design solutions using commodity expertise, technology development, and test and assembly capabilities. Our objectives are as follows:

- By the end of 2005, increase staff with component experts trained in reliability, fiber optics/photonics, and advanced microelectronics.
- By the end of 2005, establish a common part repository that included distributed project inventories linked through information technology.
- By 2006, extend our partnerships with component manufacturers through collaboration, data sharing, and continuous interaction between designers and manufacturers.
- By 2006, extend the capability to test parts in extreme environments, improve inspection and investigation capabilities, establish photonic device qualification and validation techniques, and establish modeling ability.
- By 2007, establish a fully functional test center for MEMS and consolidate the layout and design center, component expertise, and test facilities, as well as extend the EEE parts enterprise to include strategic partners.
- By 2008, develop a fully functional nanotube-based field-effect transistor.

Acronym List

AFB – Air Force Base
ASIC – Application-Specific Integrated Circuit
BAT – Burst Alert Telescope
BGA – Ball Grid Array
BiCMOS – Bipolar Complementary Metal Oxide Semiconductor
BJT – Bipolar Junction Transistor
CALIPSO – Cloud-Aerosol Lidar and Infrared Pathfinders Satellite Observations
CDR – Critical Design Review
COTS – Commercial Off-the-Shelf
cPCI – Compact Peripheral Component Interconnect
CPSL – Candidate Parts Selection List
CSA – Canadian Space Agency
C-SAM – C-mode Scanning Acoustic Microscopy
DC – Direct Current
DOD – U.S. Department of Defense
DPA – Destructive Physical Analysis
DSCC – Defense Supply Center Columbus
E-B – Emitter Base
EED – Electrical Engineering Division
EEE – Electrical, Electronic, and Electromechanical (Parts)
EEPROM – Electrically Erasable Programmable Read-Only Memory
ELV – Electromagnetic Interference
EOS – Earth Observing Satellite
ESA – European Space Agency
ESD – Electrostatic Discharge
ESDS – ESD Sensitive
ESSP – Earth System Science Pathfinders
FA – Failure Analysis
FODB – Fiber Optic Data Bus
FPGA – Field Programmable Gate Array
GIDEP – Government/Industry Data Exchange Program
GLAS – Geosciences Laser Altimetry System
GLAST – Gamma Ray Large Area Space Telescope
GPR – Goddard Procedures and Requirements
GSFC – NASA Goddard Space Flight Center
HALT – Highly Accelerated Life Test
HAST – Highly Accelerated Stress Testing
HBT – Heterojunction Bipolar Transistor
HIRDLS – High-Resolution Dynamics Limb Sounder
HST – Hubble Space Telescope
HTS – High-Temperature Storage
IB – Base Current
IPS – Integrated Procurement Service
IR – Irradiation
IRB – Reverse Bias Current
JAXA – Japan Aerospace Exploration Agency
JPL – NASA Jet Propulsion Laboratory
JSC – NASA Johnson Space Center
JWST – James Webb Space Telescope
LCS – Laser Camera System
LISA – Laser Interferometer Space Antenna
LN – Liquid Nitrogen
LSF – Least-Square Fit
LVIS – Laser Vegetation Imaging Sensor
MEMS – Micro-electromechanical System
MIT – Massachusetts Institute of Technology
MLA – Mercury Laser Altimeter
MLCD – Mars Laser Communications Demonstration
MLS – Microwave Limb Sounder
MMIC – Monolithic Microwave Integrated Circuit
NASA – National Aeronautics and Space Administration
OEM – Original Equipment Manufacturer
OMI – Ozone Monitoring Instrument
PA – Parts Analysis
PAPL – Project Approved Parts List
PCB – Parts Control Board
PdBII – Parts Engineering Database II
PDR – Preliminary (or Product) Design Review
PEMs – Plastic Encapsulated Microcircuits
PIND – Particle Impact Noise Detection
PPE – Project Parts Engineer
PPL – Project Parts List
PVT – Procurement Verification Testing
PWB – Printed Wiring Board
QPLD – Qualified Products Directory List
RBS – Reverse-Bias Stress
RF – Radio Frequency
RLEP – Robotic Lunar Explorer Program
RT – Room Temperature
S&Q – Screening and Qualification
SADA – Solar Array Drive Assembly
SAM – Safety (or System) Assurance Manager
SDO – Solar Dynamics Observatory
SDRAM – Synchronous Dynamic Random-Access Memory
SEC – Sun-Earth Connection
SEM – Scanning Electron Microscope
SiGe – Silicon Germanium
SSPA – Solid-State Power Amplifier
T&A – Test and Analysis
TES – Tropospheric Emission Spectrometer
TID – Total Ionization Dose
TRL – Technology Readiness Level
VRBS – Reverse Bias Stress Voltage

People, Parts, and Processes—We Are "Parts R Us"

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