NEPP

News Flash

June 2001

NASA Electronic Parts and Packaging Program

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SEU Testing on an IBM Prescaler Fabricated in IBMs Germanium Doped Silicon Process

Dr. Robert Reed
NASA/Goddard Space Flight Center

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The NEPP Electronic Radiation Characterization (ERC) Project reports on the first nonproprietary heavy-ion and proton -induced single event upset (SEU) testing of unhardened Germanium doped Silicon (SiGe) heterojunction bipolar transistor (HBT) digital circuits manufactured in the IBM 5HB commercial process.

Background:

ERCs motivation for investigating radiation susceptibility of SiGe technology is driven by the following three major overall objectives of the ERC:

- Provide radiation evaluations and assessments of new and emerging microelectronic and photonics technologies to enhance infusion into NASA missions,

- Develop guidelines for technology usage in radiation environments, and
- Investigate radiation hardness assurance (RHA) issues in order to increase system reliability and reduce cost and schedule.

Plans are under way to enable a managed risk approach to the use of SiGe in satellite applications by addressing radiation related qualification and performance issues. Potential failure modes and error sensitivities will be characterized, which will lead to an understanding of the mechanisms involved for radiation-induced performance degradation. The intent is to establish evaluation protocols and test methodologies, as well as evaluate the utility of "standard" predictive tools and develop new approaches where necessary. Previously, GSFC has demonstrated along with its partners at Auburn University and the Defense Threat Reduction Agency (DTRA) that unmodified commercial IBM SiGe HBT and BICMOS technology can be radiation tolerant to radiation hard. This includes total ionizing dose (TID), proton (TID and displacement damage dose - DDD) and neutron (DDD) effects. No significant degradation of device parameters were observed on all IBM processes when exposed to >4.0x1011 63 MeV protons/cm2 (a TID>50k Rad(Si)). Results have and will be reported at the IEEE Nuclear and Space Radiation Effects Conference (NSREC) 1997 to 2001. Previous work in this area has demonstrated the expected SEU sensitivity of high-speed digital technologies. Work in FY00, evaluated heavy ion and pulsed laser SEU susceptibility of a circuit hardened attempt (unsuccessful) in 5SF HBT for potential SEU critical application. The National Security Agency (NSA), NRL, the Mayo Foundation's Special Purpose Processor Development Group (SPPDG), and Goddard Space Flight Center's Radiation Effects and Analysis Group (GSFC REAG) performed this work. It was reported at the IEEE NSREC 2000.

Recent Work:

GSFC REAG has performed Single Event Upset (SEU) proton and heavy ion testing on unhardened IBM 5HP SiGe HBT prescalars. The test results indicate that this technology is very sensitive to SEU. The devices were tested over a linear energy transfer (LET) range of 0.6 to 28 MeV* cm^2 / mg. The input frequency was varied from 600 MHz to 3 GHz. No destructive single particle effects were noted. Further testing is planned for later in this fiscal year.

These results show that if SiGe (or any other high-speed technology) is to be used in space flight applications, NASA must continue to research the radiation sensitivity so that on-orbit performance can be adequately assessed. This full report has been submitted for publication in the 2001 IEEE Radiation Effects Data Workshop.

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Reliability Evaluation of MIT/LL SOI FD 0.25 µm Technology for NASA Mi4ssions (Part II)

Ashok K. Sharma
NASA/Goddard Space Flight Center
and
Alexander Teverovsky
QSS Group, Inc.

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The previous report titled "Reliability Evaluation of Fully Depleted SOI (FDSOI) Technology for Space Applications" posted on the NEPP web site, provided a general overview of SOI technology including materials, processes, reliability issues, and MIT/LL FDSOI process and associated reliability test structures. The Part II of this report discusses the test results of reliability characterization performed on some 0.25 m m FDSOI test structures supplied by MIT/LL. For this evaluation, four process monitor dice were received. There were 40 FETs in each dice with L = 0.2 µm t- 8 µm and W = 0.5 µm to 100 µm.

An objective of this MIT/LL FDSOI process evaluation is to address the hot carrier instability at Vg = Vd conditions, which are known to maximize the fixed negative charge generation. Also, a full characterization of the N- and P- channel transistors including scaling effects and estimation of the reproducibility of the front- and back- channel was performed. The transistors measurements included threshold voltage, subthreshold slopes, mobility of the charge carriers, gate leakage currents, and investigation of edge effects. These test results will be reported in an article in the next issue of EEE Links, and the final report will be posted on the NEPP web site.

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MEMS Reliability Assurance

Dr. Joanne Wellman
Jet Propulsion Laboratory

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In a recent and ongoing collaboration with students from California State University at Northridge (CSUN), Dr. Joanne Wellman is setting out to improve MEMS reliability through the investigation of manufacturing process steps and implementation of process controls. Their objective is to study MEMS reliability issues for space flight, as well as develop new techniques for the testing and characterization of MEMS devices and MEMS fabrication process variables.

Research performed by the students at CSUN varies. Helen Avila, is conducting mechanical shock studies of cantilever structures. Prudencio Alonso is exploring the piezoelectric effects in torsional polysilicion test structures; and Adalberto Garcia is researching the surface morphology and chemistry of hinged flap test structures using Atomic Force Microscopy (AFM).

The overall study establishes a bed of test structures fabricated with the MUMPS process by Cronos Integrated Microsystems, a wholly owned subsidiary of JDS Uniphase, Inc. It also has generated a number of technical reports, as well as a report on IR imaging as a MEMS reliability and failure analysis tool.

CGaAs (CHFET) Reliability

Dr. Rosa Leon
Jet Propulsion Laboratory

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Plans are in the making for Dr. Leon’s continuing study on GaAs CHFETs next quarter. She hopes to formulate a test plan and determine appropriate testing conditions, in collaboration with various projects, i.e. Europa Orbiter. Recently Dr. Leon conducted studies to investigate and document the reliability data of GaAs CHFET technology. In particular her group is making measurements of device parameters, and setting up for an accelerated life test. Her studies also include measurements of device parameters at high temperatures. The groups’ studies will help determine the suitability of the technology for NASA applications.

Past studies in this area include temperature dependence of gate current, complete noise characterization at 4K, heavy ion SEU, high temperature operation, low and high-speed applications, characteristics after high proton fluences, comparison with analogous device in Si, and radiation (ionizing) effects in GaAs devices in general.

GaAs CHFETs have higher radiation resistance to proton induced displacement damage (the Europa mission has to survive a very harsh radiation environment) than Silicon based devices. Also, GaAs devices perform better at high temperatures, and the CHFETs in particular have been shown to perform well at cryogenic temperatures as well. Due to design hardware, using the GaAs CHFETs would also represent significant savings in the total weight of the instrumentation.

Difficulties in finding published material on accelerated life testing and reliability data is what led Dr. Leon and her group to further explore this area. The measurements in their study are going well and a complete report will be available upon completion, scheduled for release this fall.

First NEPP Virtual Conference

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The first NEPP Virtual Conference was held on April 16th at Center Videoconferencing (VITS) rooms across NASA. Videos of the authors presentations are available for viewing on the NEPP web site at http://nepp.nasa.gov. The Program included: Dr. Liangyu Chen, PhD from the NASA Glenn Research Center (GRC) on "Electronic Packaging Technology for SiC based High Temperature Micro-systems", Dr. Henning Leidecker, PhD from the NASA Goddard Space Flight Center (GSFC) on "Known Problems with the Use of Pure Tin Coatings", Dr. Carl Magee, PhD from the NASA Langley Research Center (LaRC) on "Kilowatt Diode Laser Array Performance", and Dr. Rajeshuni Ramesham, PhD from the NASA Jet Propulsion Laboratory (JPL) on "Packaging and Reliability of Electronic Noses for Space Applications". NASA people from JPL, GSFC, GRC, HQ, LaRC, and JPL interacted with the speakers through VITS. Abstracts of the talks follow. The next Virtual Conference is scheduled for September.

Electronic Packaging Technology for SiC based High Temperature Micro-systems

Dr. Liangyu Chen, PhD*, Gary W. Hunter, Philip G. Neudeck, *AYT/NASA Glenn Research Center

Gold thick-film metallization based electronic packaging components, which include electrical interconnection (thick film printed wires and thick film metallization based wire-bond) system and a conductive SiC die-attach scheme, have been validated for high temperature (up to 500°C) chip level packaging. During a 1500-hour test in atmospheric oxygen with and without DC bias, the basic interconnection elements demonstrated low and relatively stable resistance in a temperature range from room temperature to 500°C. The die-attach scheme was successfully validated by testing a SiC high temperature diode which was attached to a ceramic substrate using gold thick-film material as conductive bonding layer. The attached SiC diode was tested at 500°C in oxidizing air for 1000 hours setting records of both high temperature electronic packaging and high temperature device testing. A brief discussion of the scope of high temperature electronic packaging program at NASA Glenn Research Center will also be covered.

Known Problems with the Use of Pure Tin Coatings

Dr. Henning Leidecker, PhD, NASA/Goddard Space Flight Center

Pure tin coatings grow whiskers, sometimes promptly, sometimes after delay of several years. These have shorted electrical circuits,introducing anomalies and even failures. The risk of anomalies and failures is increasing as the typical bus voltages and available currents decreases. Also, spacecraft are subject to the occurrence of a whisker-induced vacuum metal arc which sustains hundreds of amperes, until there is fatal damage. Finally, operation at temperatures below about 20°C allows the transformation of tin from its metallic phase into a semiconducting phase that is both brittle and relatively non-conducting.

Packaging and Reliability of Electronic Noses for Space Applications

Dr. Rajeshuni Ramesham, PhD, Jet Propulsion laboratory

Successful development of an electronic nose requires a development of an array of sensors that are specific to the compounds of interest. Our main objective is to assess the reliability of packaged JPL developed and commercially available electronic noses to determine their utility as an air quality monitor in crew habitat on a spacecraft, International Space Station (ISS) like missions. This presentation covers on overview of the current status of e-nose packaging technology and reliability issues from commercial-off-the-shelf (COTS) e-noses to specific application and provides lessons learned in the past missions.

Kilowatt Diode Laser Array Performance

Dr. Carl Magee, PhD, NASA Langley Research Center

In late 1962 the first demonstration of stimulated emission from GaAs homojunction (diffused) diode lasers (DLs) was reported by several laboratories in the scientific literature. These early DLs required operation at cryogenic temperatures since they exhibited threshold current densities (J_{th}) of >10,000 A/cm^2. Development of liquid epitaxy (LPE) growth technology permitted the introduction of AlGaAs alloys to be employed for improvement of DL designs. The first such design was the "single-heterojunction" (SH) structure. The SH design used resulted in the reduction of J_{th} to < 4KA/cm^2. The heterojunction design concept was further extended and resulted in a "double-heterojunction" (DH) structure. These DH AlGaAs lasers were capable of continuous wave (CW) operation at room temperature and could also be modulated at rates in the gigahertz range. These early DLs had outputs in the tens of milliwatt range and were used in initial fiber optic telecommunication experiments.

Many advances have occurred since these mid-1970's achievements. Improvements in understanding of device physics, materials quality requirements, growth technologies, processing, packaging, et cetera have yielded great gains in performance. These advances have led to the current production of linear diode arrays that emit quasi-continuous wave (QCW) powers in excess of 100 watts for a bar of ~ 1 centimeter width. Two-dimensional (2D) arrays fabricated from these linear arrays are capable of peak output powers of multiple kilowatts.

The impact of device design, materials growth, processing, and packaging upon performance of 2D kilowatt, diode laser will be presented. Also, proper application and operation of these high power devices will be discussed.

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Second Annual NEPP Conference

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The NEPP Conference on Electronic Parts, Packaging and Radiation Characterization for Space Applications held their Second Annual Conference in Pasadena, California, May 16th and 17th. The Conference, which was cosponsored by the International Microelectronics and Packaging Society (IMAPS), was attended by more than 330 attendees who enjoyed a selection of over 80 technical presentations and 74 tabletop exhibits.

NEPP is organized around three technology concentrations and the Information Management and Dissemination effort. The Technology concentrations are Electronic Parts (EPAR), Electronic Packaging (EPAC), and Electronic Radiation Characterization (ERC).

The Electronic Parts Project is intrinsically tied to satisfying the needs of NASA programs for the evaluation of newly available and advanced electronic parts. This project maximizes effectiveness and efficiency by partnering with industry and other agencies.

The primary goal of the Electronic Packaging Project is to expedite cutting-edge technology into missions and instruments during the Mission Formulation phases. They also obtain electronics packaging information and sustain the availability of that information for broad usage across the Agency, industry, academia, and other government agencies.

The Radiation Characterization Project provides radiation evaluations and assessments of new and emerging microelectronic and photonic technologies, to enhance infusion into NASA missions. They also develop guidelines for technology usage in radiation environments, and investigate radiation hardness assurance (RHA) issues in order to increase system reliability and reduce cost and schedule.

The primary objective of the Information Management & Dissemination Project is to energetically disseminate the information that is continuously generated and collected by the NEPP, to all NASA Centers and to our partners.

The cosponsoring organization, International Microelectronics And Packaging Society (IMAPS) is dedicated to the advancement and growth of the use of microelectronics and electronic packaging through professional and public education, the dissemination of information and the promotion of the Society's portfolio of technologies.

Abstracts, speaker presentations, and photos from the Conference are available on line at http://nepp.nasa.gov. Be sure to check back often, as we will be adding more presentations as they become available.

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The Newly Enhanced NEPP Information System

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The NEPP Information System will continue to provide access to NEPP research and development. However, based on your comments and feedback the NEPP web site is being enhanced to serve you better. In addition to being kept up to date with current content, the improved site will also allow the following functionality:

- Search for data in numerous ways such as – author, title, project, area of emphasis, technology
- Better search capability
- More Electronic Parts, Packaging, and Radiation data and links
- Monthly News Flash to include new NEPP activities and technologies
- E-mail notification of updated pages
- Allow Authors and Principal Investigators the ability to upload and maintain their publications and documents
- Locate experts within the NEPP community

The NEPP Site will also provide restricted access to members of the NEPP Program. This allows members the ability to add calendar events, publications, and articles. To ensure that our restricted information is seen only by our members, NEPP members will need to have a web browser that supports 128-bit encryption, as shown in figure 1.

Operating System	Netscape	Internet Explorer	America OnLine [AOL]
IBM Compatible PC	v.4.74 - v.4.76	v.4.x or higher	AOL v.4.x or higher
Macintosh	v.4.74 - v.4.76	v.4.x or higher	AOL v.4.x or higher

Figure 1 - 128-bit Encryption Web Browsers

ARTICLES ARE BEING ACCEPTED FOR THE "JULY 2001" ISSUE OF

EEE LINKS

Deadline for Articles June 19, 2001

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We want to hear from you! The EEE Links Newsletter is a great way to share practical experiences and discoveries with your colleagues. Articles can be informal and from one paragraph to three pages in length on the following subjects:

- PARTS
- PACKAGING
- QUALITY ASSURANCE ISSUES
- RELIABILITY ISSUES
- CURRENT EVENTS
- SPACE FLIGHT HARDWARE
- NEW TECHNOLOGY

If you wish to submit an article, please send it in electronic form to Nancy Ford at nford@qssmeds.com. Illustrations or pictures that accompany your article can also be sent electronically. If you are in the initial stages of research please submit that also; we want to let your colleagues know what you are working on. The deadline for the "July 2000 " issue of EEE Links is June 19, 2001. If you want to talk about possible submissions feel free to give me a call 301-867-0154 and share your ideas! You can view current and past issues of The EEE Links Newsletter at http://nepp.nasa.gov.

Thank you and I look forward to hearing from you! Nancy Ford (301) 867-0154 QSS Group Inc., Editor, EEE Links and News Flash E-mail address: nford@qssmeds.com.

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CONTACT US!

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Working on new technologies? Have an idea or suggestion? We want to hear from you! If you would like to submit an article for publication in an upcoming edition of the NEPP News Flash, please contact us.

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