FY00 PROPOSAL #85

TITLE: SiGe/Si HBT reliability study

RESPONSIBLE NASA CENTER: NASA Glenn Research Center

PROGRAM GROUP: Electronic Parts Project

PROGRAM OBJECTIVES:
1. Make a detailed survey of the state of readiness of SiGe circuits.
2. Determine the failure mechanisms of SiGe HBTs and SiGe MMICs as a function of the Ge content.
3. Determine the yield of manufacturing as a function of Ge content.
4. Determine the failure mechanisms as a function of the substrate choice.

DESCRIPTION:
Industry and government agencies are now striving to lower the cost of communication and other RF systems while at the same time increasing their reliability and functionality. It is recognized that the best way to accomplish these goals is to increase the level of integration, or to fabricate the entire system on a single chip. This reduces the packaging costs and improves the reliability by reducing interconnects. To fully integrate all of the functions onto a single chip though, a new semiconductor technology is required since GaAs and InP RF circuits are not compatible with Si memory and data processing circuits. A few companies, the University of Michigan, Auburn University, and NASA GRC have been leading an effort to develop SiGe integrated circuits employing SiGe base heterojunction bipolar transistors (HBTs). Over the past several years, significant progress has been made, and it is now reported that transistors with high frequency capability are available allowing MMICs to be built through 60 GHz. Therefore, single chip systems that incorporate the RF circuits, digital circuits, and memory are possible

To accomplish these results, two different fabrication methods have been used which yield very different material properties. The first uses a low Ge content in the base, <7%, while the second uses a very high Ge content, >30%. Although both SiGe technologies yield HBTs that meet the goals of the projects, neither has been verified to be reliable under stress. Furthermore, the technology that yields the highest performing devices, Ge>30%, has not been proven to have good yield. A second difference between the competing technologies is the substrate itself. IBM, which has the only U.S. SiGe foundry, uses CMOS grade Si wafers while the University of Michigan and Daimler-Benz use high resistivity Si wafers. In this study, we intend to collaborate with academia and industry to survey the state of readiness of SiGe technology; study the reliability of the devices fabricated with both technologies; and determine the failure mechanisms.

TECHNICAL APPROACH:
1. Establish informal working group among the partners to share information.
2. Obtain SiGe HBTs from partners.
3. Work with the University of Michigan to characterize the yield and reliability issues of SiGe HBTs as a function of Ge content.
4. Determine failure mechanisms of SiGe devices.
5. Report results.

BENEFITS: Within NASA, the JPL CISM "System on a Chip" project under Code S is relying on SiGe HBTs fabricated by the University of Michigan for its RF communication system. NASA GSFC is currently investigating the use of SiGe RF transmit/receivers for a potential 2007 launch funded by Code Y. This project will provide reliability information to these organizations.

DELIVERABLES:
1. Published papers.
2. Report on Readiness Level of SiGe MMICs.

3. Report on failure mechanisms of SiGe HBTs.
4. Industry survey on the availability of manufacturing plants.

PARTNERS:

1. University of Michigan is under grant.
2. JPL CISM project
3. JPL radiation testing group
4. We will also solicit input from Northrop Grumman, Hughes Research Laboratory, Hughes Space and Communications Co., and IBM.

SCHEDULE:

Q1/99 Chair Silicon Monolithic Integrated Circuits in RF Systems Symposium
Initiate grant with University of Michigan
Q2/99 Sign grant with University of Michigan
Initiate reliability studies on microwave transmission lines on Si
Q4/99 Complete microwave transmission line studies and publish results
First year report
Q2/00 Write review paper on Si RF circuit reliability concerns
Q4/00 Write final report and papers on SiGe HBT reliability

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