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Efforts to advance reliability prediction of RF Compound Semiconductor devices by the DoD

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A Multi-University Research Initiative titled “A 21st Century Approach to Electronic Device Reliability” is to be funded in early 2008 by the Deputy Under Secretary of Defense for Research and Engineering. This initiative is to develop new analytical approaches to reliability which will augment the current approaches used for accelerated life-testing such as: 3- temperature Arrhenius life testing and time dependent dielectric breakdown testing. Although the need for these new tools has been made clear in the context of the emerging III-V technologies of GaN and High-Voltage GaAs the products of this research are to be applicable to all solid state technologies.

As stated in the BAA, the object of this work is to” “Establish accelerated life-testing procedures that can accurately predict operational lifetimes for devices that fail because of: 1) field or current driven mechanisms, or 2) low-activation-energy mechanisms that are thermally activated. A requisite feature of these procedures is the ability to extract operational lifetimes from an analytical description of the underlying physical phenomena that lead to the device degradation. Although the demonstration vehicle will be compound semiconductors the formalisms should work for elemental materials as well.”

Proposals were received in January 2008 and an award(s) should occur in the near term. The Initiative should start in April 2008. The program is to be managed by ONR and AFOSR. A further description of the Request for Proposal can be viewed at www.onr.navy.mil/sci_tech/3t/corporate/docs/muri_08_baa.doc**.**

To be included in the distribution list for information regarding reviews of this program please contact Dr. Paul Maki, at the Office of Naval Research 703-696-3060, makip@onr.navy.mil

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This is the actual BAA originally available in July 07.

FY08 MURI Topic #1

Submit white papers and proposals to the Office of Naval Research. See AFOSR topic #9 if submitting to the Air Force Office of Scientific Research

A 21st Century Approach to Electronic Device Reliability

Background: Although historically very useful, the traditional reliability technique of three temperature accelerated life testing has, in many cases, proven inadequate for military critical systems based on compound semiconductor devices. In particular, device lifetimes can be vastly overestimated when temperature accelerated life testing requires elevated temperatures so extreme as to activate degradation mechanisms that are statistically insignificant to failure mechanisms at operational levels. This problem, and the inability to define accelerated life tests for electric field and current driven failure modes has been brought to the forefront by the emerging device technologies such as: HV-GaAs and GaN. A new class of procedures is necessary to provide adequate reliability prediction. These procedures need to augment the approach used for traditional compound semiconductor devices and develop techniques appropriate to the new family of refractory materials, which can operate at higher temperatures and significantly higher fields.

Objective: Establish accelerated life-testing procedures that can accurately predict operational lifetimes for devices that fail because of: 1) field or current driven mechanisms, or 2) low-activation-energy mechanisms that are thermally activated. A requisite feature of these procedures is the ability to extract operational lifetimes from an analytical description of the underlying physical phenomena that lead to the device degradation. Although the demonstration vehicle will be compound semiconductors the formalisms should work for elemental materials as well.

Research Concentration Areas: Given that the objective is to develop new analytical formalisms which can be used to reliably predict operational lifetimes for all compound semiconductors (similar to those that describe the degradation of Si CMOS due to hot carrier related damage to the oxide or the traditional Arrhenius testing), the research must have two main components: An experimental effort to identify and establish the dependence of the underlying physical phenomena causing degradation and a theoretical effort to develop analytical formalisms that can describe and predict the dynamics of these phenomena. The research areas should include but not be limited to: 1) materials science studies utilizing techniques such as: electron microscopy, chemical imaging, IR thermography, microRaman; 2) defect characterization techniques such as: Deep Level Transient Spectroscopy (DLTS) and Deep Level Optical Spectroscopy (DLOS); 3) the development of test structures and methodologies suitable for the characterization of accelerants other than temperature, 4) the development of physics based analytical formalisms that can be used to extrapolate operation lifetimes from the data and 5) the application of statistical methods to assure the results are statistically meaningful.

Impact: Practical, more accurate accelerated lifetime tests will provide many benefits, including:

- A more rapid and successful insertion of technologies such as GaN and HV-GaAs.
- An improved process for high yield manufacturing.
- Application-specific optimization of devices for performance, lifetime and life cycle cost.
- Improved prequalification – better understanding of device performance/lifetime characteristics before technology insertion, leading to higher confidence.
- Ability to insert device technologies into high reliability applications such as space
- Accelerated insertion of new materials and devices into DoD weapon systems.

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