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Predicting Radiation Effects and Total Ionizing Dose in Bipolar Junction Transistor Circuits

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Background

Bipolar transistors are used extensively for analog circuits utilized in spaceborne applications. However, this region of space, including the higher reaches of Earth's atmosphere, is populated by many high-energy particles that can damage the bipolar transistors. In such environments, radiation induces a large increase in bipolar base current, which can create so-called total ionizing dose (TID) effects and ultimately cause permanent damage to the bipolar transistors.

The costs associated with using linear bipolar commercial-off-the-shelf (COTS) technologies in space systems are driving the need to model parts for qualification. Due to the combination of lower cost and greater capabilities of commercial parts, the COTS technologies represent an increasing percentage of a space system's component inventory. Traditional qualification is typically expensive and inaccurate. Further, it may be prohibitive cost-wise to test every part and technology generation, particularly for lower-cost space systems. Thus, there exists a need to conduct part qualification for COTS components at reduced cost and improved accuracy.

Invention Description

Researchers at Arizona State University have developed a method for modeling excess base current in irradiated bipolar junction transistors (BJTs). The method includes quantifying and utilizing defect-related electrostatic effects (e.g., charged interface traps on surface potential and carrier concentration at bipolar base surface) of a BJT device to help improve accuracy in predicting excess base current of the BJT device in a radiation environment. Additionally, the method can be adapted to model the excess base current of a lateral P-type-N-type-P-type (LPNP) BJT device in depleted and/or accumulated surface potential states.

The predicted excess base current may be used to qualify or disqualify the BJT device or an electrical circuit including the BJT device for use in space systems as a viable commercial-off-the-shelf (COTS) component. Through this modeling, it may be possible to accurately predict a total-ionizing-dose (TID) response of the BJT device, thus enabling faster and lower-cost qualification of COTS components for space systems.

This invention is covered by U.S. Pat. Application No. 15/989,353.

Potential Applications

- Bipolar junction transistor (BJT) devices for spacebourne and high-radiation applications

Benefits and Advantages

- Predicts total ionizing dose and dose-rate responses of COTS bipolar transistors and circuits with minimal or no radiation data

- Cost-effective radiation robustness gauge for COTS BJT components

Faculty Profile of Professor Hugh Barnaby