 Silicon Carbide Power Device Performance Under Heavy-Ion Irradiation 

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Abstract: High-energy induced degradation and catastrophic failure in SiC power MOSFETs and diodes are examined to provide insight into the challenge of single-event effect hardening of SiC power devices.

Discussion Cont’d

In silicon power MOSFETs, SEE susceptibility in post-irradiation testing is often reduced by elevated temperature and/or the addition of a drain resistor to dampen the drain voltage and suppress second breakdown. In two of the SiC power MOSFETs studied here, elevated temperature tests did not impact current degradation or sudden SEB onset, suggesting different fundamental mechanisms are involved in SiC power devices. Small sample sizes limit the conclusions that can be drawn from results. Future work should progress toward a robust database of SEE results to contribute meaningfully to the growing collaboration of SiC power engineers toward the development of the next generation of SiC power systems.

From the work presented here and performed by others, it is clear that the performance of commercial off-the-shelf SiC devices are rare or non-existent. Most space applications will require SiC power devices that are designed and fabricated specifically for space environments.

All commercial SiC power devices evaluated here exhibited inelastic catastrophic SEE at biases below 250% of their rated isolation voltage and experienced a significant degradation down to much lower biases (<10% for MOSFETs). The catastrophic breakdown voltage and experience permanent degradation down to much lower biases (<10% for MOSFETs). The catastrophic breakdown voltage and experience permanent degradation down to much lower biases (<10% for MOSFETs).

Conclusions

Several conclusions emerge from Tables II & IV:

- FN double oxide stress/current ratio for high energy induced degradation of SiC, thus do SBDS, but similar susceptibility to sudden SEB.
- Different mechanisms may be responsible for the less severe degradation.
- Not surprisingly, FN diode performance is more indicative of sudden SEB behavior, whereas SBDS performance is less sudden SEB behavior. 
- Gate leakage currents (affected and prompt) play a major role in See-induced damage. 
- Comparison of Si diodes as useful for SEE in SiC power MOSFETs.

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