Silicon Carbide Power Device Performance Under Heavy-Ion Irradiation

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Abstract: Heavy-ion 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.

Introduction

High temperature operation, low on-state resistance, and high breakdown voltage are typical features of SiC power devices. SiC power MOSFETs and diodes have a body diode, which is a PiN diode. The body diode may be used for reverse bias operation or as a reverse current path for reverse recovery of internal parasitic transistors. Power diodes are reverse biased during normal operation, which may cause degradation or catastrophic failure during heavy-ion irradiation.

Results

Table II: Self-test Facilities and Tests Performed

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Discussion

Several conclusions emerge from Tables II & IV:

- 5% double oxide current (ID > IG) for heavy-ion induced degradation of VDUB and Vh, but similar susceptibility to SEE.
- Different mechanisms may be responsible for the two effects.
- Not surprisingly, SiC diode performance is more tolerant to heavy-ion irradiation than SiC MOSFETs. SiC diodes may be used to suppress second breakdown. In two of the SiC power MOSFETs examined, irradiation-induced 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 Table II, but irradiation-induced performance degradation or catastrophic failure in SiC power devices may be more severe than in SiC power MOSFETs. From the work presented here and performed by others, it is clear that SiC power devices are not SEE immune and may provide an attractive alternative to silicon power devices in order to harden these devices against heavy ions and neutrons.

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Fig. 4. J-V characteristics of a SiC power MOSFET under heavy-ion irradiation. Right: Double oxide current of ID > IG for heavy-ion induced degradation of VDUB and Vh, but similar susceptibility to SEE. Different mechanisms may be responsible for the two effects.

Fig. 5. Elevated temperature (100°C) has no effect on SEE in SiC power MOSFETs.

Discussion Cont’d

In silicon power MOSFETs, SEE susceptibility by radiation testing is often reduced by elevated temperature and/or the addition of a slow reactor term (SRT) to the drive voltage and suppress second breakdown. In two of the SiC power MOSFETs examined, irradiation-induced current degradation or sudden SEB onset, suggesting different fundamental mechanisms are involved in SiC power devices.

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