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13th Edition of the IEEE International Symposium on Diagnostics for Electric Machines, Power Electronics and Drives
22-25 Aug, 2021
A Virtual Conference

Aging Mechanisms, Reliability Tests and Condition Monitoring of SiC MOSFETs

Abstract:

Featuring low on-resistance and switching loss, Silicon Carbide (SiC) MOSFETs have enabled high-efficiency, high-power-density power electronics converters in various applications. However, as an emerging device, there is limited field data regarding its reliability, and it raises reliability concerns for the mission-critical applications.

This tutorial focuses on the aging mechanism, reliability test, and condition monitoring of SiC MOSFETs. At first, a review of the reliability issues in SiC MOSFETs is presented: both the device-level and package related degradations in SiC MOSFETs are summarized and the physical cause of the aging mechanism is discussed. Afterward, different reliability test methods are introduced targeting the reliability qualification for SiC MOSFETs. Different reliability test methods are compared and correlated to the aging mechanisms. Then, taking the power cycling as an example, progressive degradation of SiC MOSFETs is provided considering the devices from different vendors/generations. Through the failure analysis, the parameter shifts of the device are summarized and related to different aging mechanisms. Lastly, to prevent unexpected shutdowns and catastrophic failures in the converter system, the existing in-situ and online state-of-health condition monitoring methods are summarized and compared in this tutorial. The content of the tutorial helps to establish a comprehensive understanding of the reliability issues in SiC MOSFETs, provides a summary of reliability tests for different aging mechanisms, and promotes a self-monitoring of the SiC devices in the system through various condition monitoring methods.

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