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Switching Performance of 750A/3300V Dual SiC-Modules

Generally, the emerging SiC technology is associated with very high switching frequencies resulting in compact converters

This article focuses on this switching behavior of SiC devices and compares Full SiC and Hybrid SiC with the behavior of a silicon device. All considered modules are rated for 3.3 kV and similar current ranges to give a fair and illustrative comparison. Finally, the article gives an outlook on future higher-voltage 6.5 kV SiC technology.

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Introduction

Since the 1990s, Mitsubishi Electric researches and develops semiconductor devices made of silicon carbide (SiC) [1]. Since 2017, the development of the 3.3 kV devices is finished. This 3.3 kV Full SiC module uses the most recent dual package, the LV100, and is rated for 750 A (cf. Fig. 1).

Figure 1: 3.3 kV / 750 A Full SiC module in the LV100 package

For increasing blocking voltages, the electrical resistance of MOSFETs increases steadily. Therefore, Silicon (Si) MOSFETs are usually available up to 600 V. For higher voltage levels, Si-based semiconductors require the use of bipolar devices, which are able to reduce the on-state voltage by conductivity modulation. Therefore, high-voltage Si devices are usually bipolar IGBTs and PiN diodes.

Owing to the higher dielectric breakdown, SiC may use unipolar MOSFETs and Schottky Barrier Diodes (SBDs) even at high-voltage levels. The advantage of unipolar devices is the absence of charge carrier accumulation. Hence, these unipolar devices switch faster and have lower switching loss compared to their bipolar counter parts.

In this article, a comparison of the switching behavior of bipolar Si devices and unipolar SiC devices, all rated for 3.3 kV and similar current ratings, is shown. The measurements demonstrate the nature of these two different semiconductors regarding their switching performance.

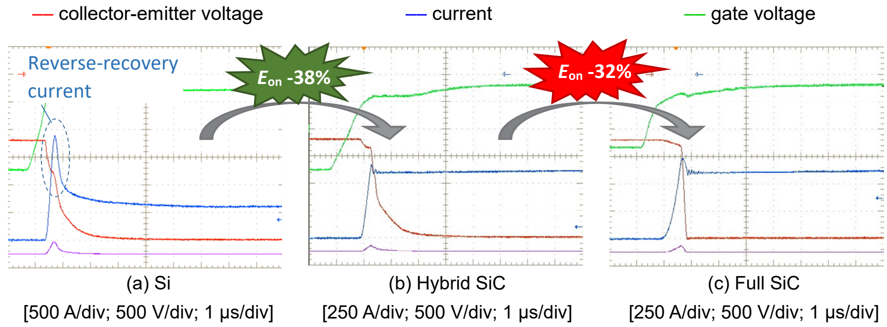

Figure 2: Turn-on waveforms (V_{cc} = 1800 V, I_C = 600A, T_j = 150 °C, L_s = 65 nH

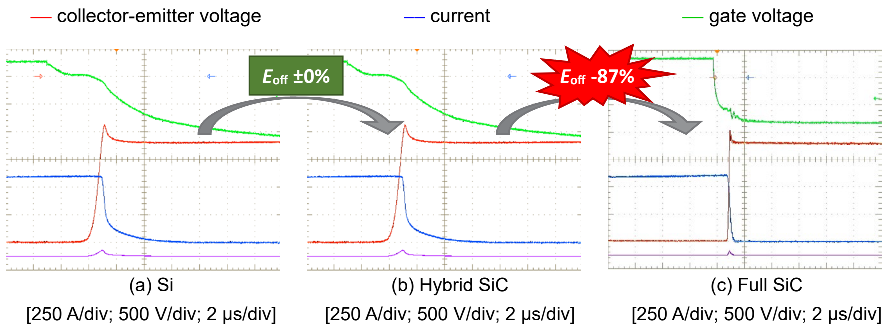

Figure 3: Turn-off waveforms (V_{cc} = 1800 V, I_C = 600A, T_j = 150 °C, L_s = 65 nH)