Novel 1300V Trench IGBT Optimized for Automotive Applications with Bus Voltage above 900V

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Introduction

In automotive applications, the higher bus voltage, the lower conduct current and lower stray loss. In order to improve the power density, the bus voltage of 1200V IGBT is set from 800V to 900V or move. When the bus voltage is increased, the power loss of device is increased simultaneously. Specially, the device speed is limited by the application constrains like turn-off peak voltage, recovery dvf/dt and short circuit capability, the final switching loss is further increased due to higher driving resistance. Consequently, the IGBT device should be specially optimized for higher bus voltage applications.

Fig.1a showed the turn-on waveform of 1200V IGBT tested at 800V and 900V separately, as can be seen the turn-on loss is increased due to higher power integration. Fig.1b showed the reverse-recovery waveform tested at 10% rated current, the reverse-recovery dvf/dt and peak voltage are increased observably. In order to reduce the reverse-recovery peak voltage, the turn-on driving resistance must be increased and hence the turn-on loss is increased higher.

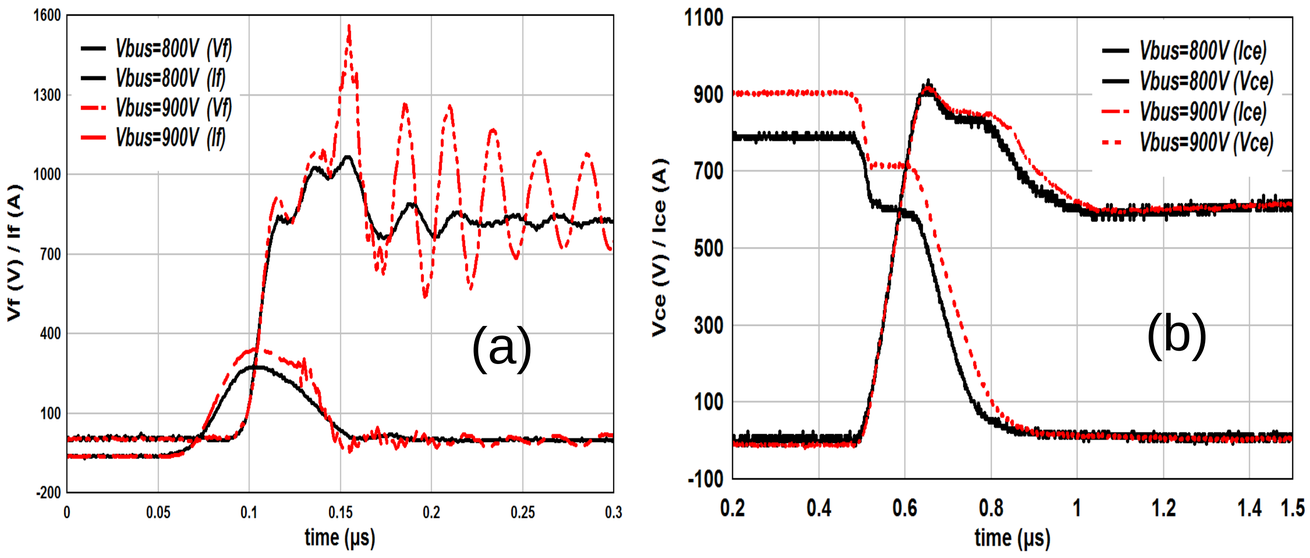

Fig. 1. Tested switching waveform between 800V and 900V

7th generation IGBT technology

As shown in Fig. 2, due to the progress of fabrication platform, the new device is verified using the 7th IGBT technology.

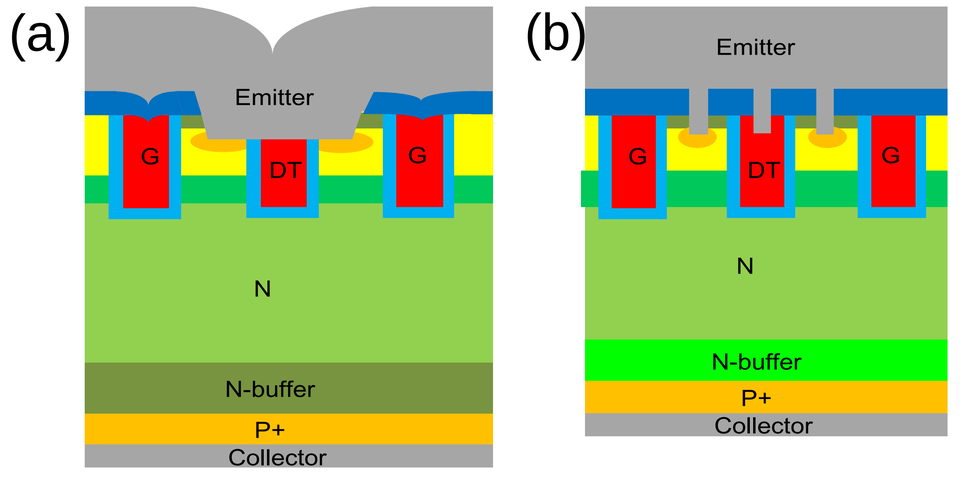

Fig. 2. Schematic cross-section of (a) 6th IGBT and (b) 7th IGBT technology in CRRC.

In order to reduce the total switching loss, the 1200V IGBT device is extended to 1300V IGBT device with higher blocking voltage and specially optimized chip design to improve the dynamic trade-off. The following tested bus voltage is set as 900V.

Fig.3 showed the compared reverse-recovery waveform of 1200V module and the new 1300V module. In the new 1300V IGBT chip, the ratio of capacitance Cgc over Cge is adjusted, which results in a soft reverse-recovery at 10% Icn test.

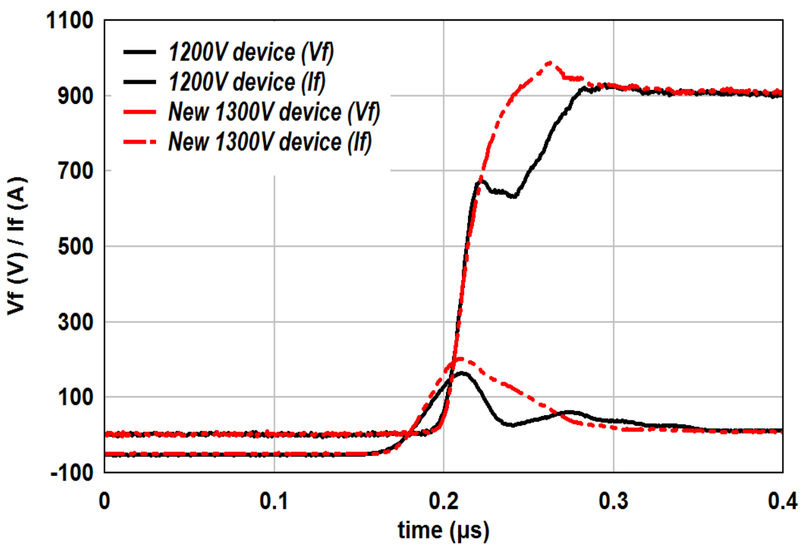

Fig. 3. Tested switching reverse recovery at 10% rated current

Fig.4 showed the compared turn-on waveform at large current. Due to such optimization, the Fast-Recovery Diode can be designed faster and the turn-on driving resistance is reduced at the same time, finally a lower turn-on loss is achieved.

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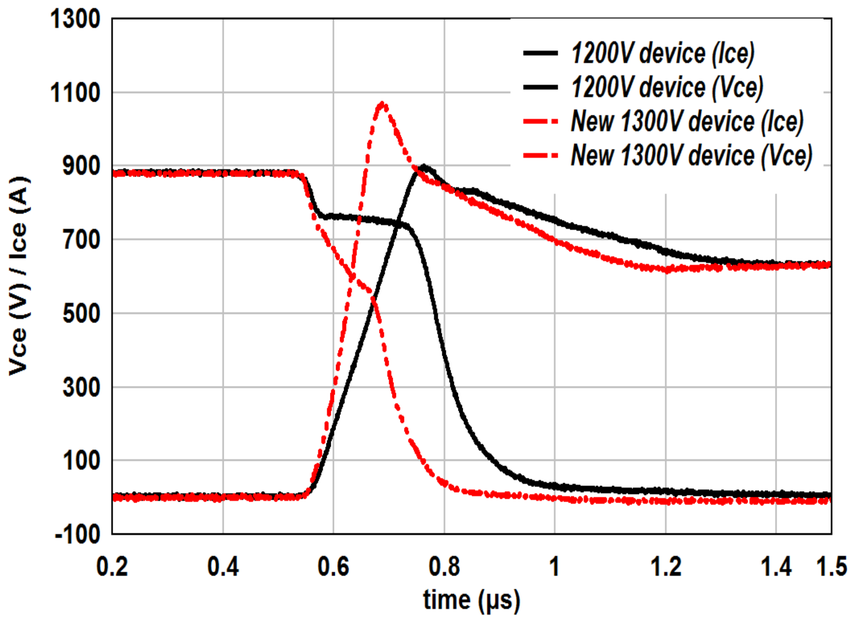

Fig. 4. Tested switching turn-on waveform

Fig.5a and Fig.5b showed the compared turn-off and short circuit tested waveform. In order to reduce the turn-off loss, the new 1300V device is designed with a smoothed carrier distribution and back electric field optimization during short circuit. Due to higher block voltage and chip design, the turn-off loss is reduced and the short circuit capability is also enhanced.

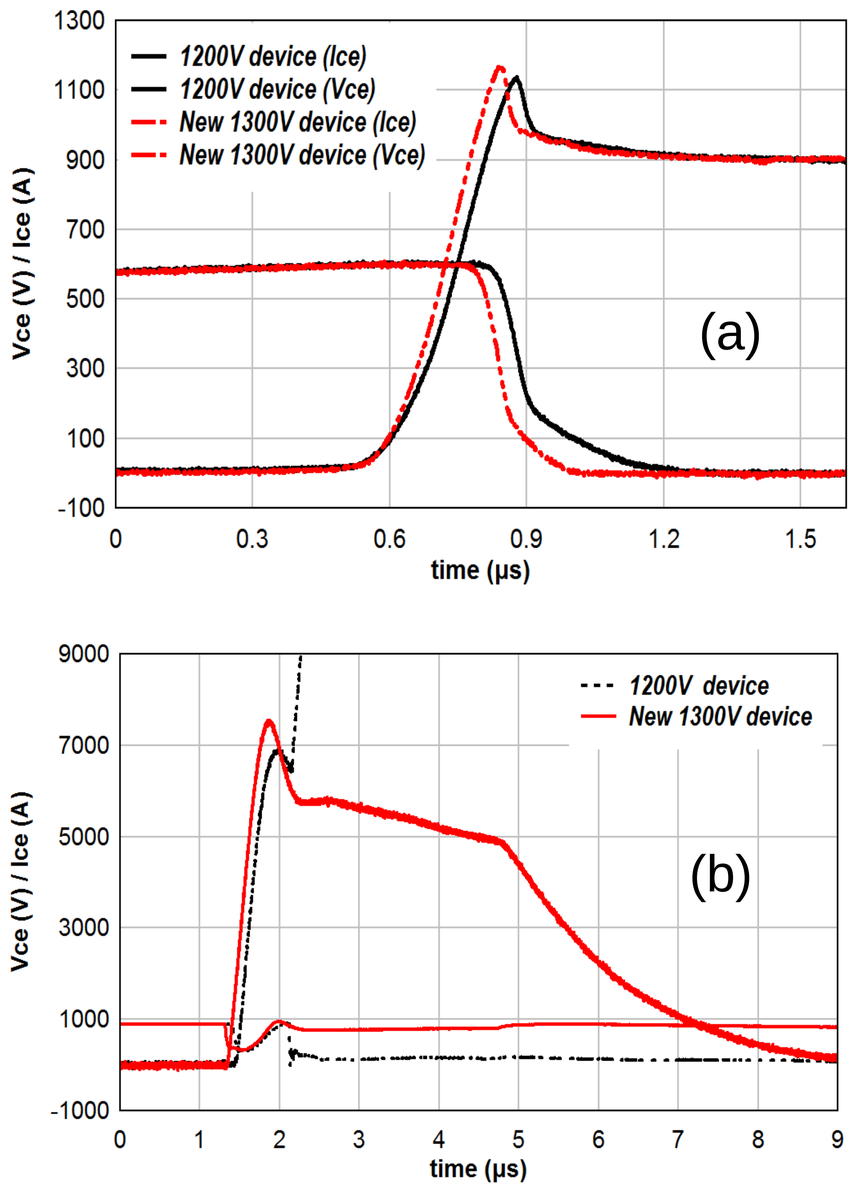

Fig. 5. Tested switching waveform between 1200V and proposed 1300V IGBT (a) turn-off and (b) short circuit.

IGBT module performance

As shown in Fig.6, the new 1300V device is verified and packed in a 600A/1300V S3+ module.

Fig. 6. Demonstrated 600A/1300V S3+ module.

Fig.7 showed the simulated power loss distribution during inverter at 10kHZ. Owing to the optimized design in 1300V IGBT, the total power loss is reduced by 15%, and the output current of the module can be increased.

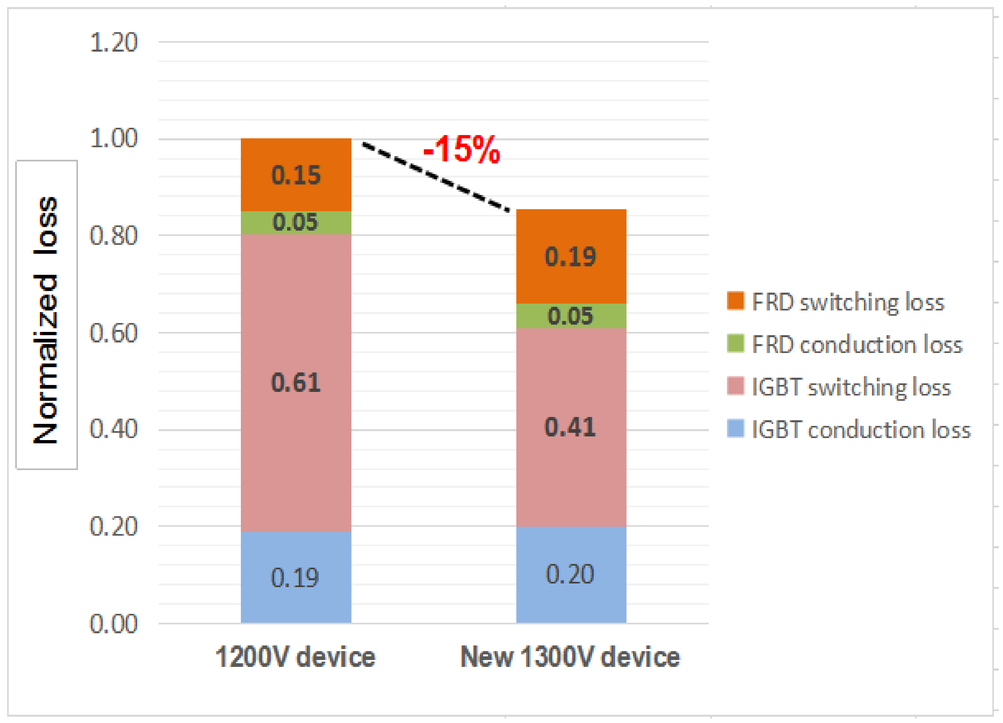

Fig. 7. Normalized loss distribution at 10kHZ by simulation.