The Research on Influencing Factors of 650 V IGBT's Turn-off dV_{ce}/dt Controllability

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Introduction

The trench insulated gate bipolar transistor (IGBT) is an important switching device in power electronic applications. IGBTs are moving towards higher power density and operating frequency. However, during the switching phase, excessive current density and excessive dV_{ce}/dt can lead to dynamic avalanche. Through experimental tests and simulations, the factors affecting the controllability of turn-off dV_{ce}/dt were researched, including the front structure (FSTR) of IGBT, as well as the bus voltage (V_{BUS}) and the load current (I_{load}) in the application conditions.

Structure and Mechanism

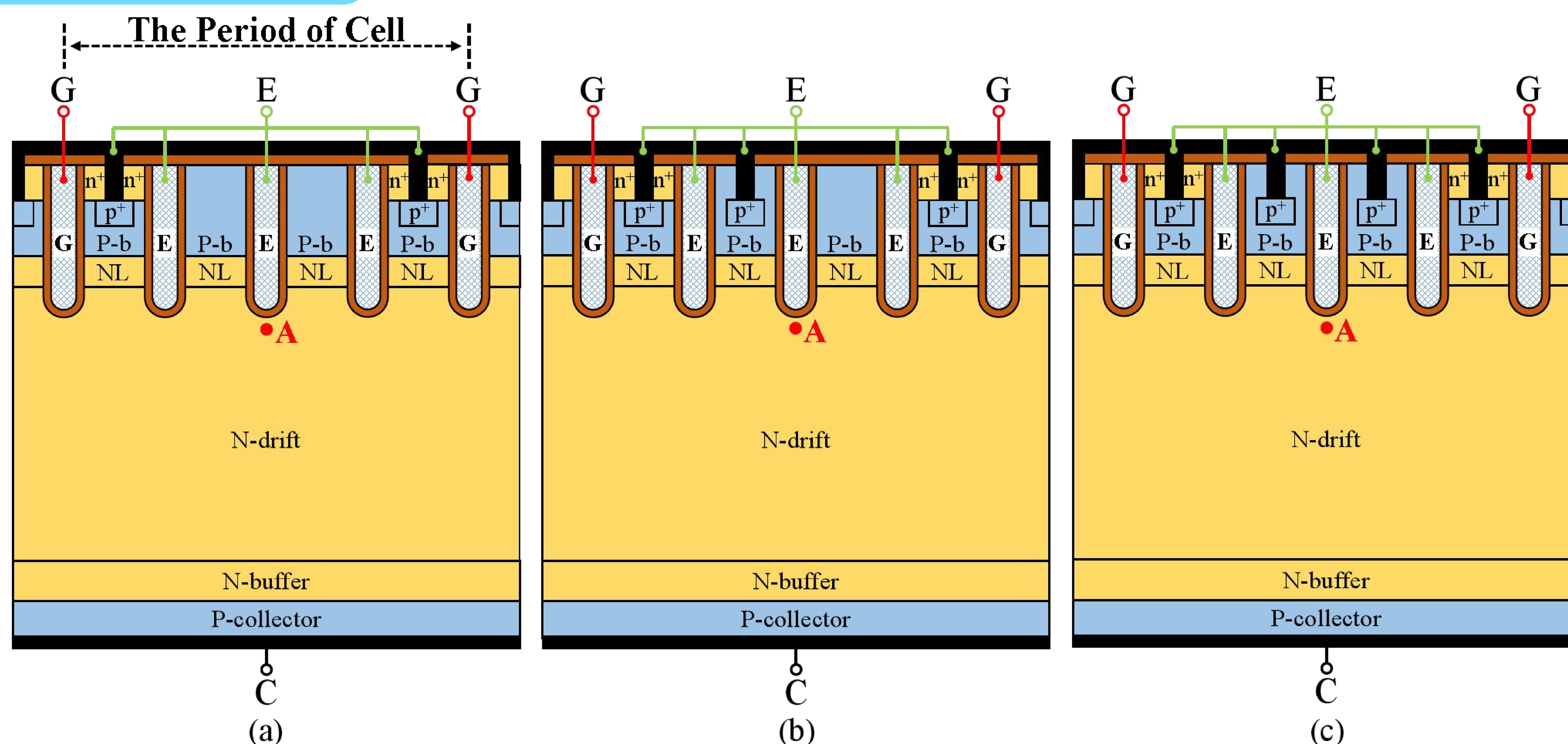
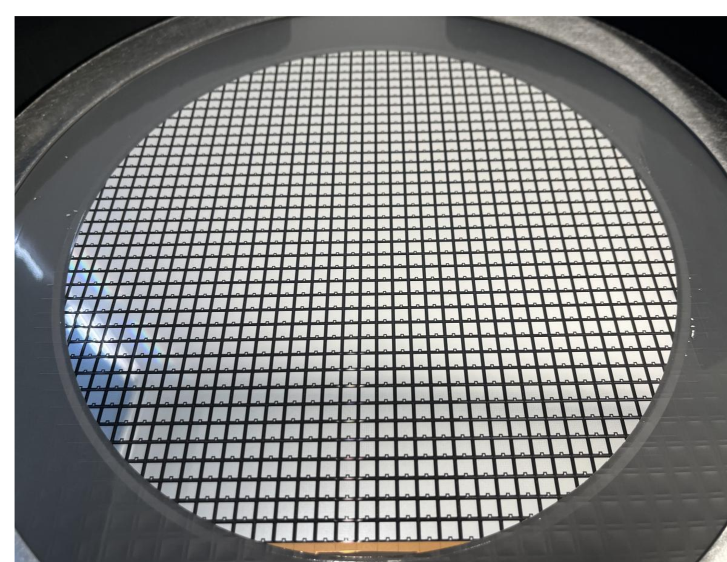


Fig. 1. Schematic diagrams of IGBTs with diffrent frontal structures: (a) FSTR-1, (b) FSTR-2 and (c) FSTR-3. The gate trench (GT) is connected to the Vg through the gate resistance (Rg), and the emitter trench (ET) is shorted together with the emitter metal.

Wafer appearance

Adopted frontal structure 1 (FSTR-1)



Size	Value
Wafer	8 inches
Chip	5 mm × 5 mm

Fig. 2. The chip appearance diagram of IGBT designed by adopted FSTR-1.

Test Results of 650V-75A IGBT Samples

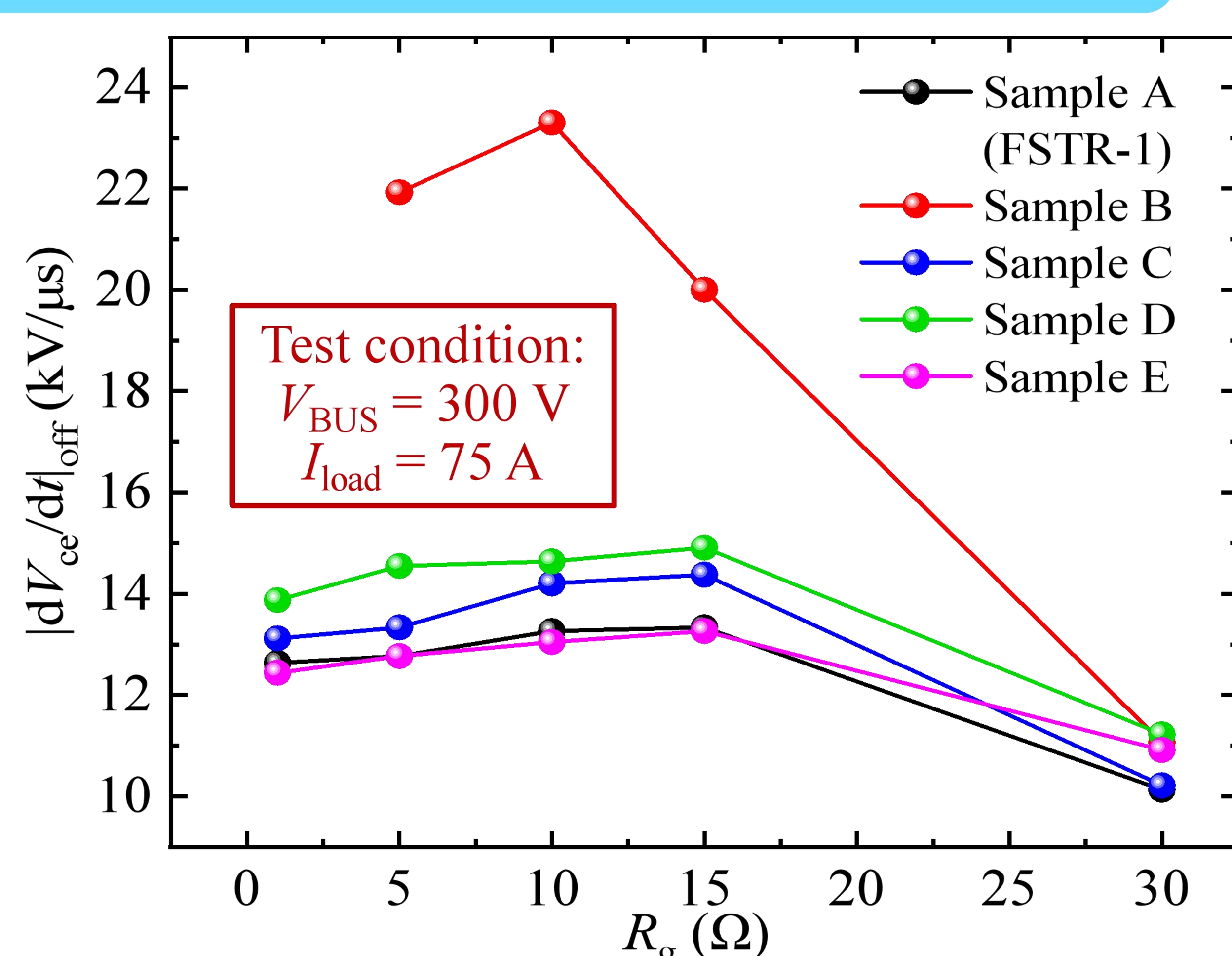


Fig. 3. The relationships between turn-off dV_{ce}/dt and R_g of different IGBT samples.

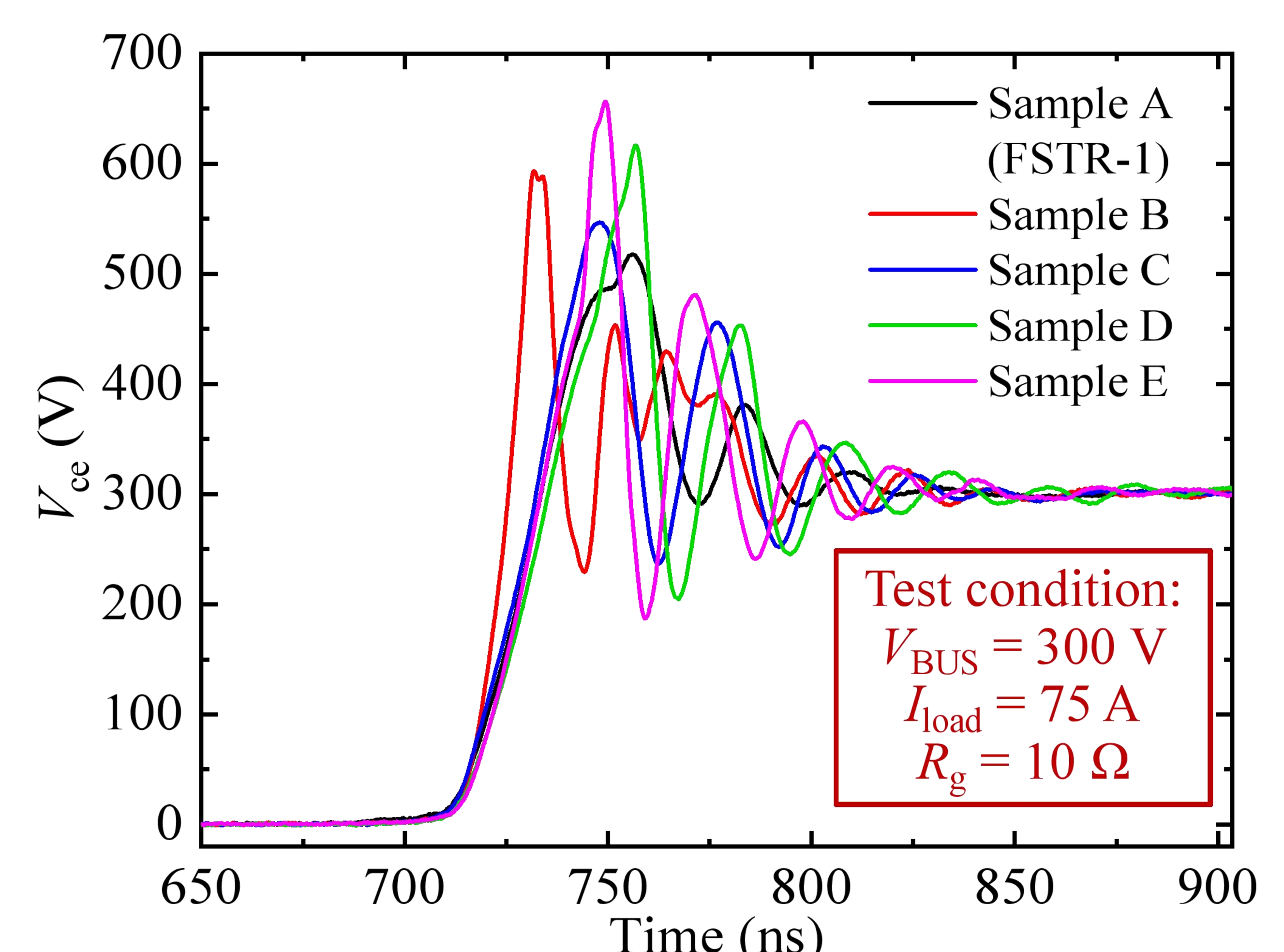


Fig. 4. The turn-off V_{ce} waveforms of different IGBT samples.

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Simulation Results of Different FSTR

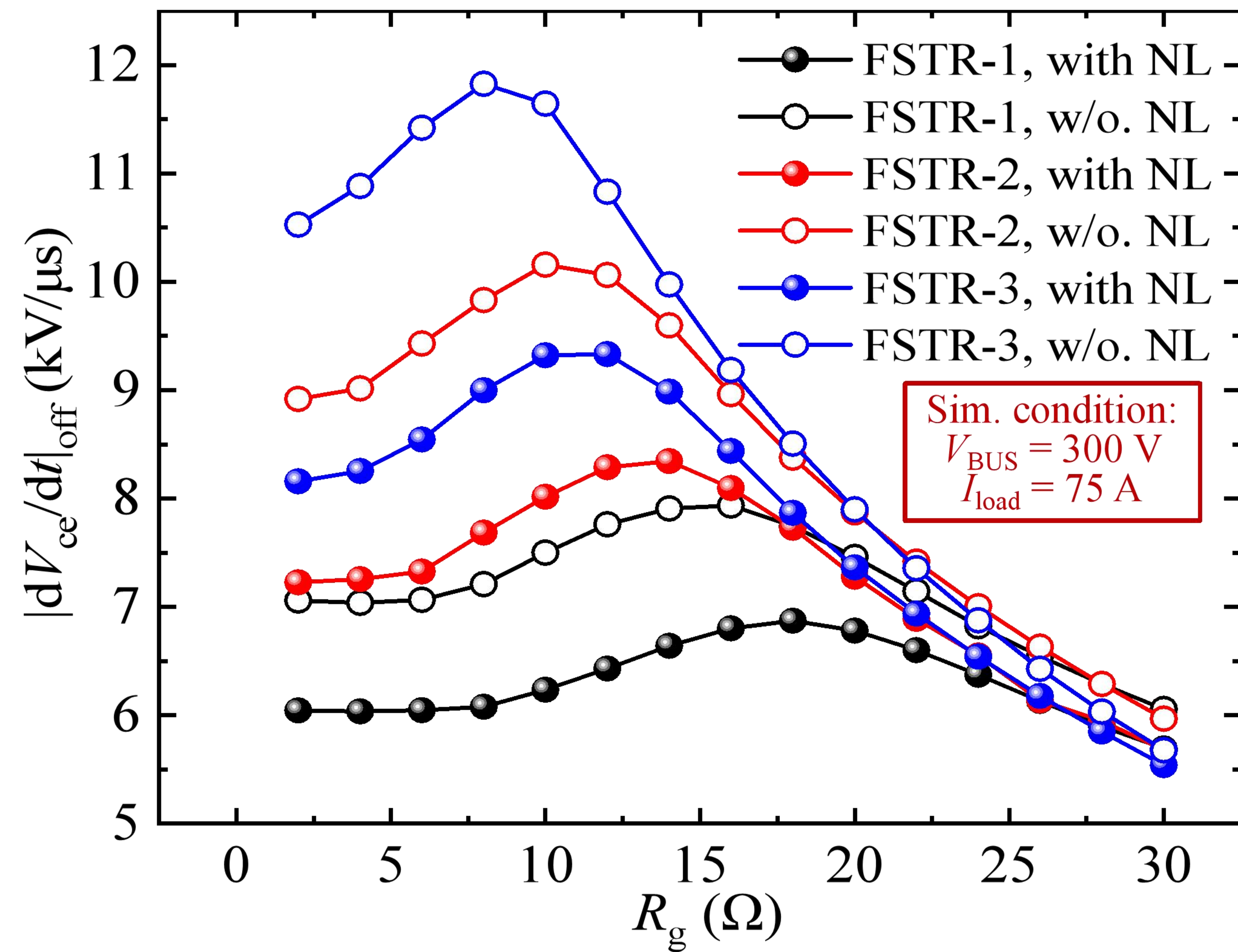

Fig. 5. The relationships between turn-off dV_{ce}/dt and R_g of different FSTRs.

Simulation Results of Different V_{BUS} & I_{load}

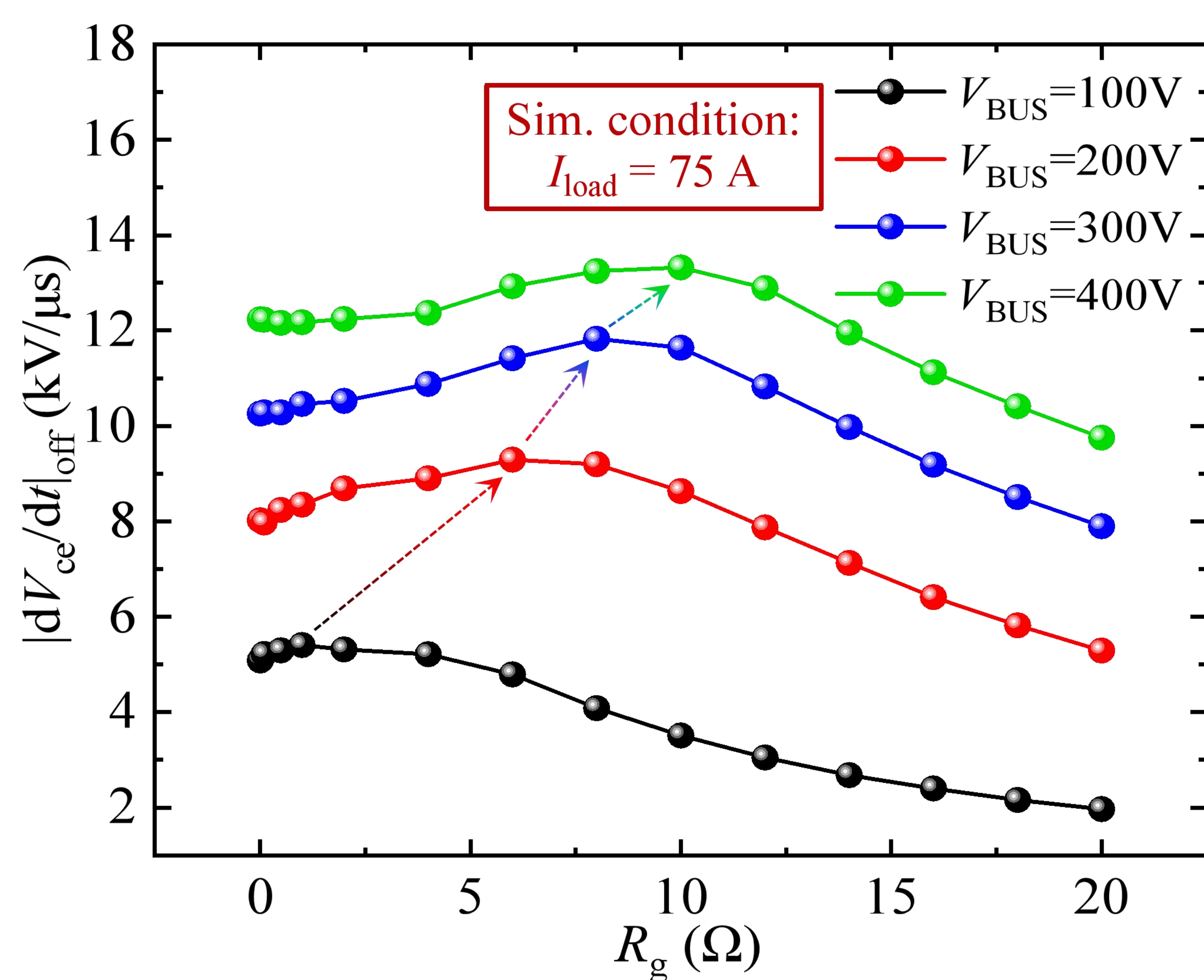

Fig. 8. The relationship between turn-off dV_{ce}/dt and R_g of different V_{BUS}.

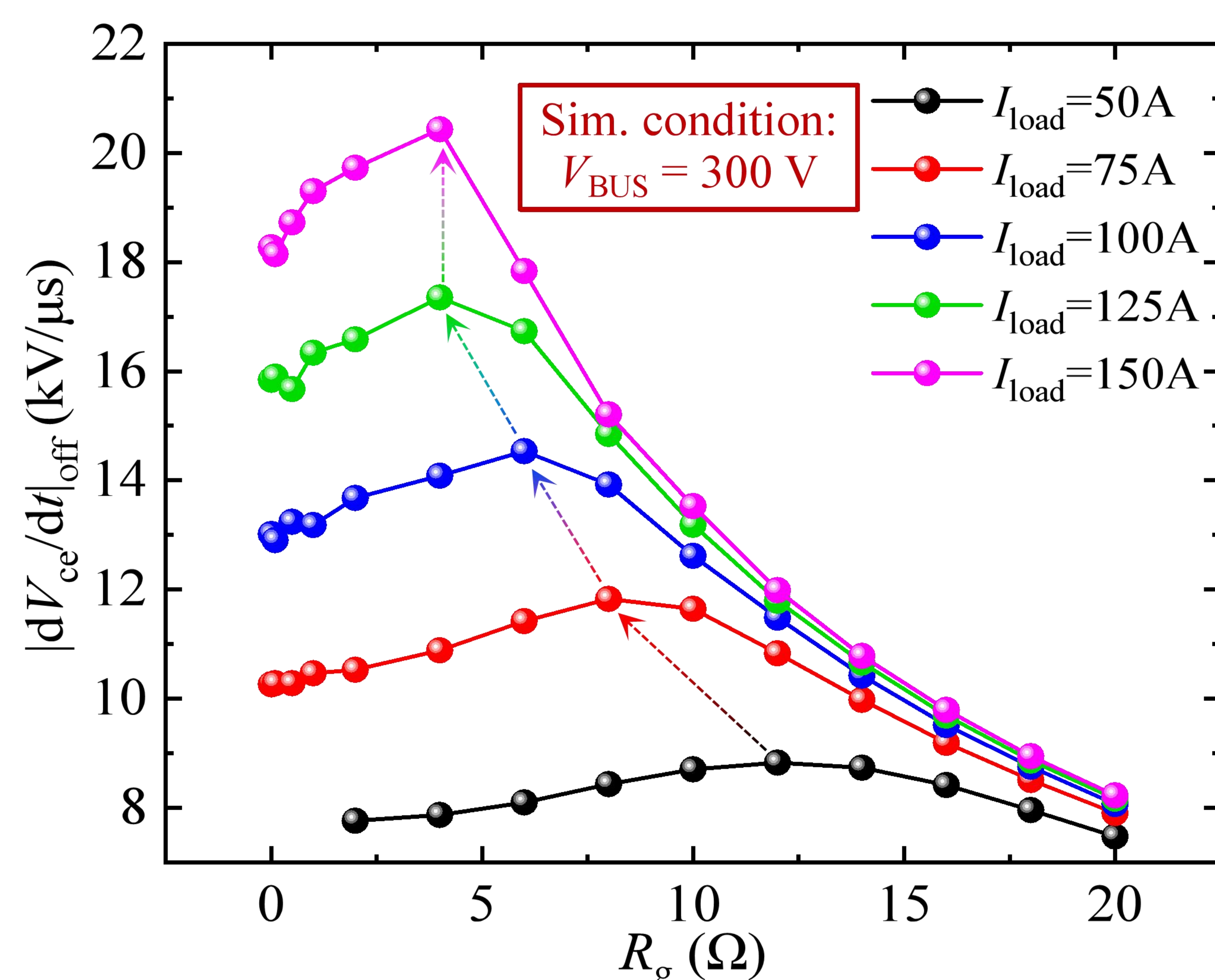

Fig. 9. The relationship between turn-off dV_{ce}/dt and R_g of different I_{load}.

Analysis of phenomenas

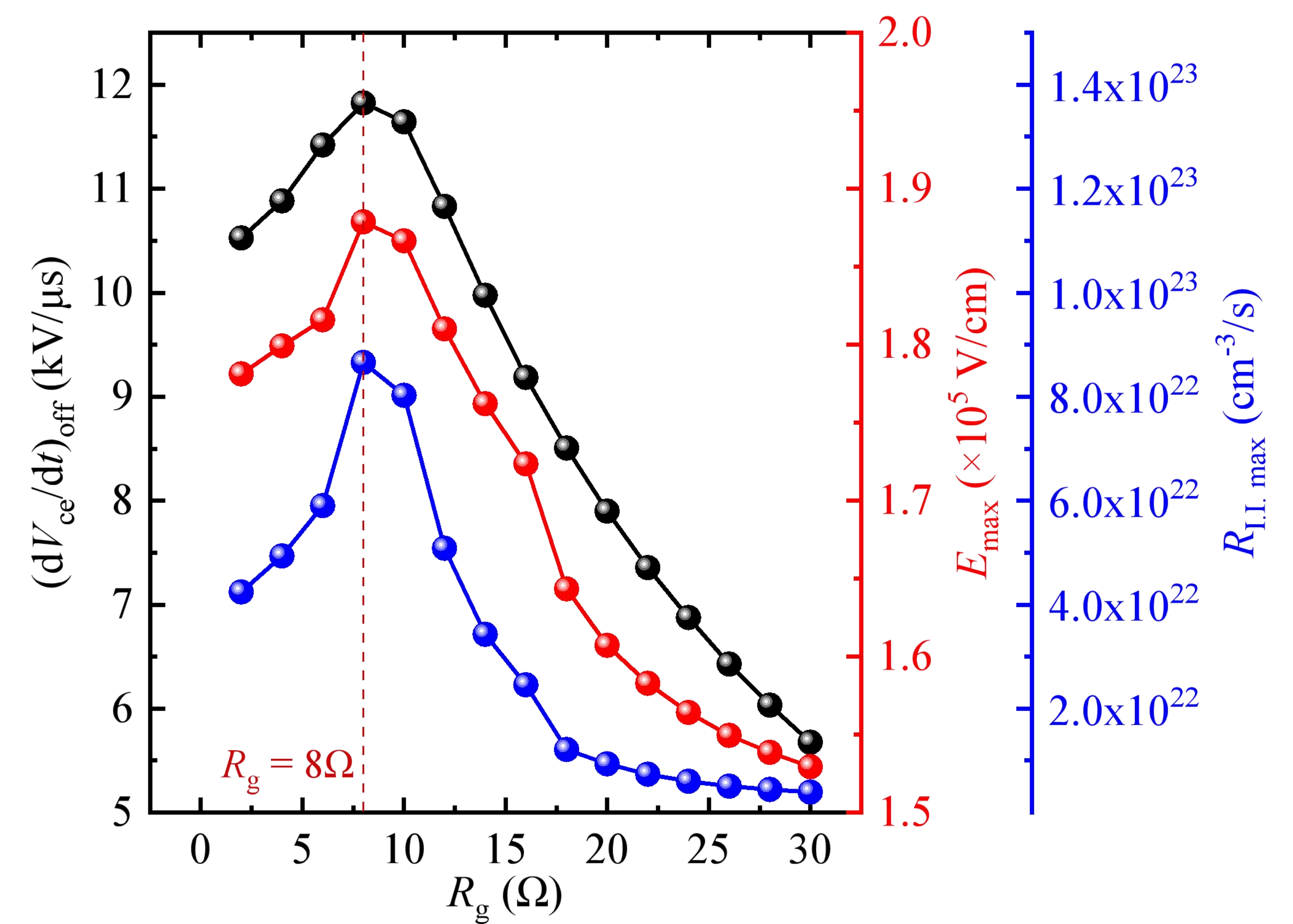

Fig. 6. Influence of R_g on E_{max} and $R_{I.I.max}$ of point A in FSTR-3 without NL during turn-off period (at the moment the V_{ce} increases to 300V).

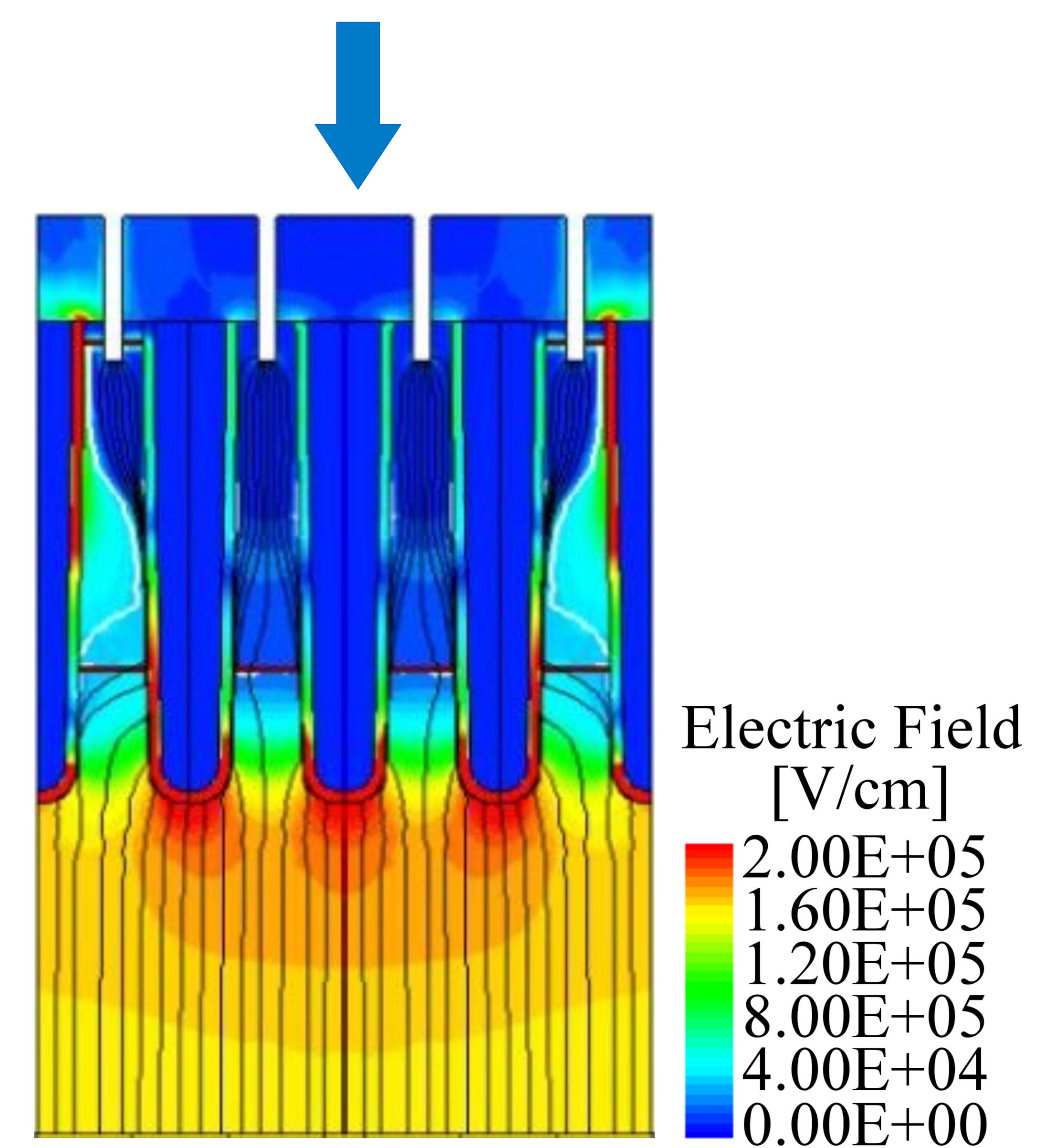

Fig. 7. (a)Distributions of electric field and current flow lines of FSTR-3 without NL when V_{ce} increase to 300 V during turn-off period.

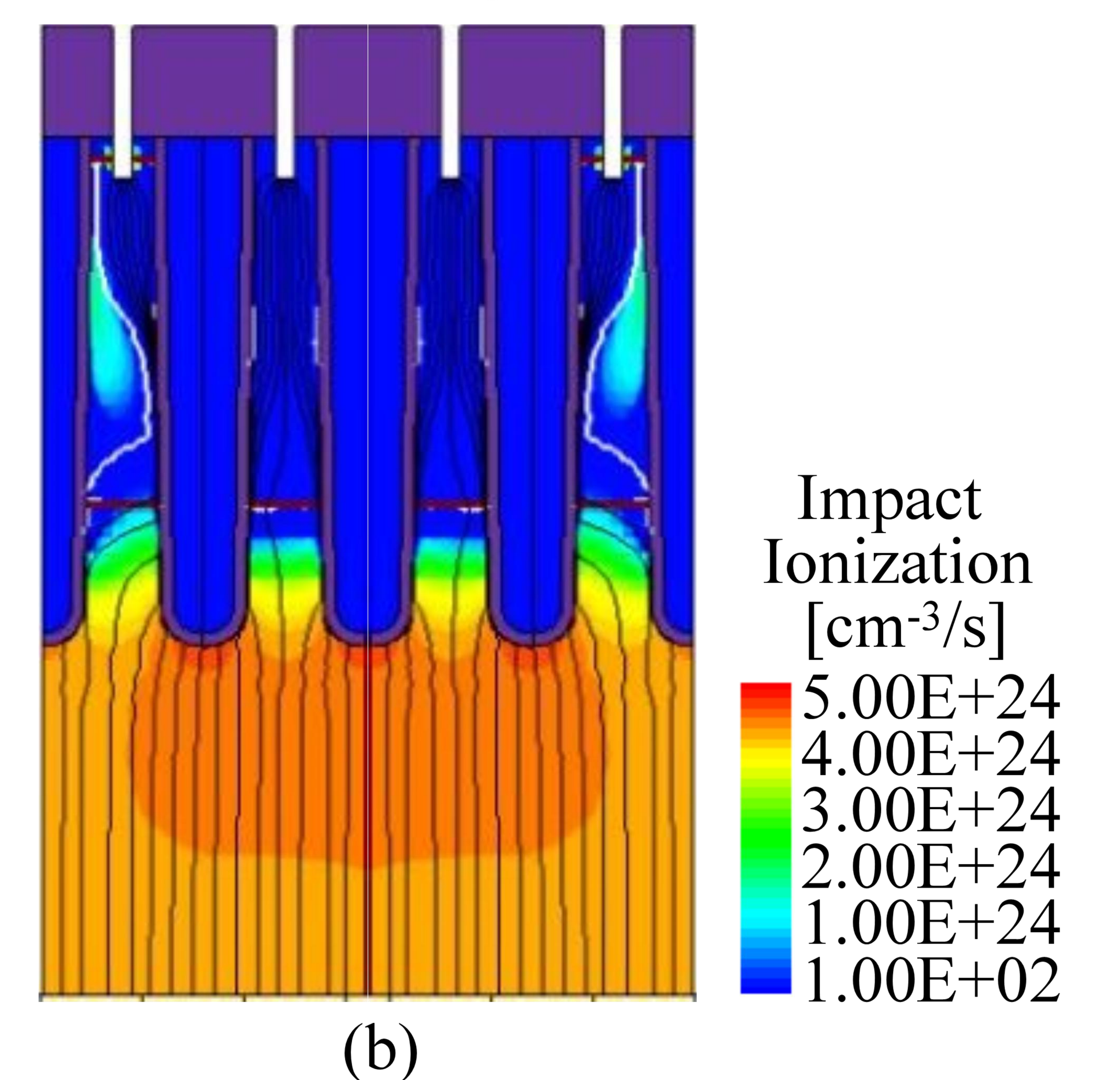

Fig. 7. (b)Distributions of impact ionization rates and current flow lines of FSTR-3 without NL when V_{ce} increase to 300 V during turn-off period.