Research on Electrical Characteristics of 1200V SiC Trench MOSFET with Periodic Arrangement of 3D P-shield Structure

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Introduction

Compared to planar MOSFETs, trench MOSFETs can reduce cell-pitch and enhance current density, earning them increasing favor. This paper developed a 1200V trench MOSFET featuring a periodic P-type shielding structure in three dimensions(3D P-shield), exhibits outstanding current capacity robustness.

Structure Design

The top and cross-sectional views of the 3D P-shield SiC Trench MOSFET are shown in Fig1,2.

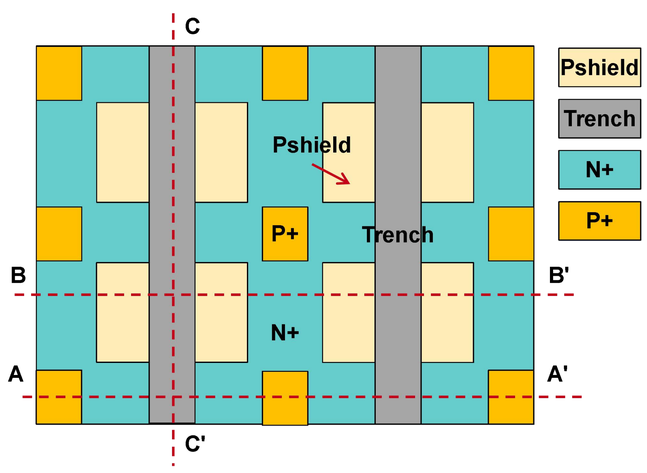

Fig.1 3D P-shield SiC trench MOSFET

When the device is turned on, channels form on both sides of the trench in region AA', with the N+ area supplying electrons for conduction.

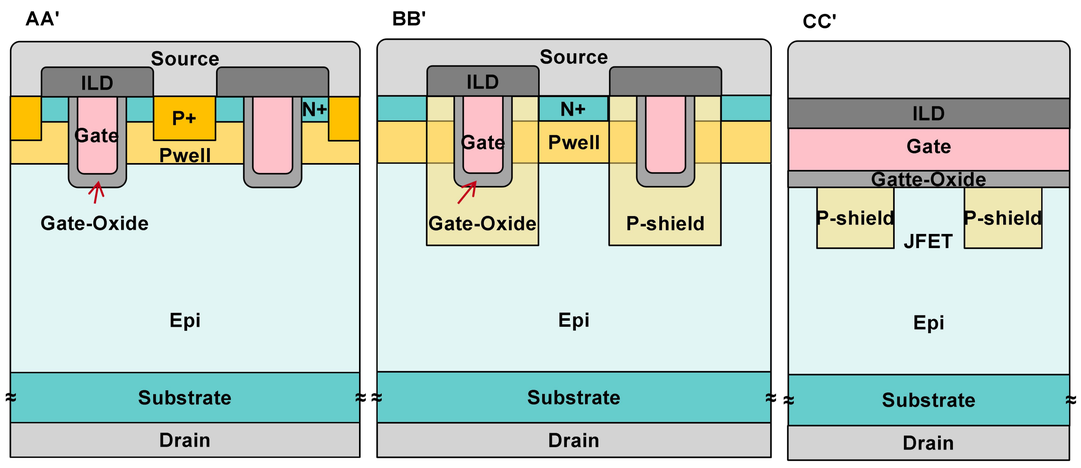

Fig.2 Cross section of the 3D P-shield SiC trench MOSFET

In the reverse bias state, the P-shield structure depletes within the epitaxial layer, reducing electric field stress concentration at the trench bottom's gate oxide layer

Critical process

A roughness of 0.11 nm on the trench sidewalls was achieved, mitigating the scattering effects of surface roughness.

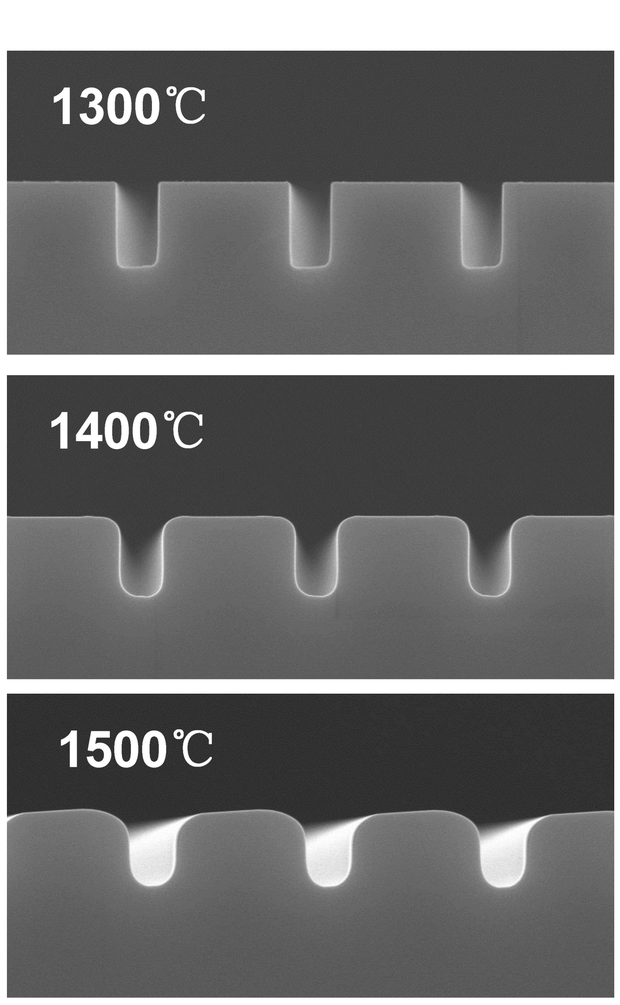

Fig.3 Trench appearance after different H_2 annealing temperature

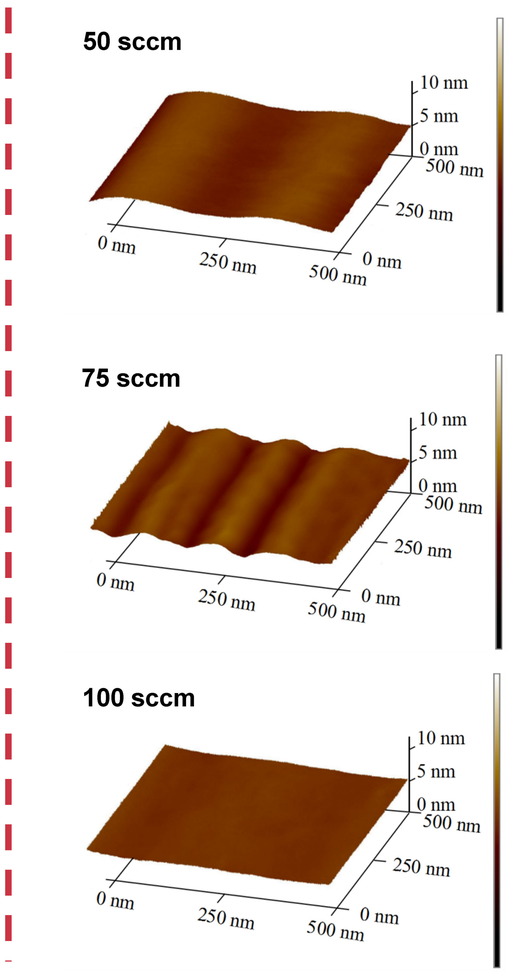

Fig.4 Trench side-wall roughness under different H_2 flow rate

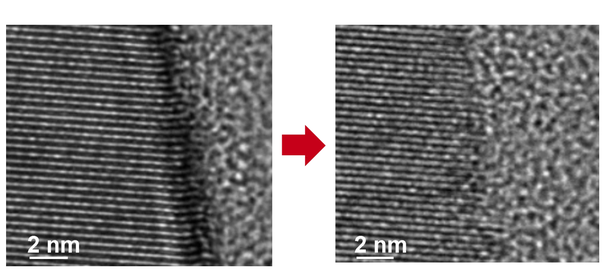

Fig.5 Effect of lattice repair after high-temperature annealing

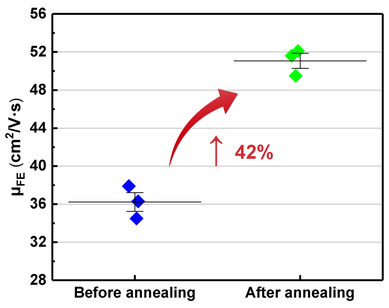

Fig.6 Field-effect mobility before and after process optimization

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Electrical Characteristics

Chip size 5mm*5mm, L5 series format (8 chips in parallel)

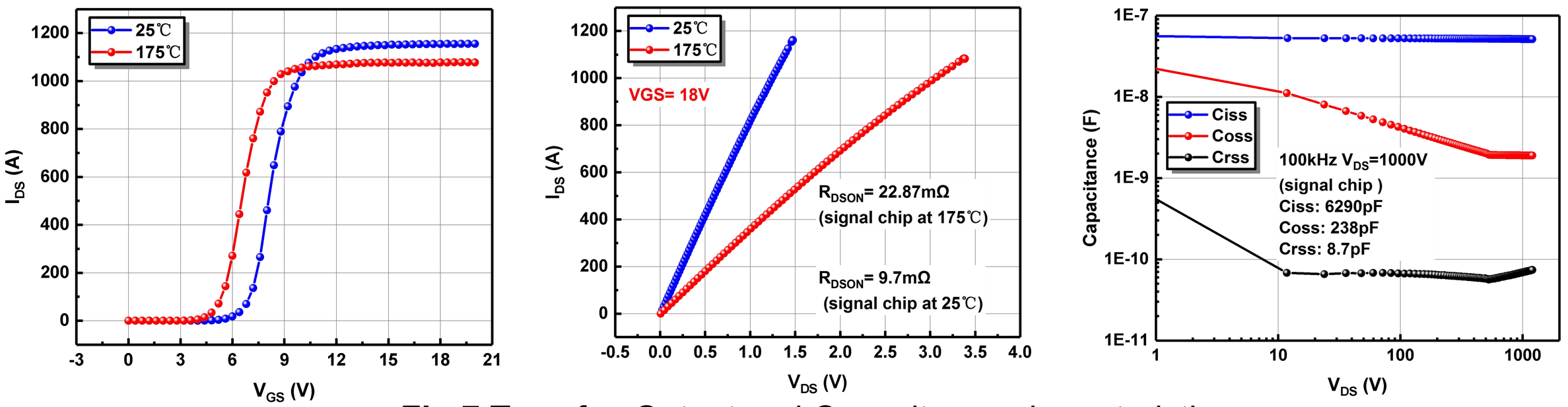

Fig.7 Transfer, Output and Capacitance characteristic

The Vrm during turn-on processis higher due to the rapid carrier extraction in the body region during the reverse recovery process, leading to a large dirr/dt and severe voltage overshoot, which constrains further increases in turn-on speed.

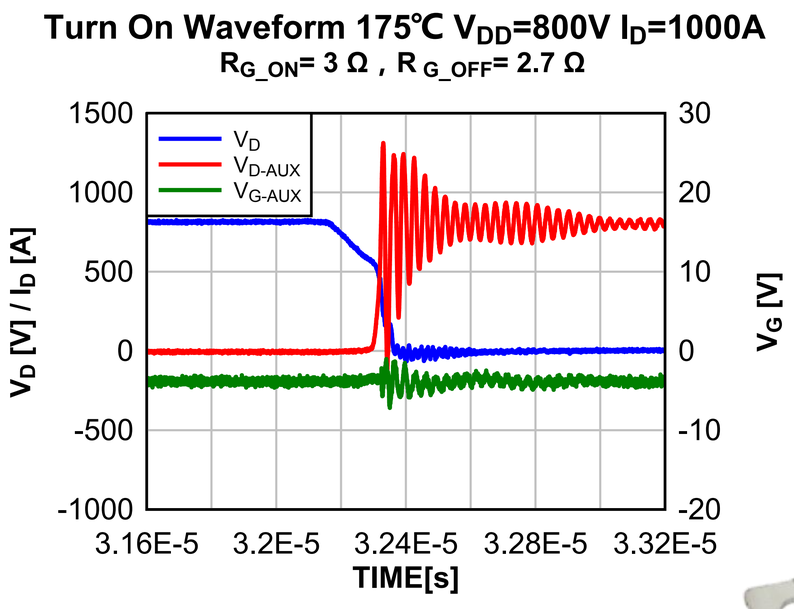

Fig.8 Turn-on waveform

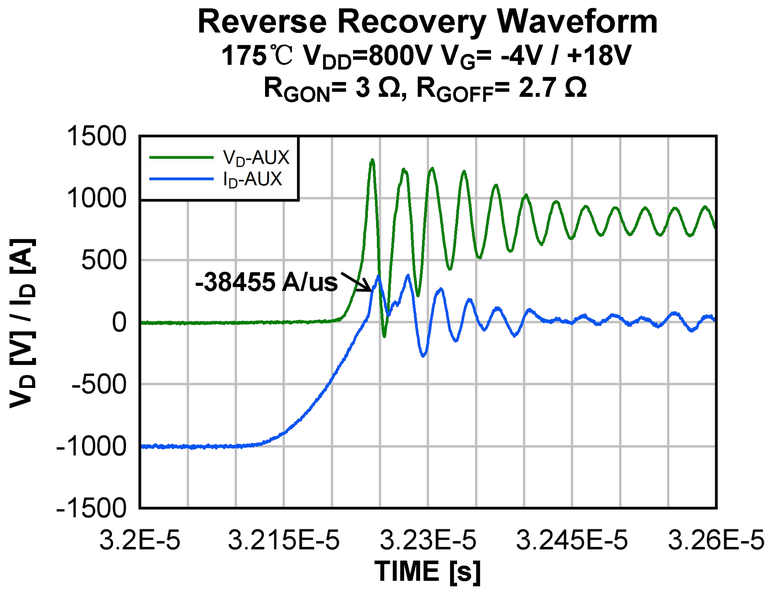

Fig.9 Reverse recovery waveform

The 3D P-shield structure reduces the device's saturation current, thanks to its high doping concentration and junction depth, achieving a short-circuit withstand of 3μs and a short-circuit energy (ESC) of 13J

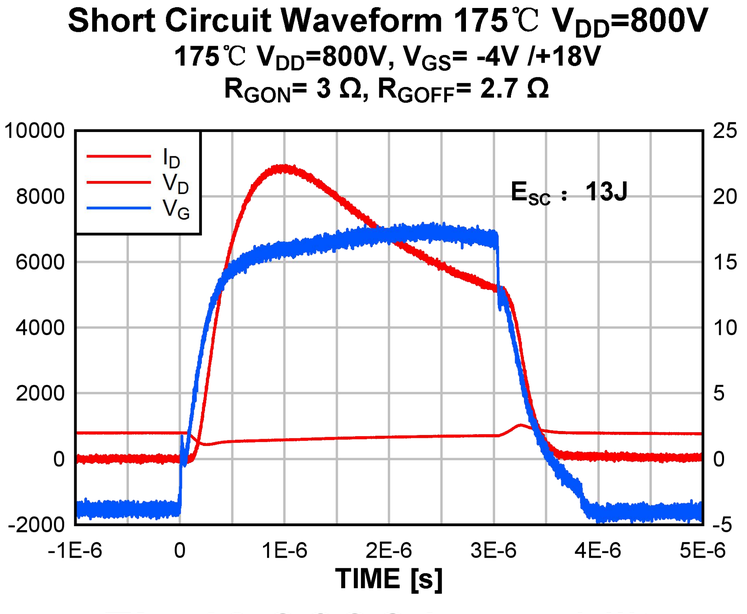

Fig.10 SCSOA capability

Fig.11 RBSOA capability