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Influence of the Junction Temperature on the Dynamic Gate Bias Test of SiC MOSFETs

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Abstract

- SiC MOSFETs showed gate switching instabilities in extensive high-frequency operations, which may result in an unexpected influence on the applications. Researchers found frequency, duty ratio, voltage range and overshoots show significant impacts on the lifetime of SiC MOSFETs in dynamic gates bias test (DGS). We designed an experiment to find the influence of junction temperature of SiC MOSFETs on the dynamic gate bias test, which showed an insignificant effect on the lifetime of the devices in the DGS test.

Introduction

- The switching instability behavior of SiC MOSFETs has been found, which results in a drift of threshold voltage (Vth) known as gate switching instability (GSI).

Parameter	Value
Switching cycles	≥ 10^{11} cycles
Test temperature	25°C
Drain-source voltage	V_{DS} = 0 V [a]
dV_{GS}/dt (at DUT)	1 V/ns (no overshoot)
Switching frequency	f ≥ 50 kHz (with duty cycle > 20%)
Gate voltage	$V_{GS,off} = V_{GS,min,recom}$ and $V_{GS,on} = V_{GS,max}$
[a] V_{DS} = 0 V only sufficient, if the influence of V_{DS} on $V_{GS,th}$-drift has been excluded by chip-level test. Note: The proposed test parameters are derived from typical application conditions or are based on best practice.	

Table 1: Basic test conditions of DGS test

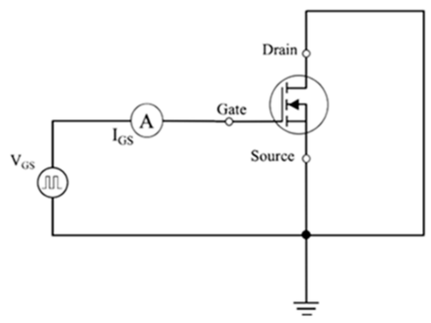

Fig. 1: The test circuit of DGS test.

- The test conditions and the test circuits are based on the automotive reliability test standard AQG-324 2021 edition and CASA-China group standard.

Test Set-up

- The DGS test in this study was performed in the DGS Tester (PSL-DHTGB-Pro) which is designed and fabricated by PowerSemiLab® in Wuxi, PR China. The DGS Tester (PSL-DHTGB-Pro) can measure the parameters such as Vth, Igss, case temperature (Tc), junction temperature (Tj) and every single waveform of Vgs.

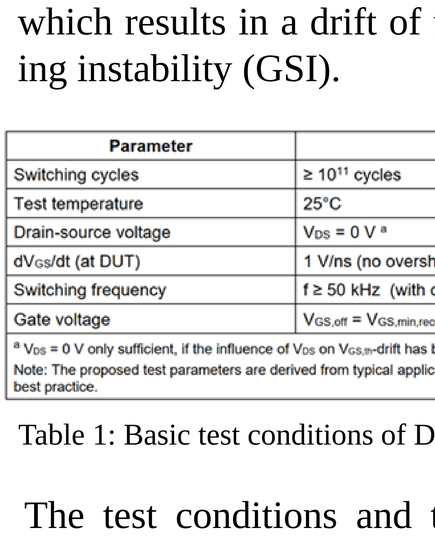

Fig. 2: The DGS Tester (PSL-DHTGB-Pro) and the DUTs mounted inside the DGS tester.

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DGS Test Results

- The setting parameters of the DGS test are 50kHz, Vgson =+18V, Vgsoff=-5V, dVgs/dt=1V/ns..

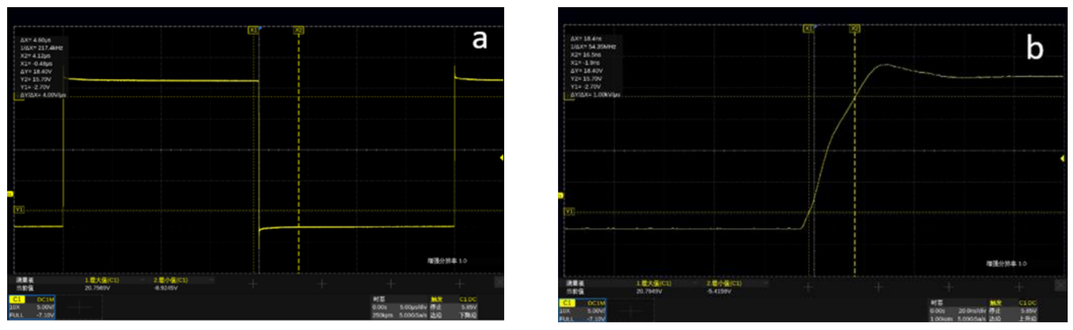

Fig. 3: The waveform of Vgs of DUTs in the DGS test, (a) the overview of the Vgs waveform, (b) the switch-on part of the Vgs waveform with speed of 1V/ns.

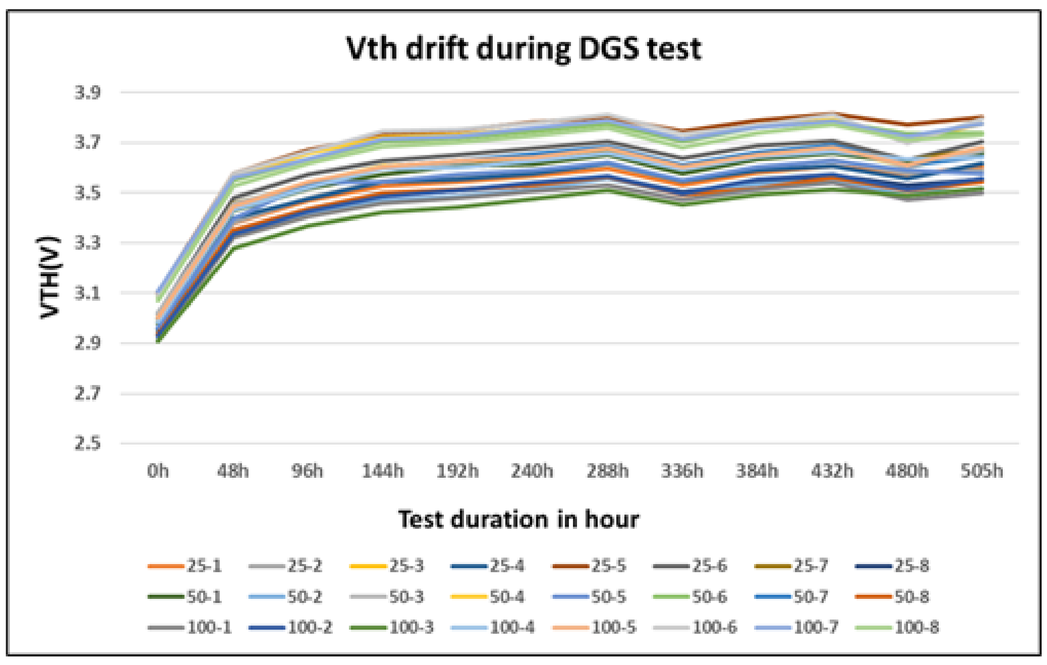

Fig. 4: The DUTs' Vth drift during DGS Test.

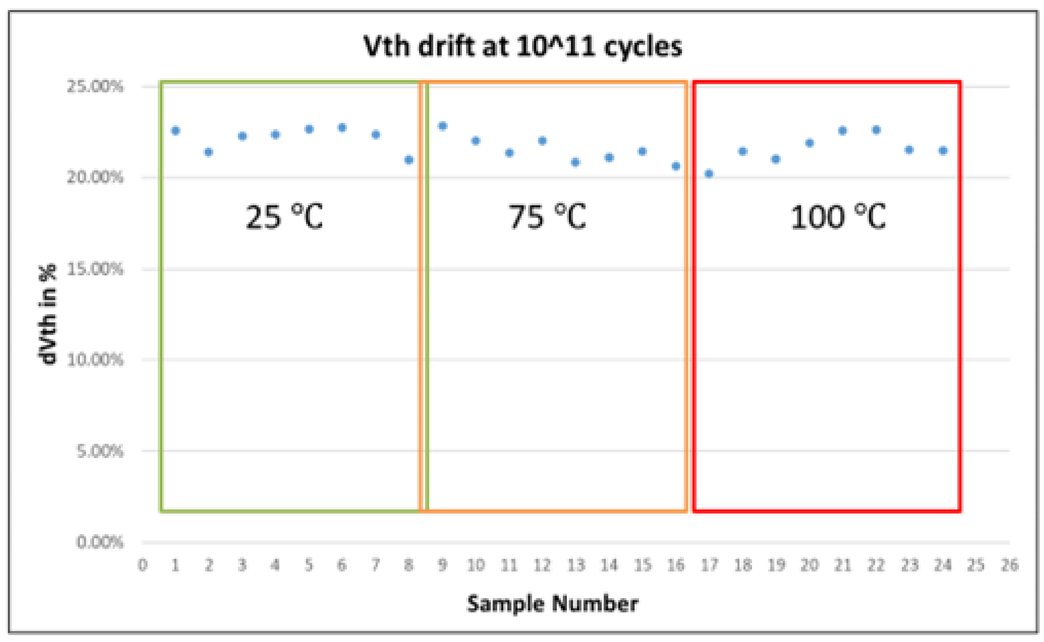

Fig. 5: Vth drift measurement at the end of the Test.

Conclusion

- This study showed that the temperature has an insignificant influence on the drift of Vth of SiC MOSFETs in the DGS test under temperature conditions of 25° C, 50° C and 100° C. However, the DUTs in this study were not fully damaged in the DGS test. Further tests and failure analysis should be done in the future.