

# SiC Power Device Hammer and Burn-In System

Zhong Ye, Hailong Yang InventChip, China

Zhenye Wang, Shanghai Univ. China

InventChip Technology Co., Ltd. 上海瞻芯电子  
[www.inventchip.com.cn](http://www.inventchip.com.cn)

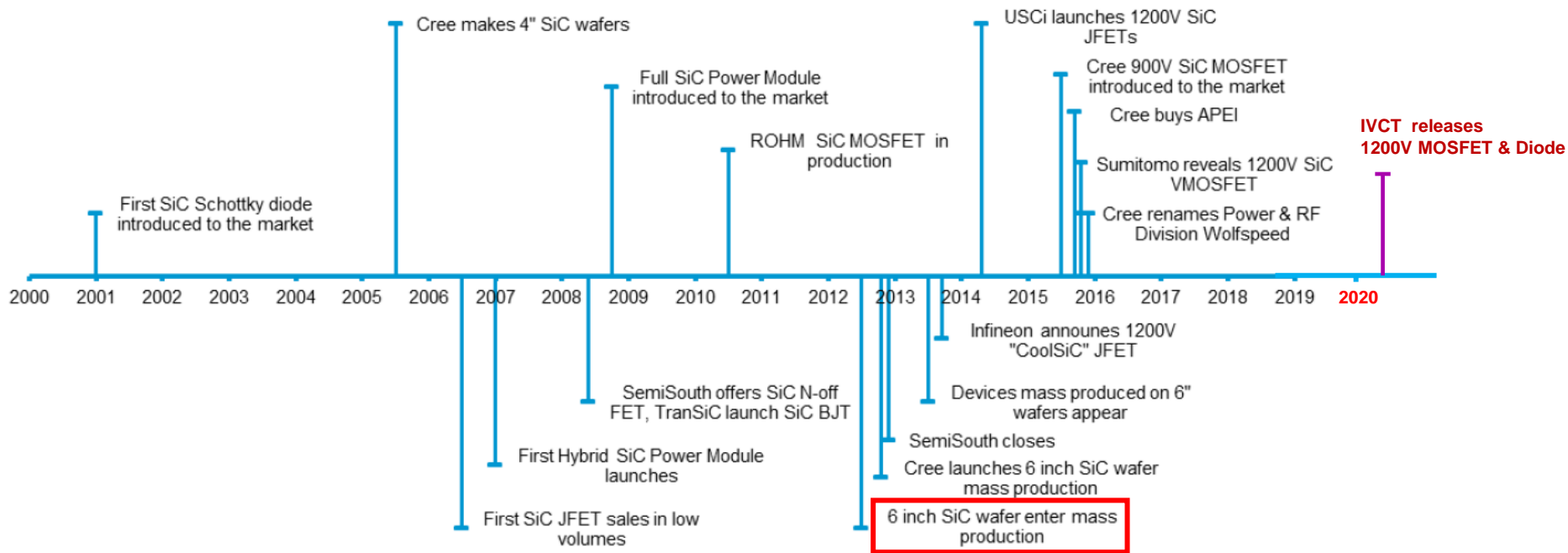
# Contents

- SiC technology milestone overview
- SiC qualification and reliability tests
- Hammer and Burn-In system introduction and applications
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# SiC Technology Milestones



In Sept. 2012, Cree's announcement of 6" SiC mass production is the turning point of the technology's consumerization.

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# SiC MOSFET/Diode Qualification and Reliability

JEDEC Standard for SiC devices ( **JC-70.2** , **Not ready yet**)

High temperature reverse bias (HTRB)

High temperature fate bias (HTGB)

} Chip level test

High temperature, high humidity and high reverse bias (H3TRB)

HV-H3TRB

HASS (High Temp, High Humidity, High Air Pressure)

Thermal cycling (TC)

Power cycling/Intermittent Operation Life (IOL)

Unclamped inductive switching (UIS)/ Avalanche

Short circuit tests (SC)

Cosmic rays

Vibration

Mechanical shock

} Package level test

Hammer tests

Application soft switching and hard switching tests

} System level test

# SiC Industrial-Grade Qualification beyond Si JEDEC Limits

Test	Si Conditions	SiC Conditions
HTRB	JEDEC 150°C	JEDEC 150°C /175°C
HV-H3TRB	JEDEC 100V	JEDEC 80% Vds rating
HTGB	JEDEC	JEDEC
IOL	Not required	AEC-Q101/MIL-STD-750
TC	JEDEC -55°C-150°C	JEDEC -55°C-150°C /175°C
HAST	JEDEC	JEDEC

# Qualification vs Reliability

- Qualification analysis is based on accelerated test models
- Pass-fail outcome reflects whether the product exceeds a minimum acceptable key indicator
- Qual Pass  $\neq$  reliable in the lifetime
- Qualification is a “gate”, while Reliability is a “marathon”



Qualification  
Test



Extended tests  
with data collection



End Products

Highly accelerated tests

Problem  
Solution

Reliability  
Issues



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# Hammer and Burn-In Test Purposes

## Switching Devices should be tested in switching mode !



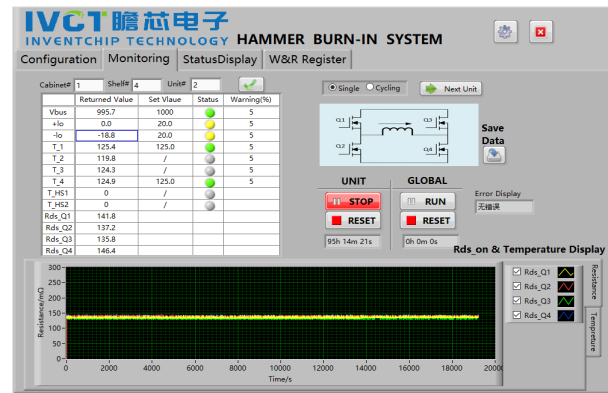
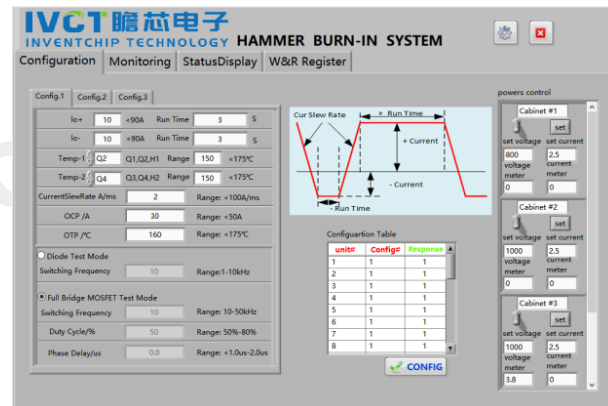
- Stress power devices with any combination of  $V_{ds}$  bias, gate voltage,  $dv/dt$ ,  $di/dt$  and elevated temperature
- Mimic real applications
- Find device weakness
- Find early failure or duplicate application failure mode for device problem debugging
- Collect quantitative reliability data ( device-hours )
- Predict devices' real application lifetime
- Product screen

# IVCT Hammer and Burn-In System

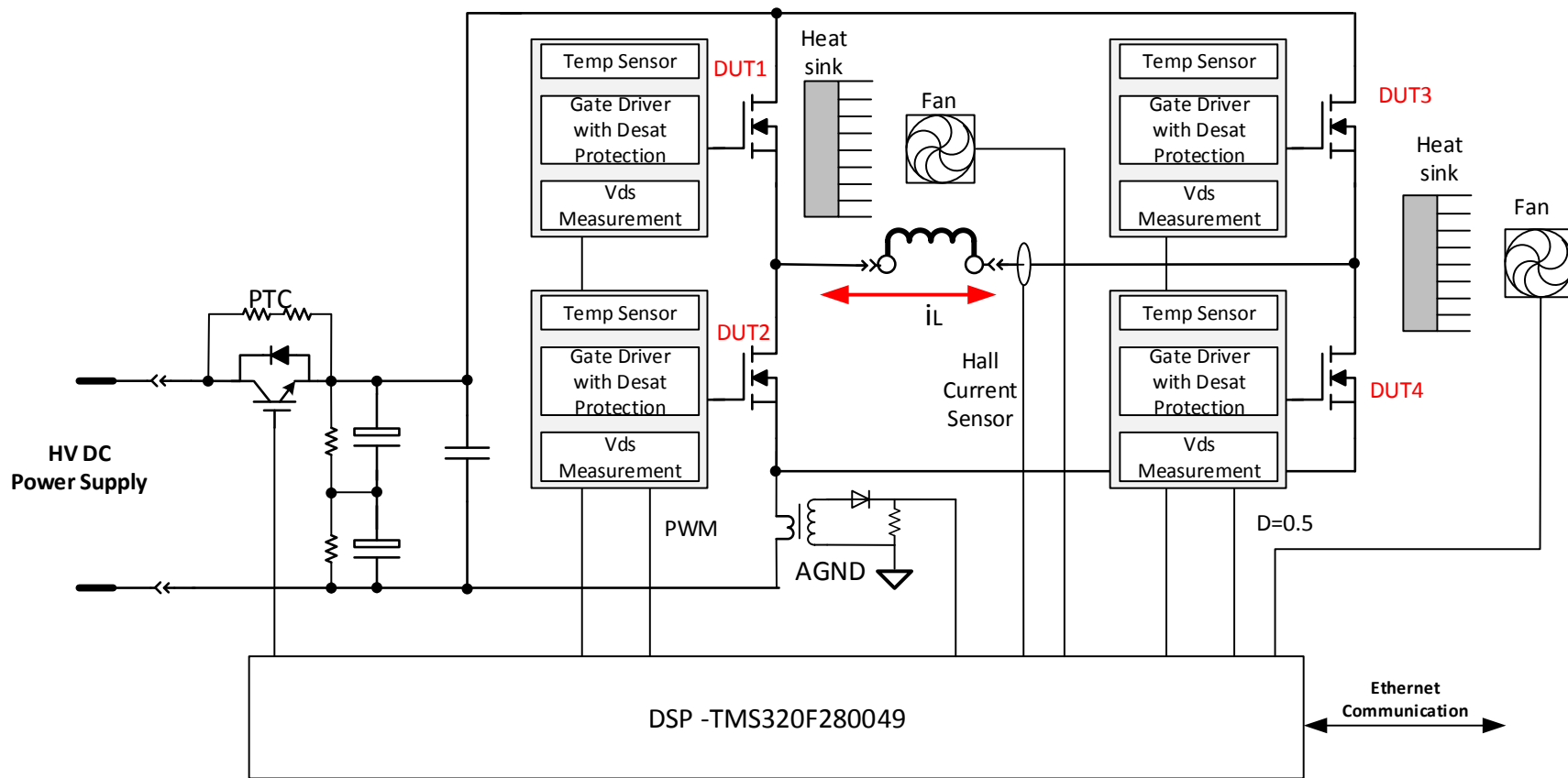
Emulate real applications-模拟真实应用

Collect Device-Hour reliability data-收集长时可靠性数据

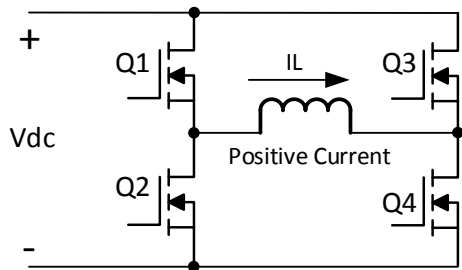
高温高压大电流老化系统



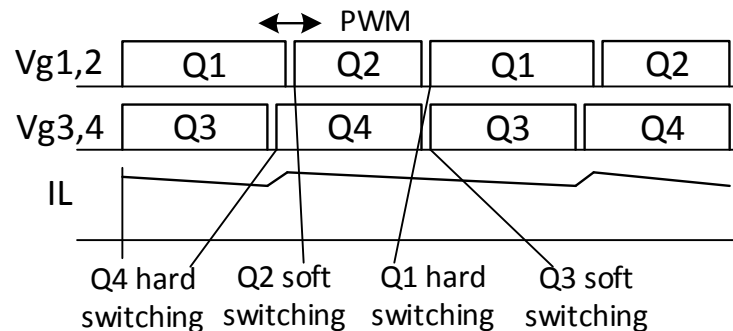
# IVCT Hammer and Burn-In System



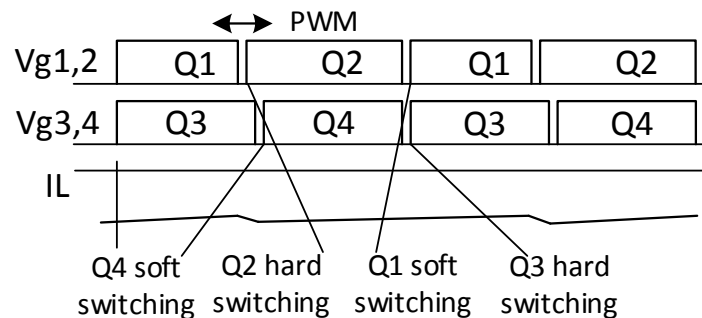
# Soft-Switching and Hard-Switching Operations



Positive Current  
Operation

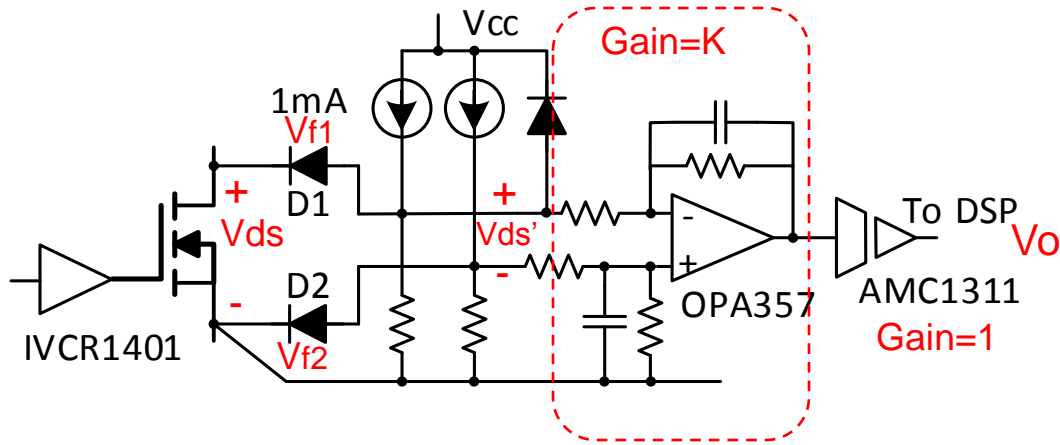


Negative Current  
Operation



**Energy can be recycled efficiently.**  
**System consumes no power except the device losses.**

# Real-time Dynamic Rds\_on Sensing



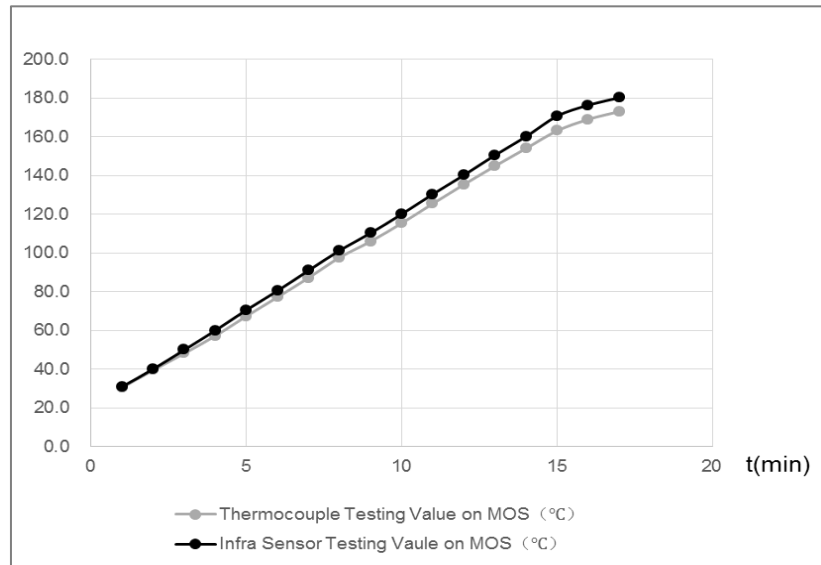
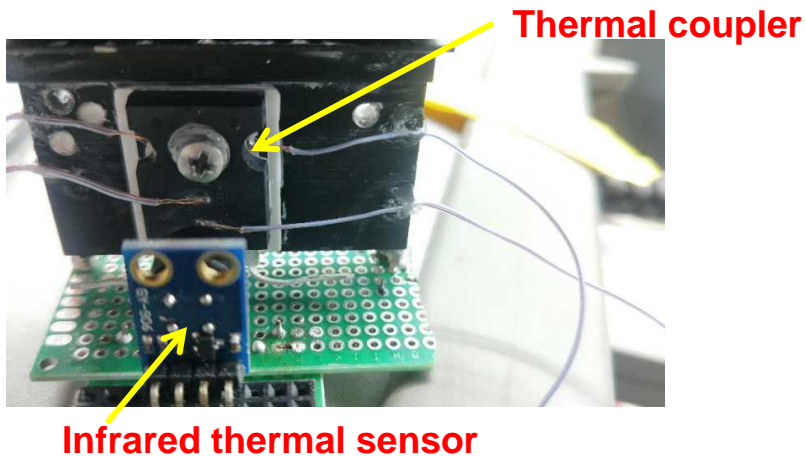
D1 and D2 are well matched high voltage isolation diodes  $\Rightarrow V_{f1} = V_{f2}$

$$V_{ds}' = V_{ds} + V_{f1} - V_{f2} = V_{ds}$$

$$V_o = K \cdot V_{ds}$$

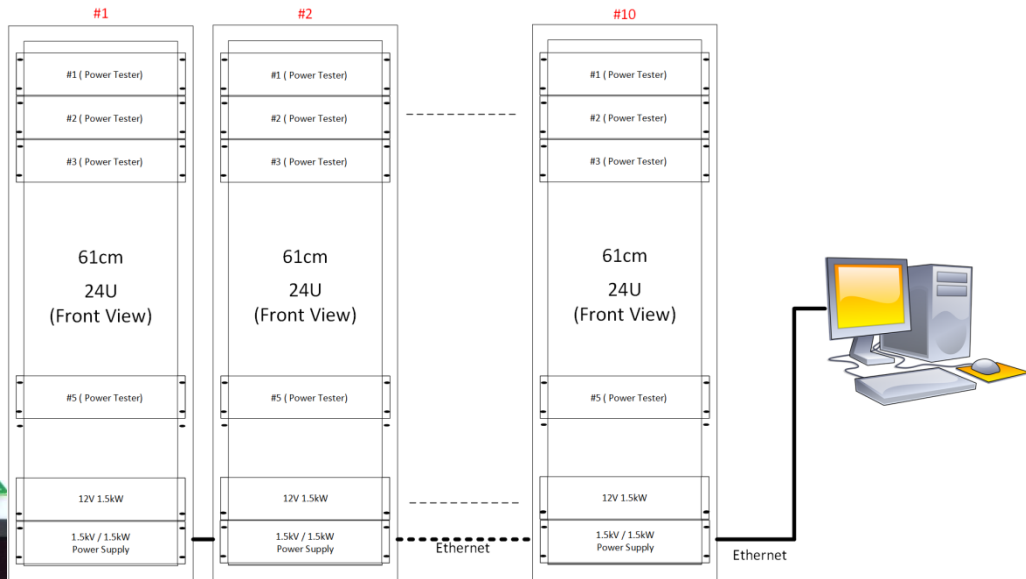
$V_o$  and the inductor current are sensed simultaneously for Rds\_on calculation

# Real-time Device Temperature Measurement



- Infrared sensor remotely senses temperature, more suitable for device test
- Infrared sensor can achieve more accurate device temperature sensing

# IVCT SiC Device Hammer Burn-In System





# Test Configuration and Data logging

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INVENTCHIP TECHNOLOGY HAMMER BURN-IN SYSTEM

Configuration | Monitoring | StatusDisplay | W&R Register

Config.1 | Config.2 | Config.3

Io+ 10 <90A Run Time 3 S  
Io- 10 <90A Run Time 3 S  
Temp-1 Q2 Q1,Q2,H1 Range 150 <175°C  
Temp-2 Q4 Q3,Q4,H2 Range 150 <175°C  
CurrentSlewRate A/ms 2 Range: <100A/ms  
OCP /A 30 Range: <50A  
OTP /°C 160 Range: <175°C

Diode Test Mode  
Switching Frequency 10 Range: 1-10kHz

Full Bridge MOSFET Test Mode  
Switching Frequency 10 Range: 10-50kHz  
Duty Cycle/% 50 Range: 50%-80%  
Phase Delay/us 0.0 Range: <1.0us-2.0us

Configuration Table

unit#	Config#	Response
1	1	1
2	1	1
3	1	1
4	1	1
5	1	1
6	1	1
7	1	1
8	1	1

CONFIG

powers control

Cabinet #1  
set voltage set current  
800 voltage meter 2.5 current meter  
0 0

Cabinet #2  
set voltage set current  
1000 voltage meter 2.5 current meter  
0 0

Cabinet #3  
set voltage set current  
1000 voltage meter 2.5 current meter  
3.8 0

- Flexible test settings
- Settable warning and protection thresholds
- Selectable MOSFET and Diode test
- Suitable for TO-247-2L/3L/4L and TO-220

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INVENTCHIP TECHNOLOGY HAMMER BURN-IN SYSTEM

Configuration | Monitoring | StatusDisplay | W&R Register

Cabinet# 1 Shelf# 4 Unit# 2

Returned Value Set Value Status Warning(%)  
Vbus 995.7 1000  
+Io 0.0 20.0  
-Io -18.8 20.0  
T\_1 125.4 125.0  
T\_2 119.8  
T\_3 124.3  
T\_4 124.9 125.0  
T\_HS1 0  
T\_HS2 0  
Rds\_Q1 141.8  
Rds\_Q2 137.2  
Rds\_Q3 135.8  
Rds\_Q4 146.4

Single Cycling Next Unit

Save Data

UNIT GLOBAL  
STOP RUN  
RESET RESET  
95h 14m 21s 0h 0m 0s

Error Display  
无错误

Rds\_on & Temperature Display

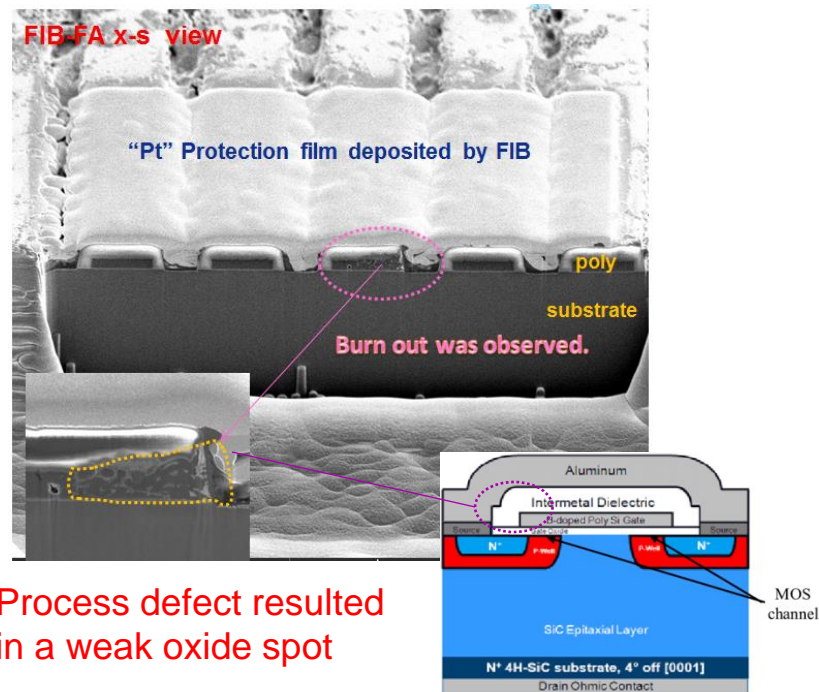
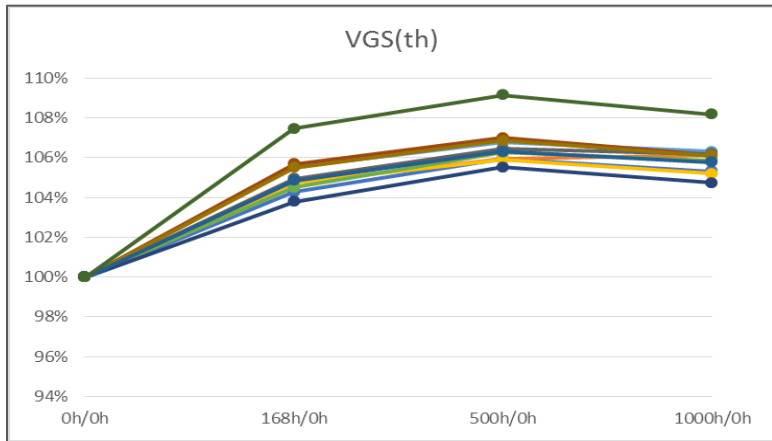
Resistance/mΩ  
Temperature

Resistance/mΩ  
Temperature

Time/s

- Real-time Rds\_on and device temperature monitoring
- Selectable static or alternating unit monitoring
- Auto data logging

# Device Analysis Examples After Hammer Tests



Process defect resulted in a weak oxide spot

- How stable device's parameters can be
- Help to find out design problems, material defect and process issues in the early development phase
- Test to device limitation and find out weakness in real application modes

# Summary

- A hammer and burn-in system is introduced. It is a powerful supplemental SiC device test equipment
- Application-oriented test is a necessary step to ensure product reliability
- The system is able to accelerate product development
- Able to collect quantitative device-hours of real operation before product release
- The system is energy efficient, it consumes only device power losses.

临港滴水湖

谢谢!  
Thank You!