WBG Products Validation by Double Pulse Test

Aya Chan
Marketing of WBG Products
2023/02/16

Version 1.0

Company Profile

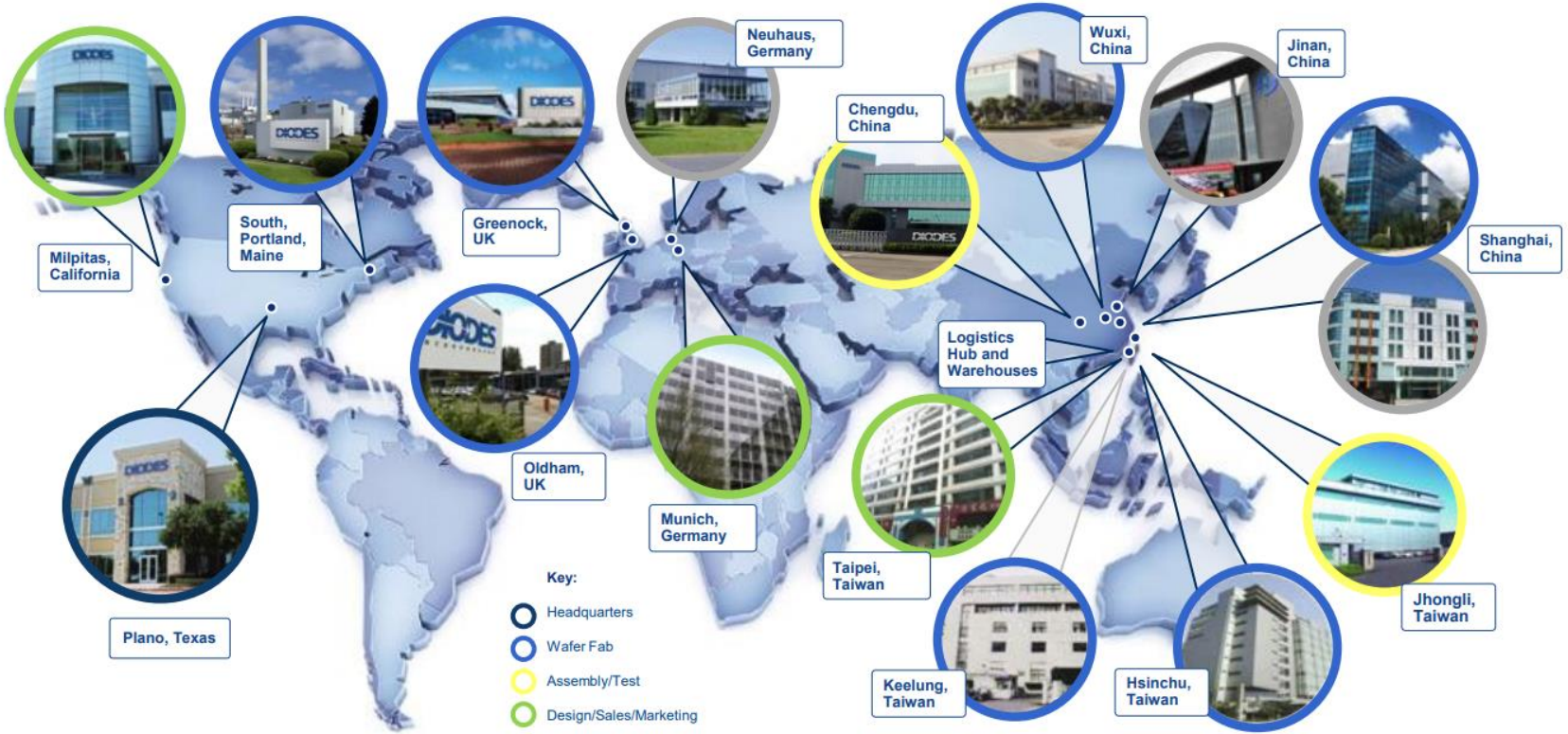
Diodes delivers high-quality (discrete, analog, and mixed signal) semiconductor products to the world's leading companies in the automotive, industrial, computing, consumer electronics, and communications markets

Vision: Profitability Growth to Maximize Shareholder Value

Our Core Values: Integrity, Commitment, Innovation

Global Organization

- Headquartered in Plano, TX; 32 locations globally
- Manufacturing in US, UK, Germany, China, and Taiwan



Products

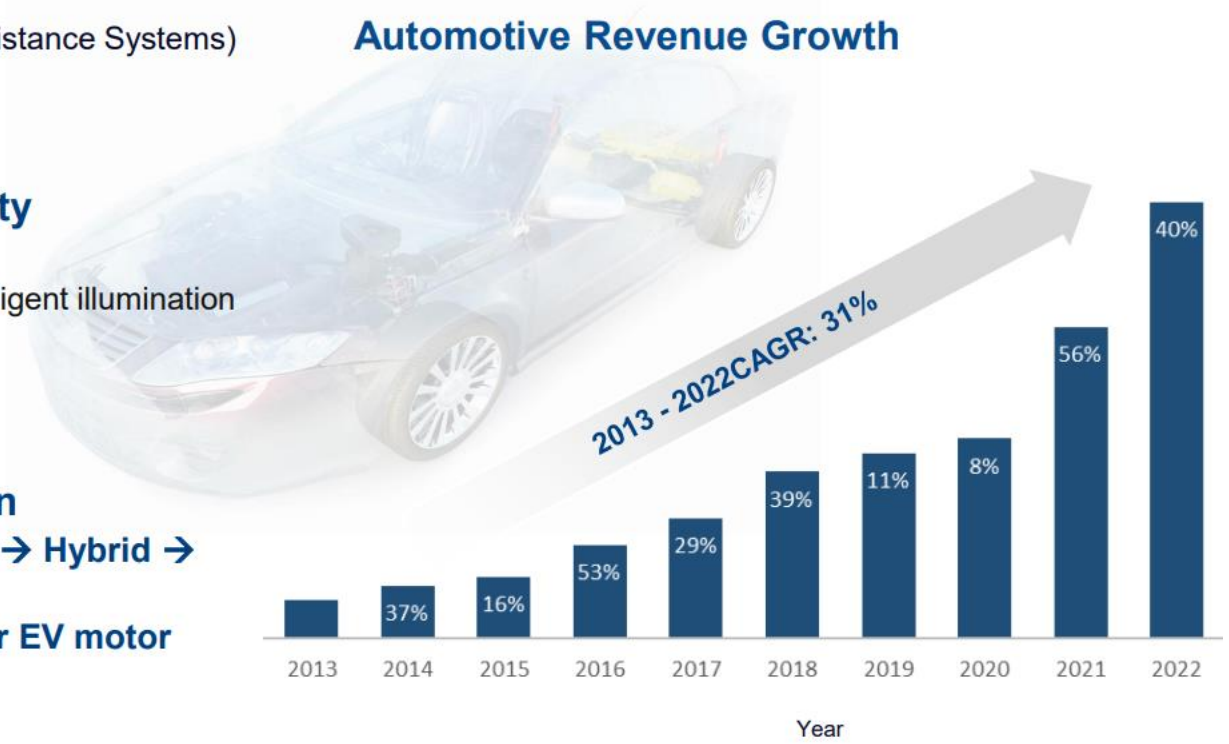
Automotive Applications Driving Growth

Focus Applications:

Connected Driving
- **ADAS** (Advanced Driver Assistance Systems)
- **Telematics**
- **Infotainment Systems**

Comfort, Style, and Safety
- **Lighting**
  - Migration to LED and intelligent illumination
- **BLDC motor control**
  - Migration from Brushed to Brushless DC Motors

Electrification/Powertrain
- **Conventional Powertrain → Hybrid → Electrification**
- **Power Module Inverter for EV motor**
- **Battery management**
  - Move to 48V battery



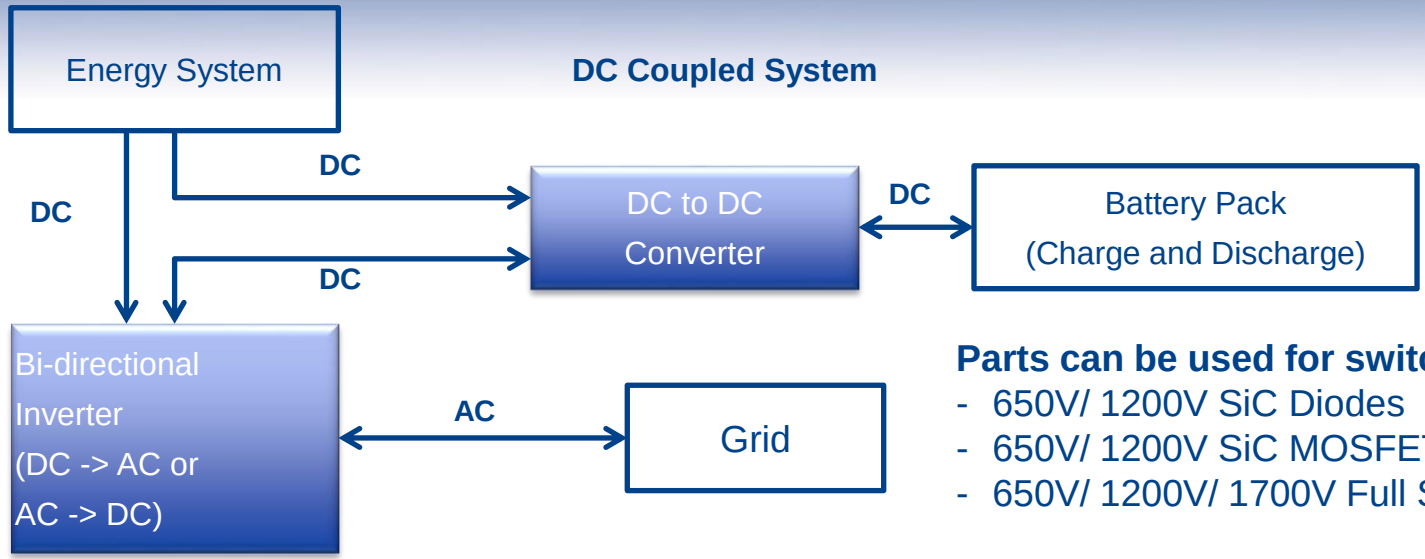
Our Sustainability Commitment

We view sustainability as a competitive advantage and have adopted a sustainability-oriented approach to assess and address related risks that may influence our operational activities, business results, and financial performance.

- Key focus areas regularly reviewed by our Board of Directors
- Instituted a cross-functional Sustainability Steering Team to address the sustainability related risks and opportunities
- The Sustainability Steering Team provides periodic updates to the Board of Directors

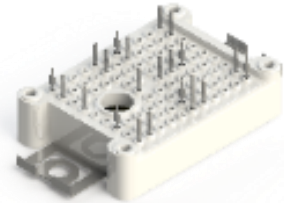
What Will Our Products Be….?

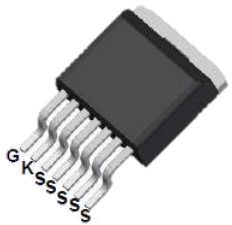
SiC Applications

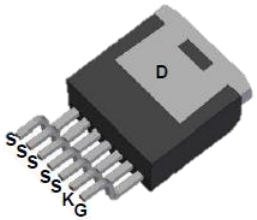


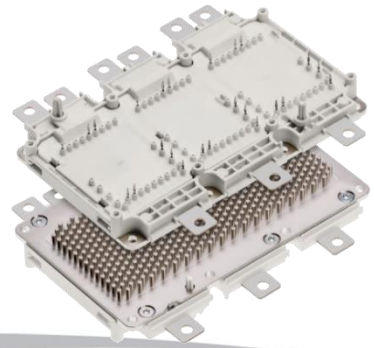
Parts can be used for switching:

- 650V/ 1200V SiC Diodes
- 650V/ 1200V SiC MOSFETs
- 650V/ 1200V/ 1700V Full SiC Modules



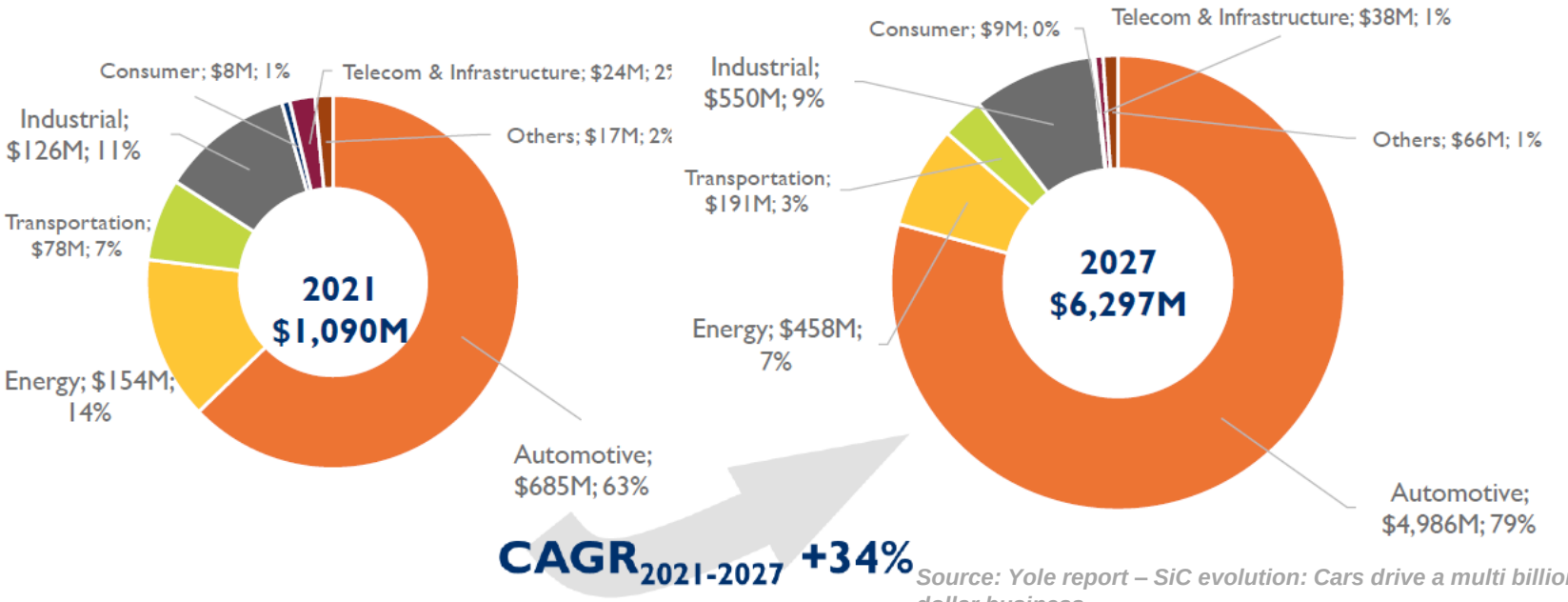






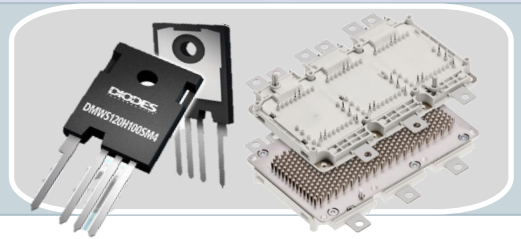
Power SiC Device Market ($M)

- Split by Application:

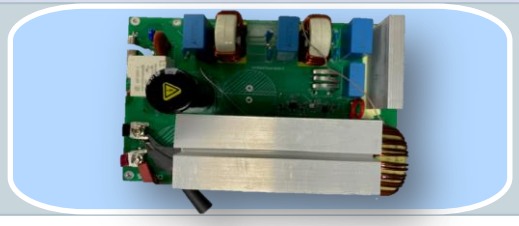


Source: Yole report – SiC evolution: Cars drive a multi billion dollar business

Design Products Fit Requirement



Power Components



Sub-Systems

Motors
(Reference: Tesla Motor)

Characteristic		Symbol	Value	Unit
Total Power Dissipation (Note 5)	T_C = +25°C	P_D	208	W
	T_C = +100°C		83	
Thermal Resistance, Junction to Ambient (Note 6)		$R_{\theta JA}$	25.5	°C/W
Thermal Resistance, Junction to Case (Note 5)		$R_{\theta JC}$	0.6	
Operating and Storage Temperature Range		T_J, T_{STG}	-55 to +150	°C

Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

Characteristic	Symbol	Min	Typ	Max	Unit	Test Condition
OFF CHARACTERISTICS (Note 8)						
Drain-Source Breakdown Voltage	BV_{DSS}	1200	—	—	V	V_{GS} = 0V, I_D = 100μA
Zero Gate Voltage Drain Current	I_{DSS}	—	—	100	μA	V_{DS} = 1200V, V_{GS} = 0V
Gate-Source Leakage	I_{GSS}	—	—	±200	nA	V_{GS} = +15/-4V, V_{DS} = 0V
ON CHARACTERISTICS (Note 8)						
Gate Threshold Voltage	$V_{GS(TH)}$	1.8	2.5	3.5	V	V_{DS} = V_{GS}, I_D = 5mA
Static Drain-Source On-Resistance	$R_{DS(ON)}$	—	80	100	mΩ	V_{GS} = 15V, I_D = 20A
Diode Forward Voltage	V_{SD}	—	4.06	—	V	V_{GS} = -4V, I_S = 10A
Transconductance	gfs	—	3.8	—	S	V_{DS} = 20V, I_D = 20A

+

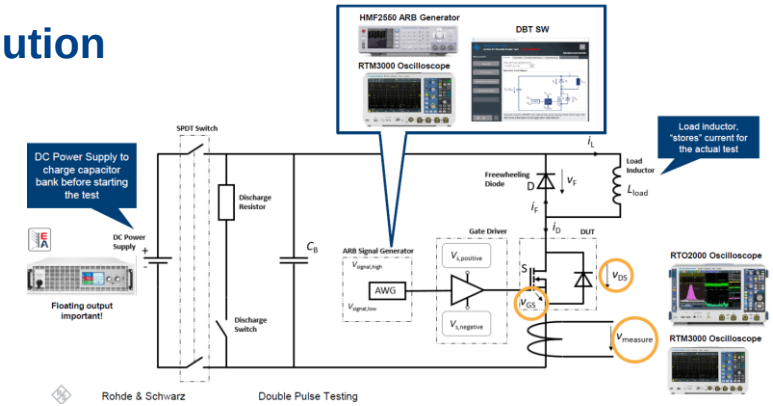
Name	Details
Measurements according to IEC 60747-8 and IEC 60747-9	► Turn-on and turn-off delay times ► Rise and fall time ► Turn-on energy and Turn-off energy ► Reverse recovery time ► Reverse recovery charge ► Reverse recovery energy ► Reverse recovery current
Gate charge	► Gate charge ► Plateau charge ► Total charge ► V_g vs. Q_g
Extraction of DUT stray inductance	
dv/dt and di/dt	
(Dynamic on-resistance) according to JC70 standards	
Switching locus	► I_d and V_{ds} vs. t ► I_g and V_{gs} vs. t ► Energy vs. t ► I_d vs V_{ds} (switching locus)

Dynamic Parameters Measurement on SiC Devices

- The methodology and theory of dynamic characteristics measurement of SiC is similar with that of Si semiconductors.

- Double pulse test is the preferred test method to measure the switching parameters and evaluate the dynamic behaviors of power devices.

- But fast switching time of SiC power components increase the number of effects influencing the measurement.
  - Stray inductances of DC-link
  - Smaller losses => high measurement resolution
  - Bandwidth voltage and current probes
  - …



Theory of Double Pulse Test

- **Double pulse test is a tool which enables a power switch to be turned on and off at different current levels as shown in figure 1.**

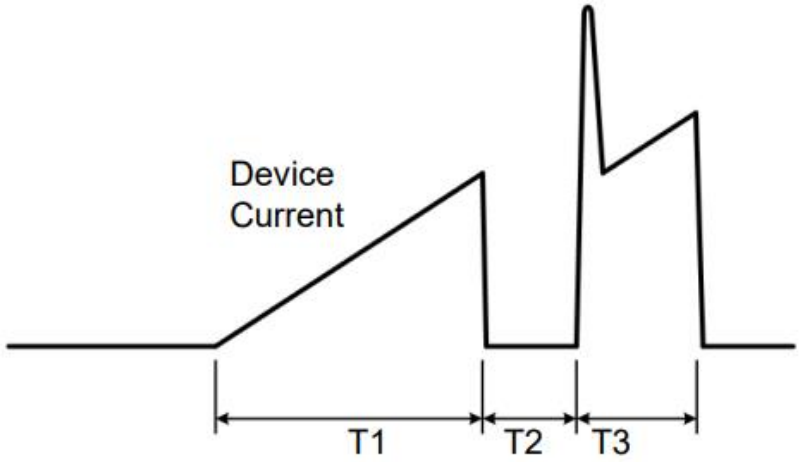
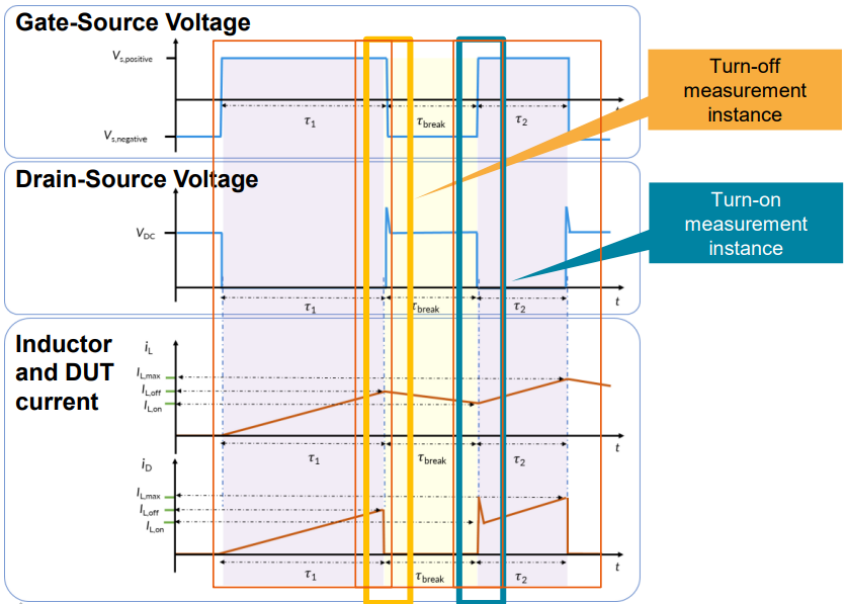


Figure 1: Double pulse waveform

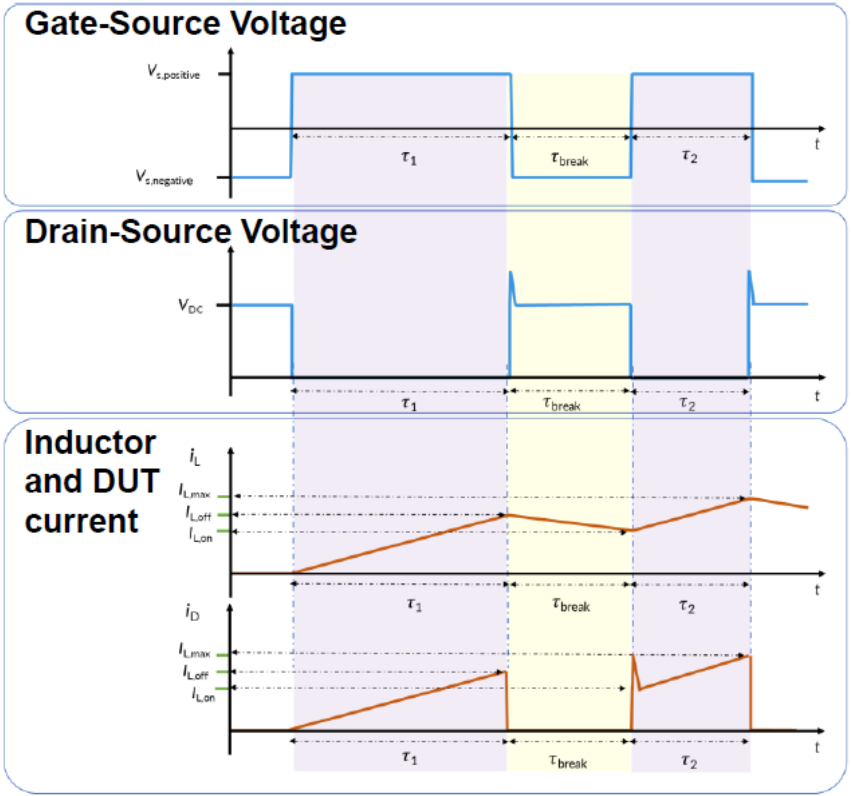


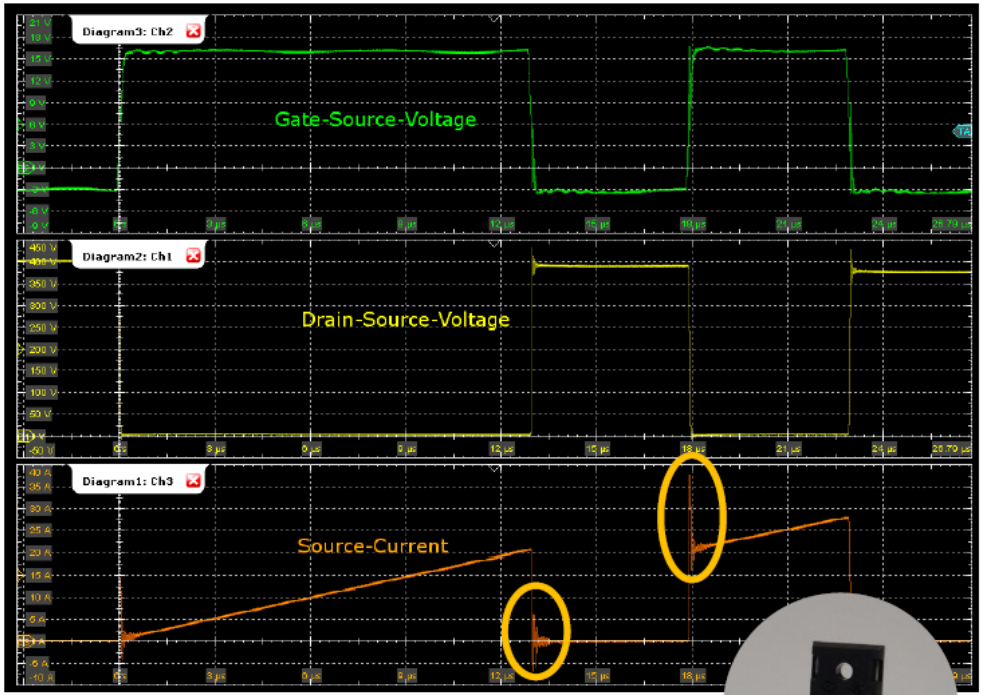
Why Not Single Pulse?

- ✓ **In most power devices, inductive load is bigger. When DUT turn off, inductive current continue to flow, causing diode to turn ON.**

- ✓ **Turning ON the DUT at time stage, the diode will have a reverse recovery process. This is unavailable if we only do a single pulse test.**

DPT Wave Form



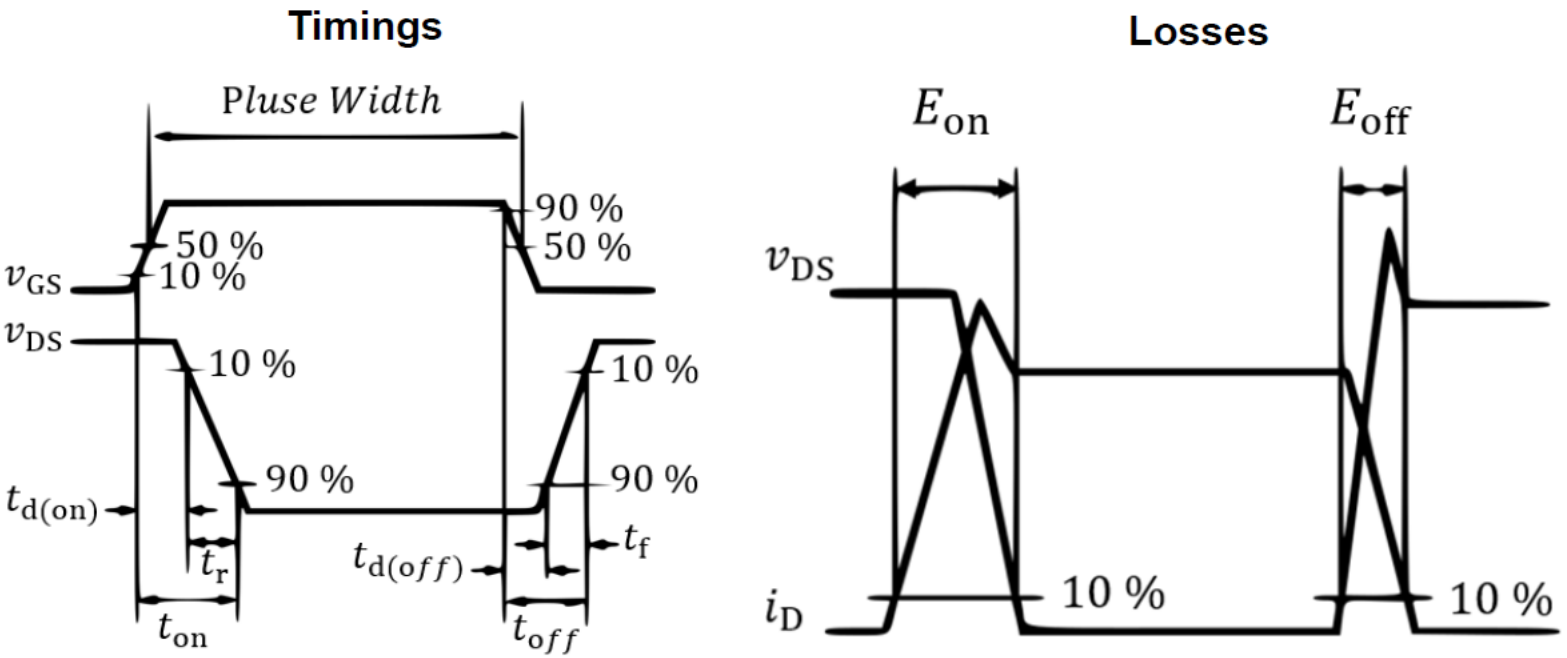


Reference: R&S Report -掌握雙脈衝測試原理和方法

Rohde & Schwarz

Double Pulse Testing

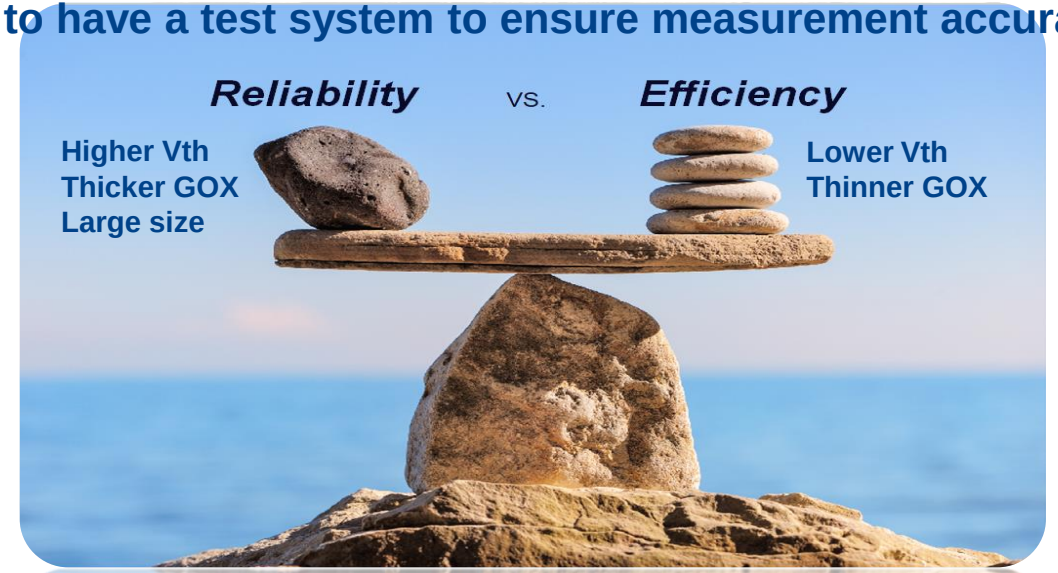
Turn-on And Turn-off Timing And Energy



Definition from IEC 60747-8 for MOSFET

Conclusion

- From design point of view, double pulse test helps power component designers to get relevant data of switching.
- With the dynamic data, components designers can get the sweet point between reliability and efficiency.
- On SiC products, the conduction and switching loss is much smaller. It is important to have a test system to ensure measurement accuracy.



Thank you