

# **Next-Generation 2300 V IGBT Chipset for Renewable Energy Applications**

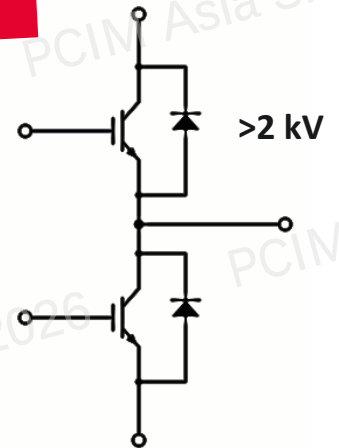
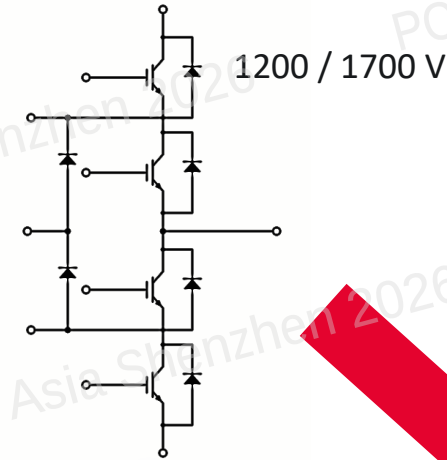
Nick Schneider, SwissSEM Technologies AG

## Introduction and motivation

- Renewable applications such as wind and solar are moving towards higher DC link voltages
- Currently many systems use 1500 V
- To improve efficiency and reduce complexity, 3-level topologies can be replaced by 2-level using higher voltage rating

Considerations:

- Package with higher isolation voltage needed
- Chip current density needs to be high for economic viability



# Introduction & motivation

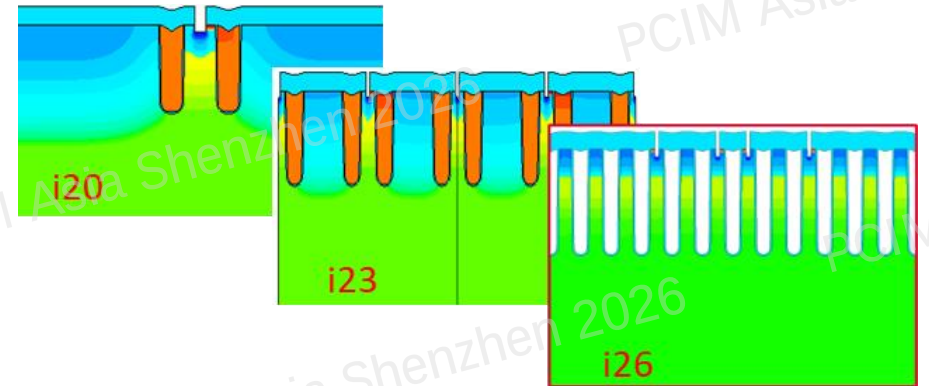
SwissSEMs design approach

Package **XP module**:

- Phaseleg module with high current capability (1600A rating)
- Copper baseplate for better cost
- Well known industry standard to replace ED
- Isolation and creepage distance meets requirement

Chipset **i26**:

- Bring performance of LV IGBTs to higher voltage
- Ultra scaled pitch and latest technology node for next-gen performance
- Ruggedness & reliability as expected from higher voltage classes
- QLLC diode technology for soft and low-loss switching



# IGBT cell design

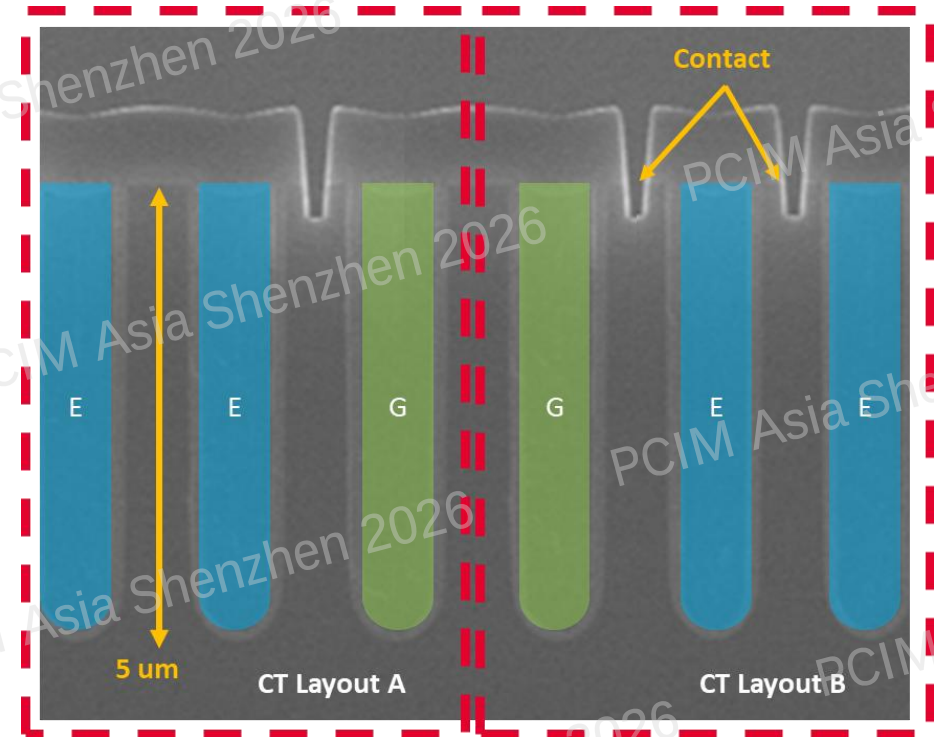
i26 IGBT

IGBT cell improvement drivers:

- Higher cell density by feature size shrinking
- Optimized arrangement of gate and emitter trenches
- H<sup>+</sup> implant for tailored FS enabling very aggressive thinning

Conduction and switching losses can be improved, but we need to consider:

- Turn-off controllability (Peak voltage at turn-off)
- Reverse bias safe operating area (RBSOA)
- Short-circuit safe operating area (SCSOA)
- Ultra fine pattern for high carrier confinement without high CS implant
- Very high controllability can be achieved



## Diode design

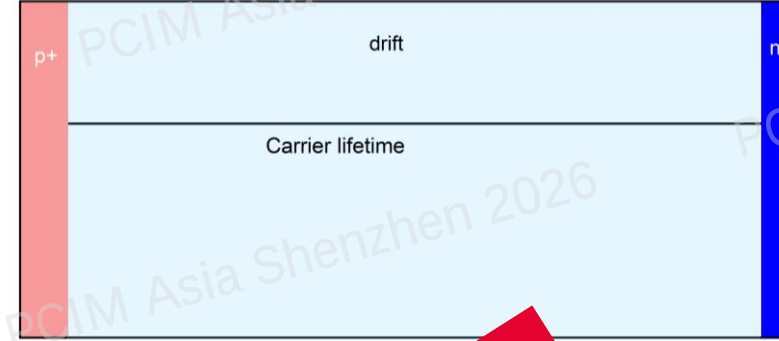
### QLLC Diode

Diode improvement drivers:

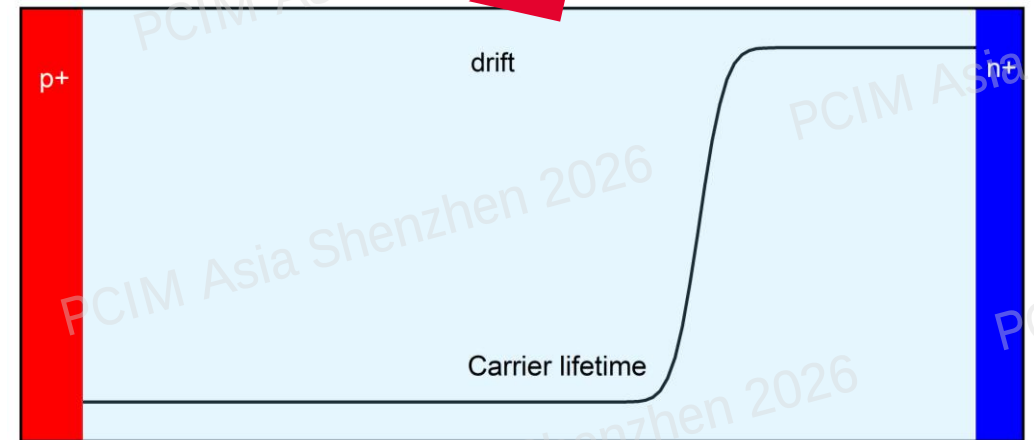
- Anode injection tuning
- Carrier lifetime control
- Drift region thickness

Conduction and switching losses can be improved, but we need to consider:

- Soft recovery behavior
- Diode safe operating area (DSOA)
- Temperature coefficient



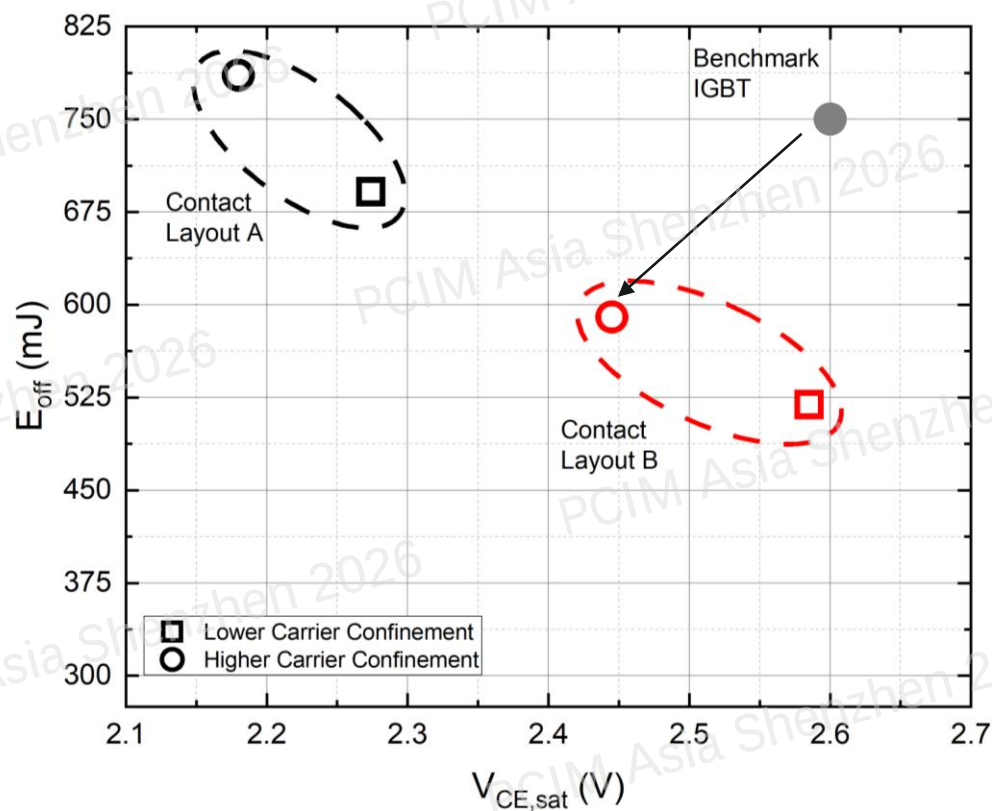
Higher anode efficiency  
and carrier lifetime control



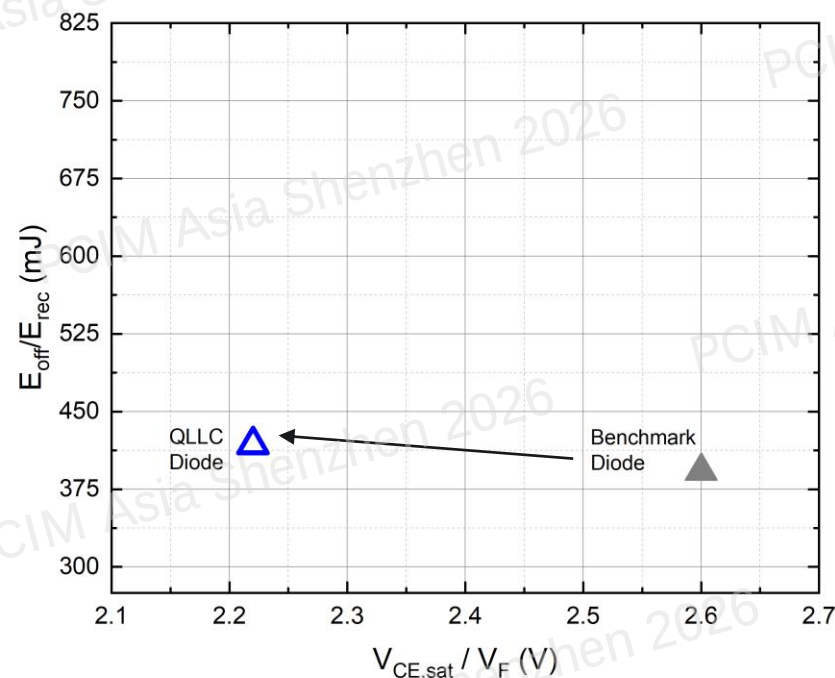
## Technology curve

750 A, 1500 V,  $L_g = 55$  nH, 175 °C

### Technology curve IGBT ( $R_{G,off} = 18 \Omega$ )



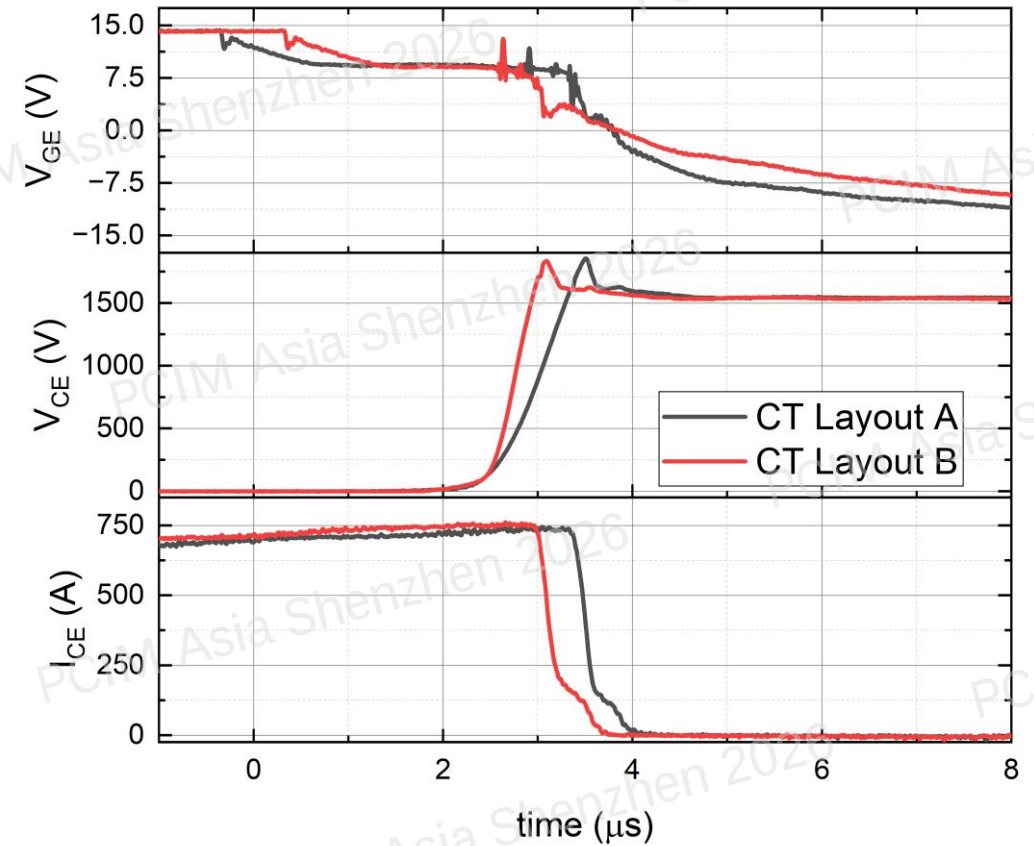
### Technology curve Diode ( $di/dt = 8.9$ kA/ $\mu$ s)



## IGBT turn-off waveforms

750 A, 1500 V,  $L_o = 55$  nH, 175 °C,  $R_{G,off} = 18$   $\Omega$

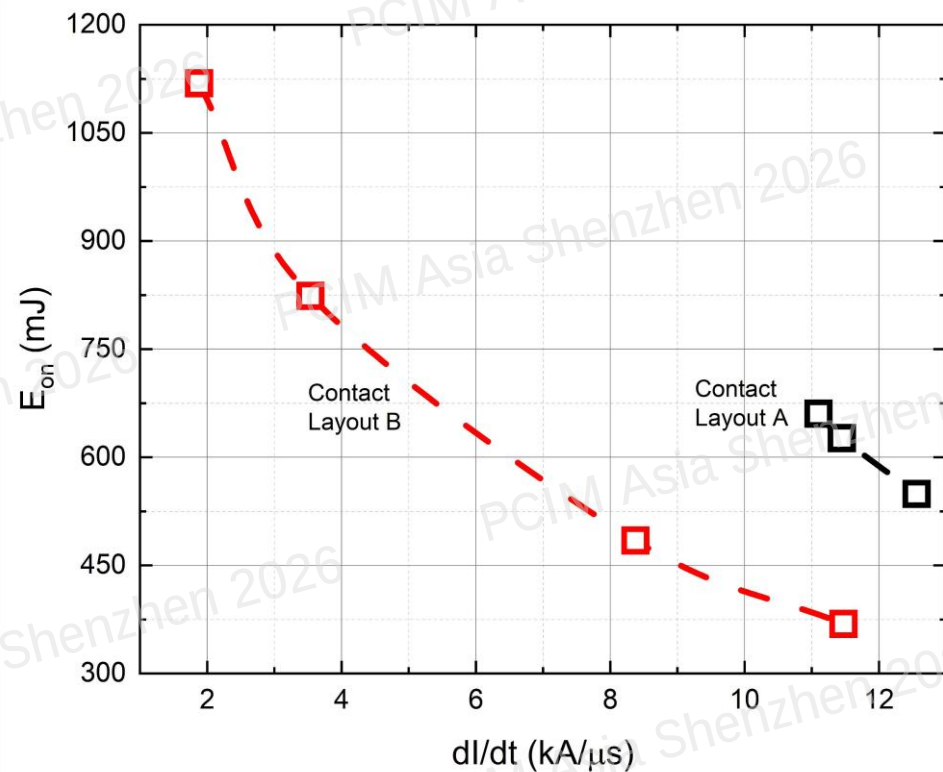
- Both CT layouts are switched with the same  $R_{G,off}$
- CT Layout B results higher  $dV/dt$ , but lower voltage peak
- The gate resistor is chosen for safe SOA
- If the worst-case requirements are relaxed, the turn-off can be accelerated for lower losses



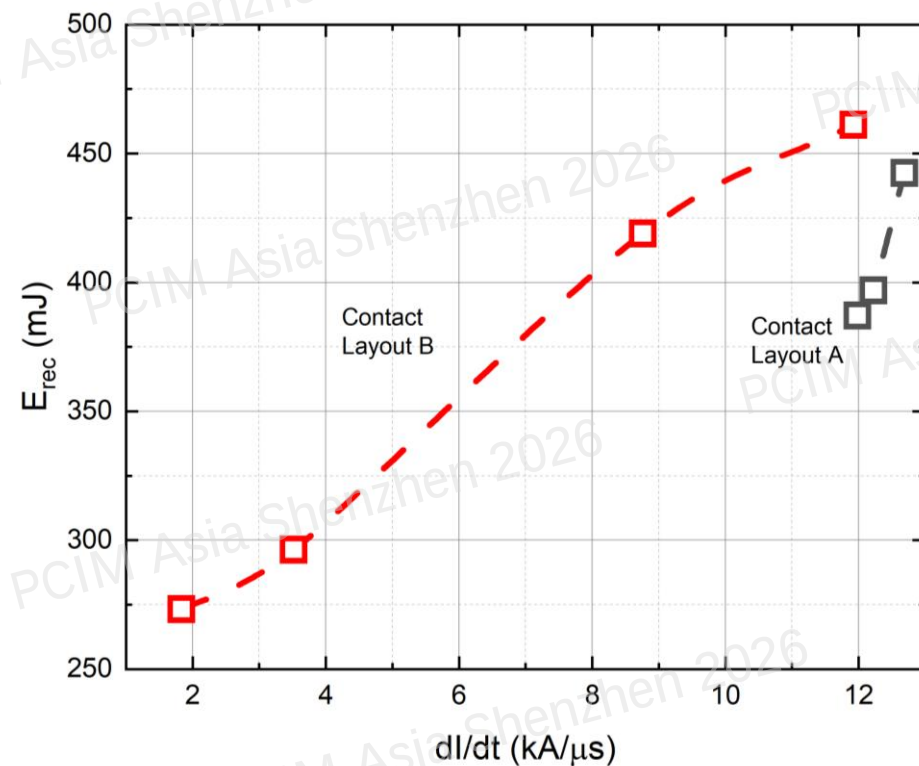
# IGBT turn-on / diode recovery

750 A, 1500 V,  $L_g = 55$  nH, 175 °C

## Turn-on energy vs $di/dt$



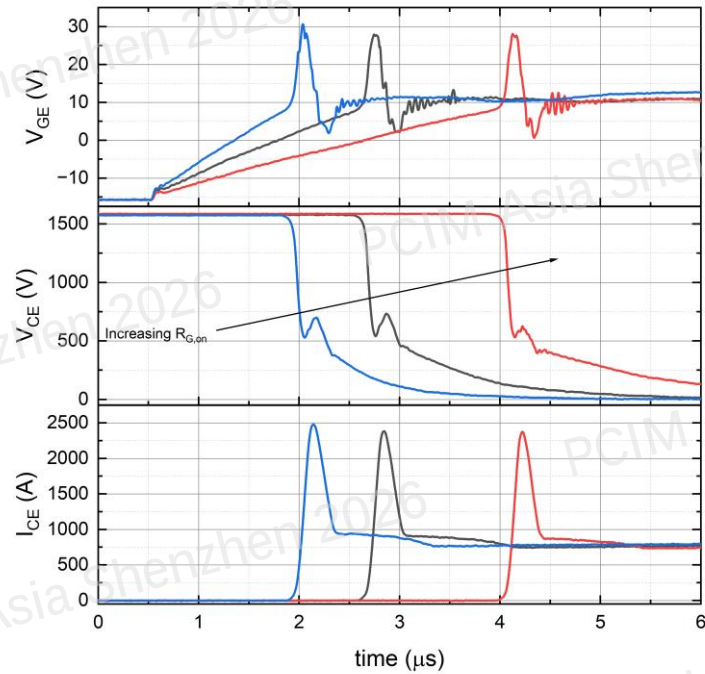
## Recovery energy vs $di/dt$



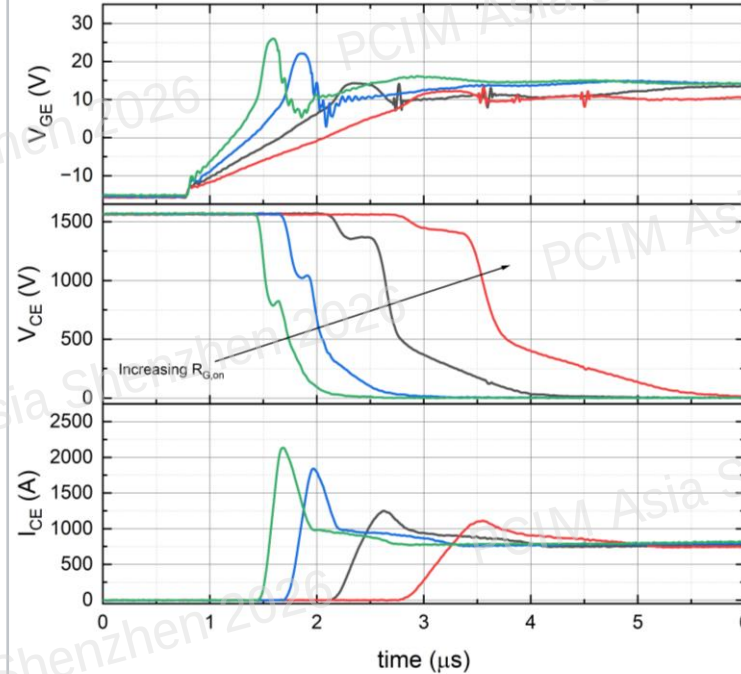
# IGBT turn-on / Diode recovery waveforms

750 A, 1500 V,  $L_g = 55$  nH, 175 °C

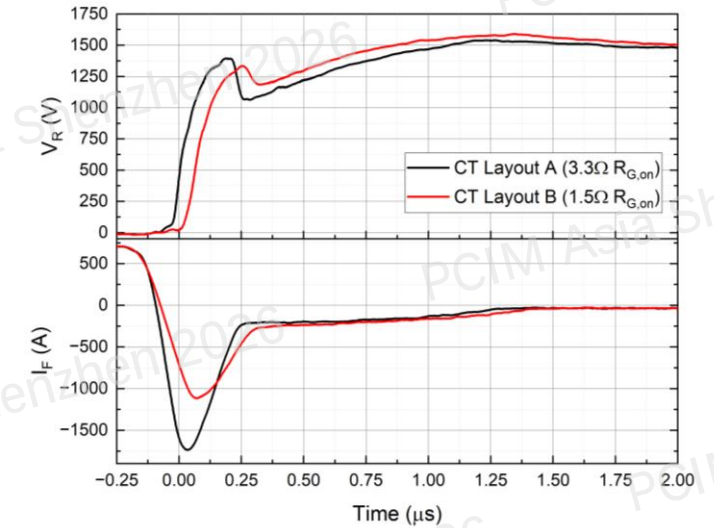
## Contact Layout A



## Contact Layout B



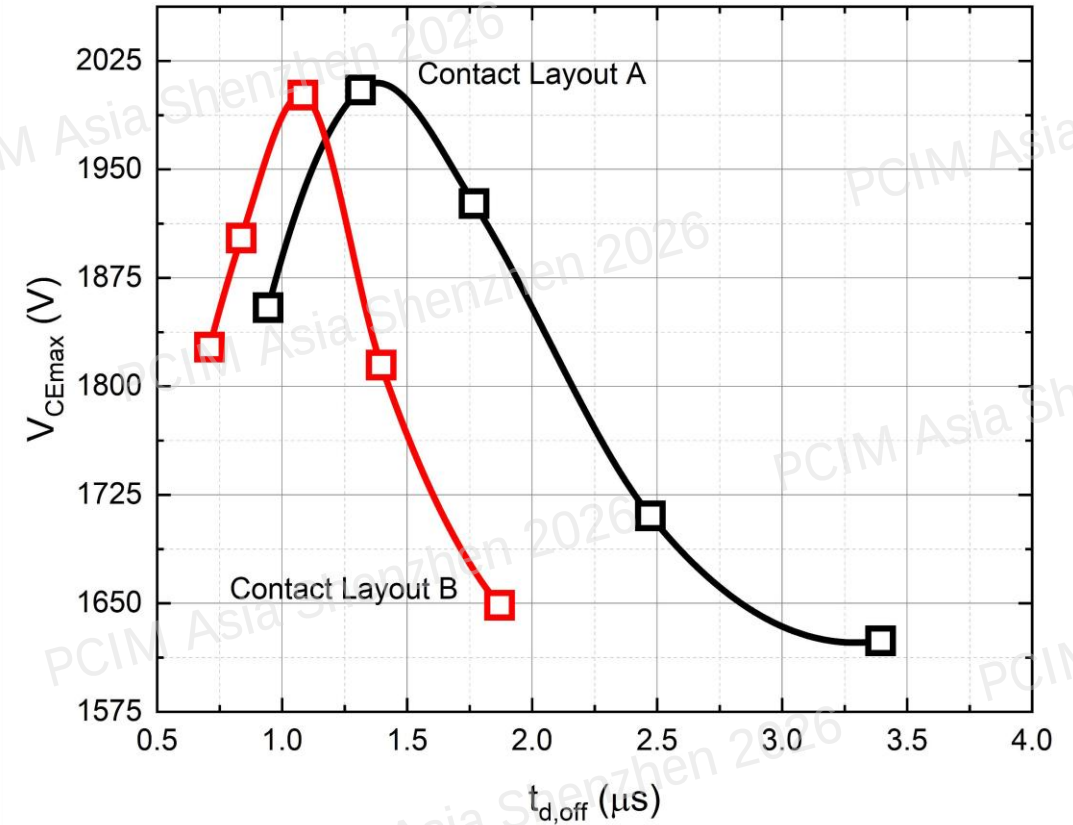
## Diode



## Turn-off controllability

1300 A, 1500 V,  $L_o = 55$  nH, 25 °C

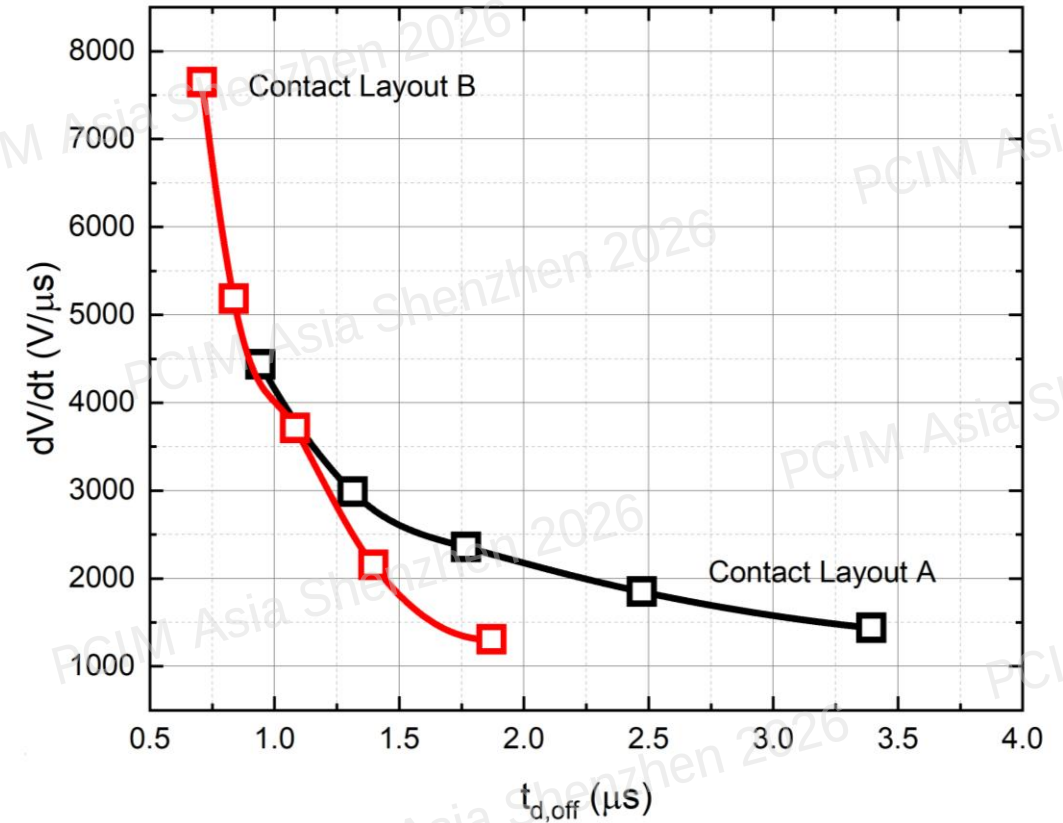
- The IGBT are switched off at elevated current condition with different gate resistors
- The overvoltage is plotted against the turn-off delay time
- Contact Layout B enables much shorter delay times for the same overvoltage



## Turn-off controllability

1300 A, 1500 V,  $L_o = 55$  nH, 25 °C

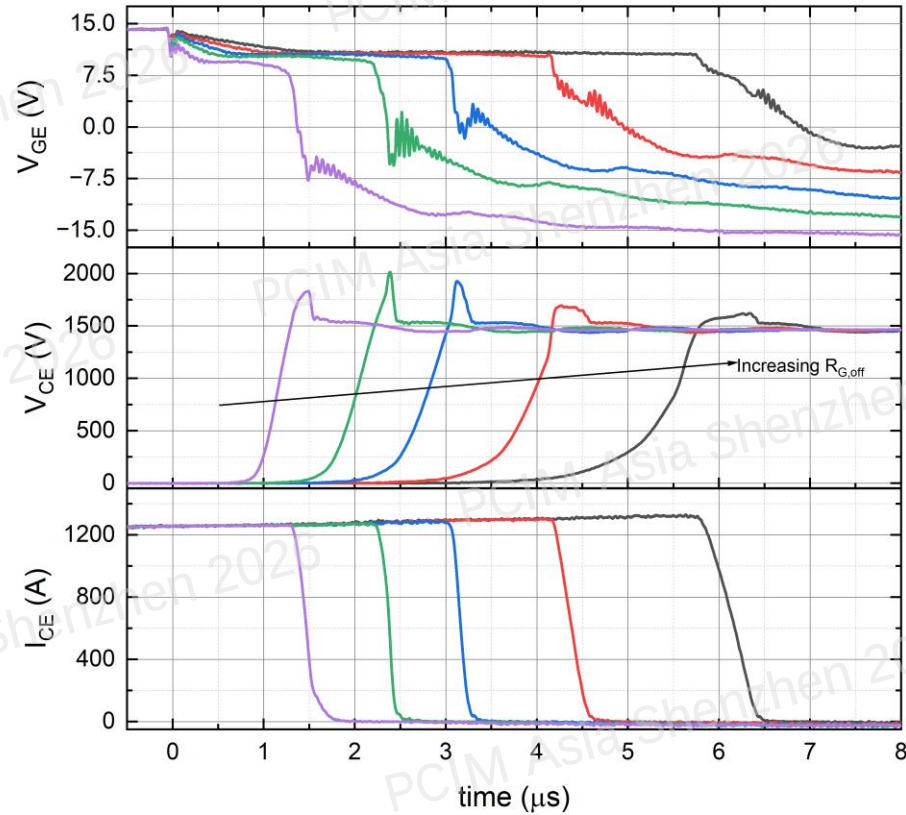
- The IGBT are switched off at elevated current condition with different gate resistors
- The  $dV/dt$  is plotted against the delay time
- Again, CT Layout B can achieve the same  $dV/dt$  as Layout A at much shorter switching times



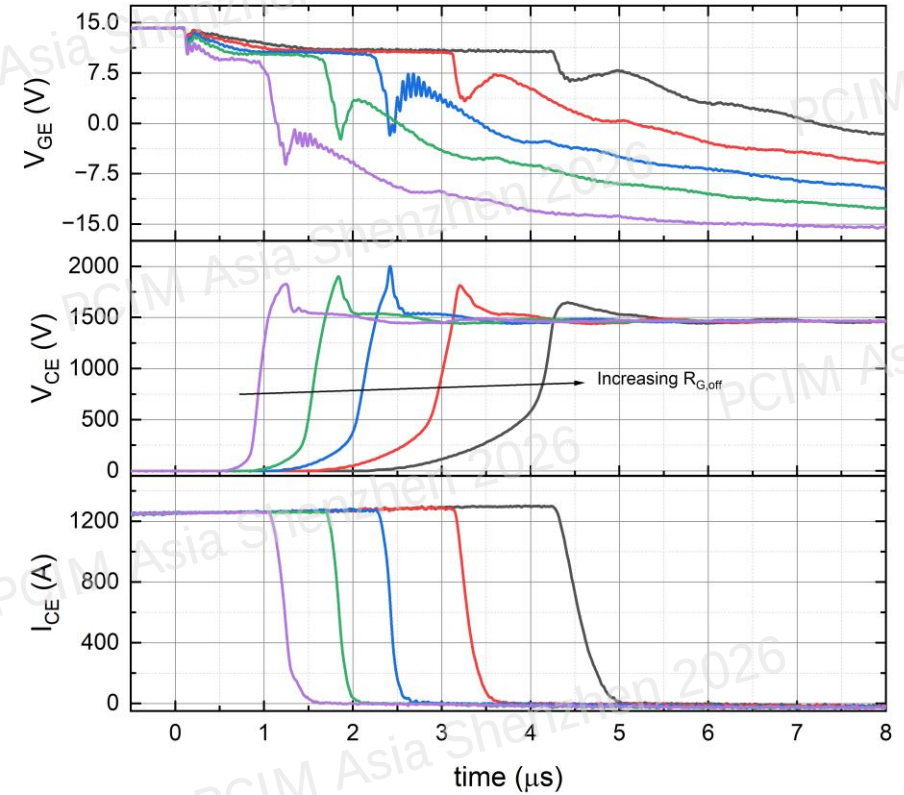
## Turn-off controllability waveforms

$I_{CE} = 1300 \text{ A}$ ,  $V_{CC} = 1500 \text{ V}$ ,  $R_{G,off} = 0.5 \dots 40 \Omega$ ,  $25^\circ\text{C}$

### CT Layout A



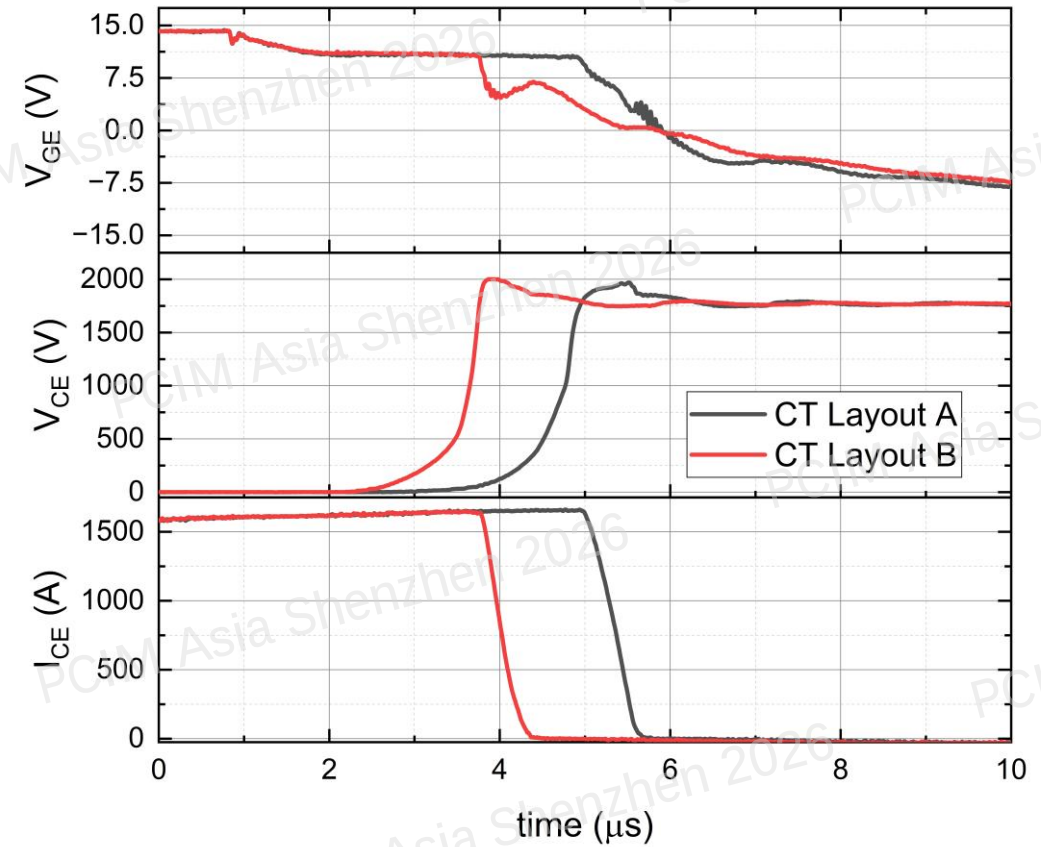
### CT Layout B



## RBSOA waveforms

$I_{CE} = 1600 \text{ A}$ ,  $V_{CC} = 1800 \text{ V}$ ,  $R_{G,off} = 18 \Omega$ ,  $25 \text{ }^{\circ}\text{C}$

- Initial RBSOA tests performed to confirm the capability
- Soft switching and controllable  $dV/dt$  at high turn-off current and DC link voltage



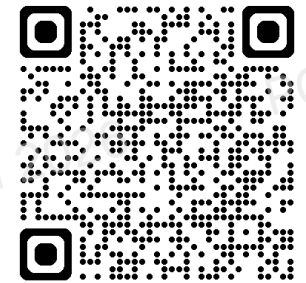
## Summary and conclusion

- Summary:

- The phaseleg XP package from SwissSEM Technologies has been introduced
- A new 2.3 kV i26 chipset has been developed and the results shown
- The XP package will be offered with a rating of 1600 A and 2300 V

- Conclusion:

- The new SwissSEM i26 chipset combines the low losses of current LV IGBTs with higher voltage blocking
- The novel chipset features class leading performance, and enables a high current module which can help simplify renewable converters
- Inquire at our booth D16 hall 16 for samples
- Check our website for detailed product information: <https://www.swiss-sem.com/product-catalogue>



**mesago**

**pcim**

# Thank you for the attention!

I'm pleased to answer your  
questions.

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Messe Frankfurt Group