

ST power transistor solutions for vehicle electrification

Power transistors in EVs



Silicon carbide MOSFETs



SiC power modules for EVs

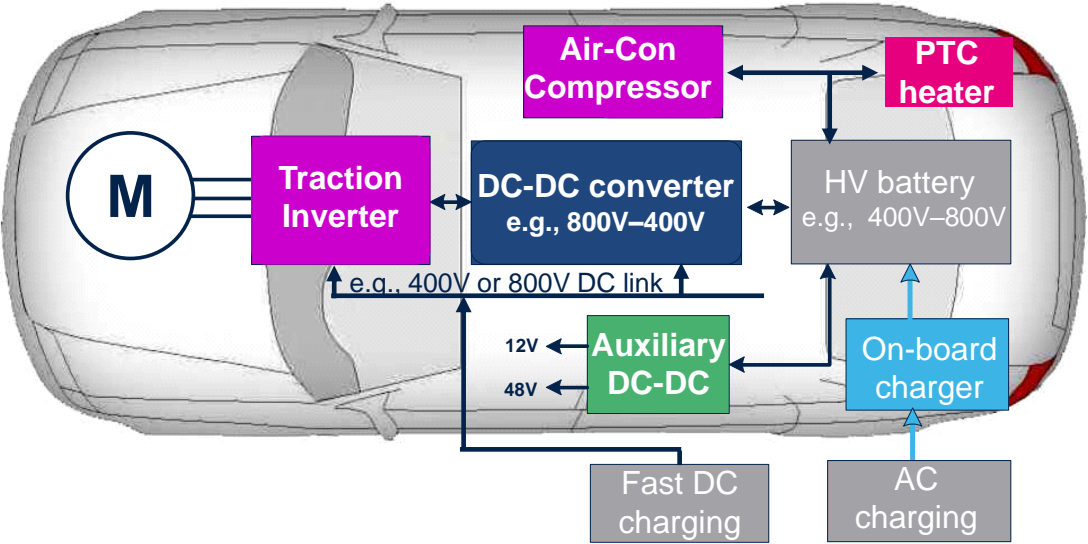


Advanced packaging technologies



Power electronics subsystem overview

HEV/EV and ecosystem overview

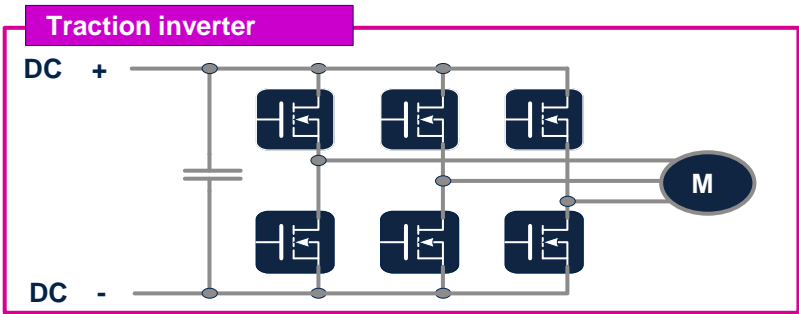


Key power technology	Focus applications
IGBT	Traction, OBC, DC-DC, PTC heater and air-con
SiC MOSFET	Traction, OBC, and DC-DC converter
HV Si MOSFET	OBC, DC-DC converter, and exploring traction inverter
Power GaN	OBC and DC-DC converter
PM and IPM	Traction, OBC, DC-DC converter and air-con

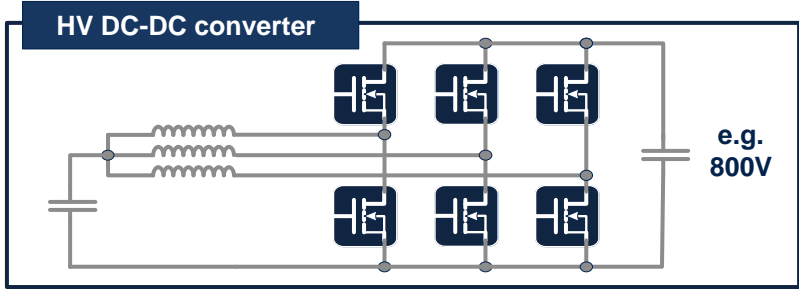
PM = power module, IPM = intelligent power module

Main power electronics subsystems

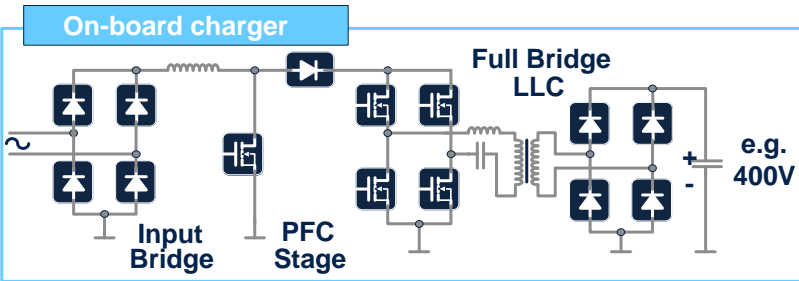
Key points



Increase traction inverter efficiency



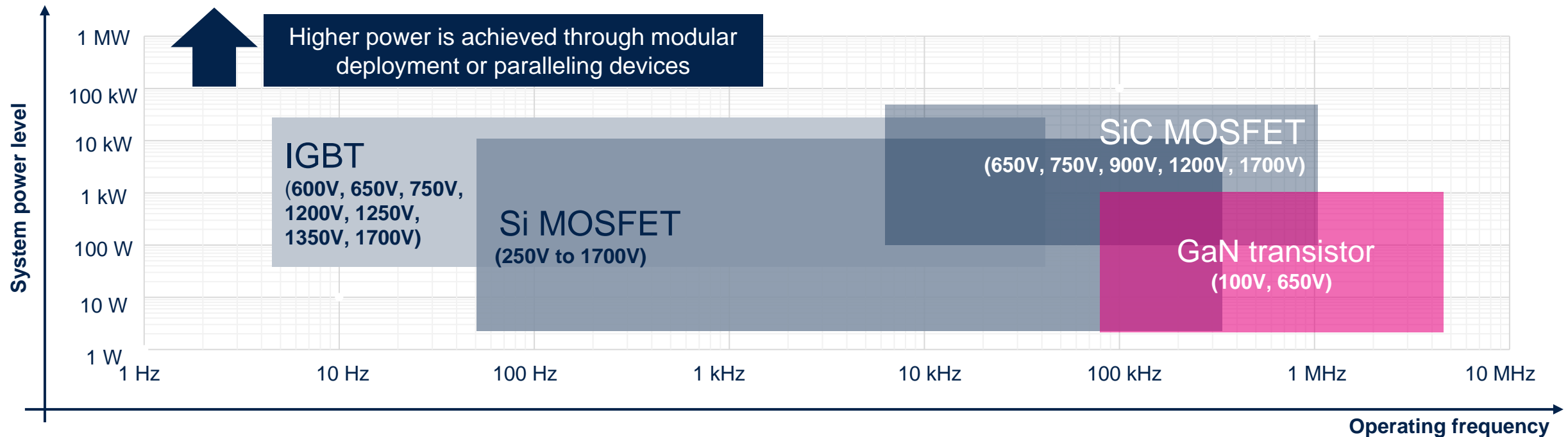
Minimize conduction and switching losses



Speed-up system charging time



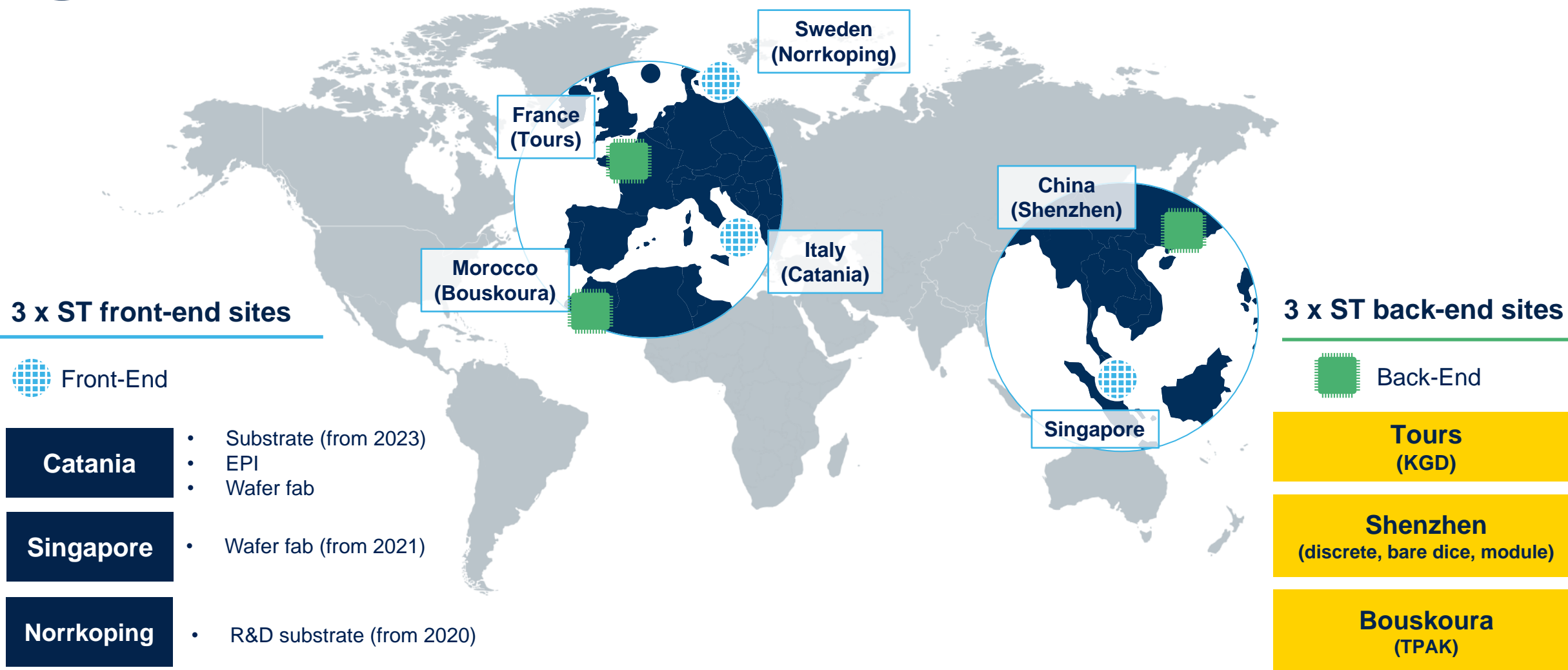
High voltage power technologies



Technology	Features	Typical automotive applications
Si HV MOSFET	Medium-high power, high voltage, high frequency	DCDC converter, motor control, on-board charger...
IGBT	Very high power, high voltage, medium frequency	Traction inverter, heating, climate compressor, on-board charger ...
SiC MOSFET	Very high power, high voltage, frequency, and temperature	Traction inverter, High power DC/DC, on-board charger, Aux. DCDC ...
GaN transistor	Very high frequency	LiDAR, 48V/12V DCDC, on-board charger ...



ST power transistor manufacturing operations



ST silicon carbide history



25 years of SiC History
in STMicroelectronics Catania



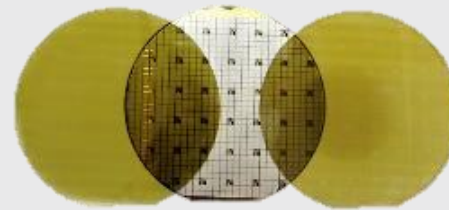
Over 70 patents

Silicon carbide was discovered by Edward G. Acheson in 1891. He named it Carborundum.

1891

1907: Phenomenon of electroluminescence was discovered using silicon carbide.

1907



1958: 1st silicon carbide conference held in Boston, USA.

1958

1966: First MOS transistor (H.R. Phillip, E.A. Taft)

1966

ST major milestones

April 1998:
1st contract on SiC with CNR-IMETEM



June 1996:
Collaboration with Physics Dept.



February 2003: ETC epitaxial reactor prototype installed in ST



May 2002: Schottky diode demonstrator (CNR line)



May 2004: Schottky diode demonstrator (ST)



October 2007: 1st Gen DIODE Start production



March 2009: Power MOSFET 3" demonstrator



May 2012: 2nd Gen DIODE Start production



June 2014: 3rd Gen DIODE Start production



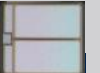
September 2014: 1st Gen MOSFET Start production



June 2017: 2nd Gen MOSFET Start production



Dec 2020: 3rd Gen MOSFET Qualification



1996

2003: 2" ST line

2006: 3" ST line

2011: 4" ST line

2016: 6" ST line

2020



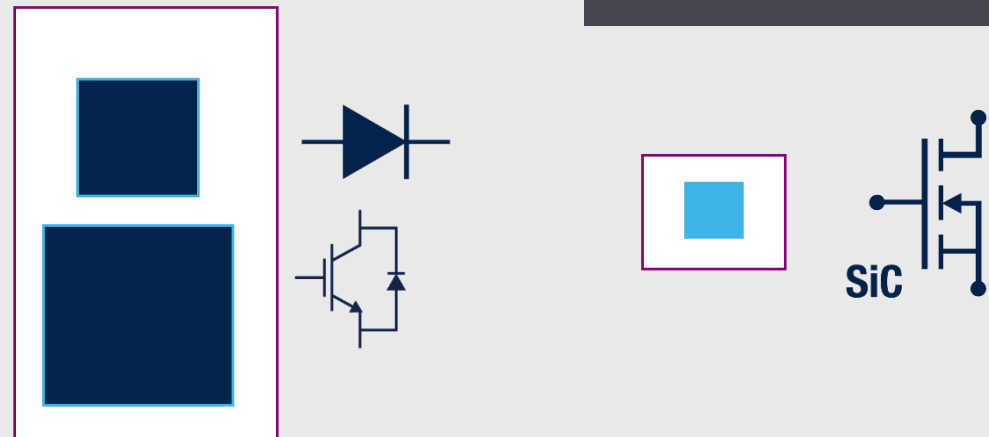
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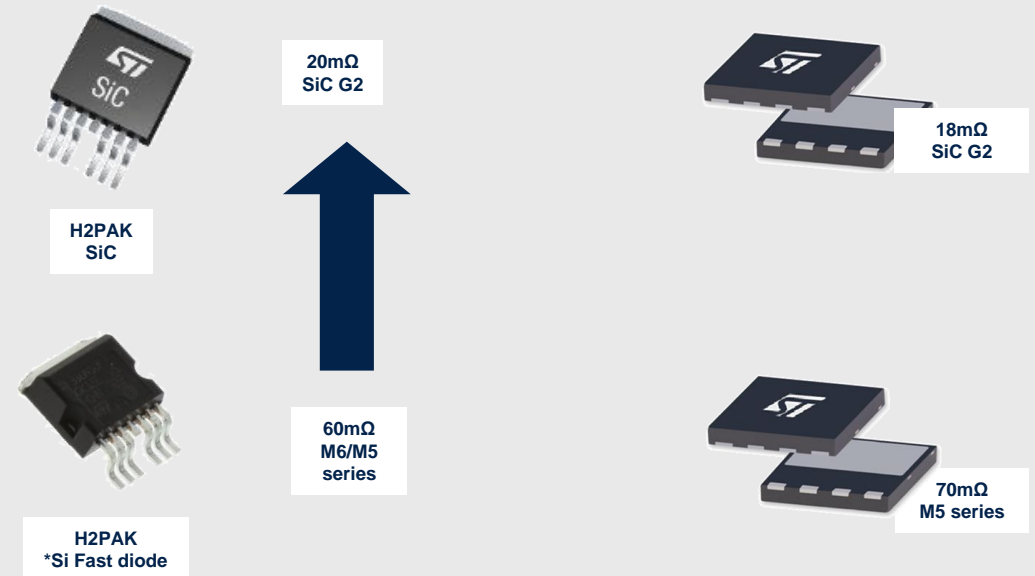


MOSFET size comparison

IGBT + diode vs SiC MOSFET

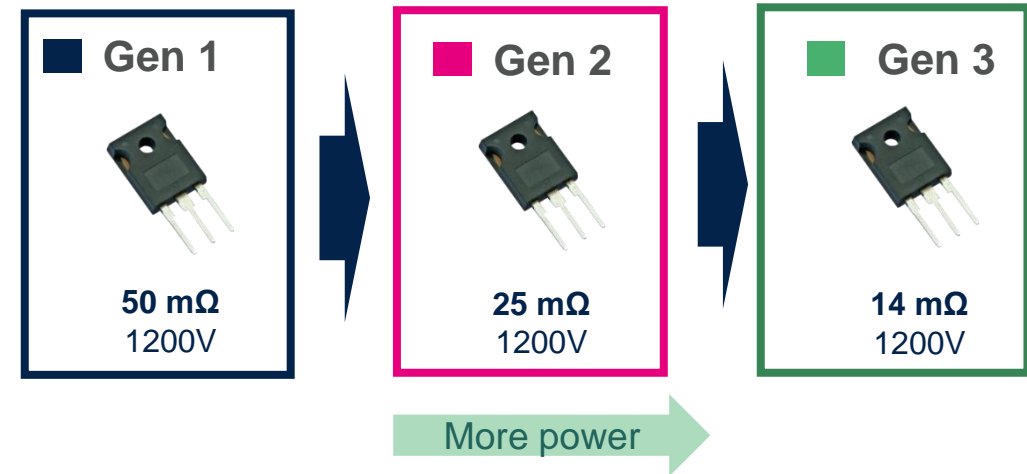
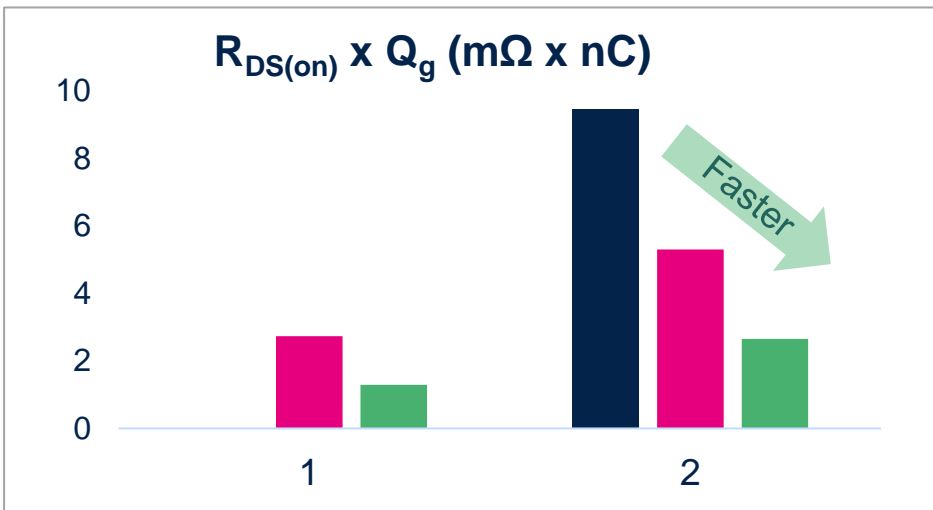
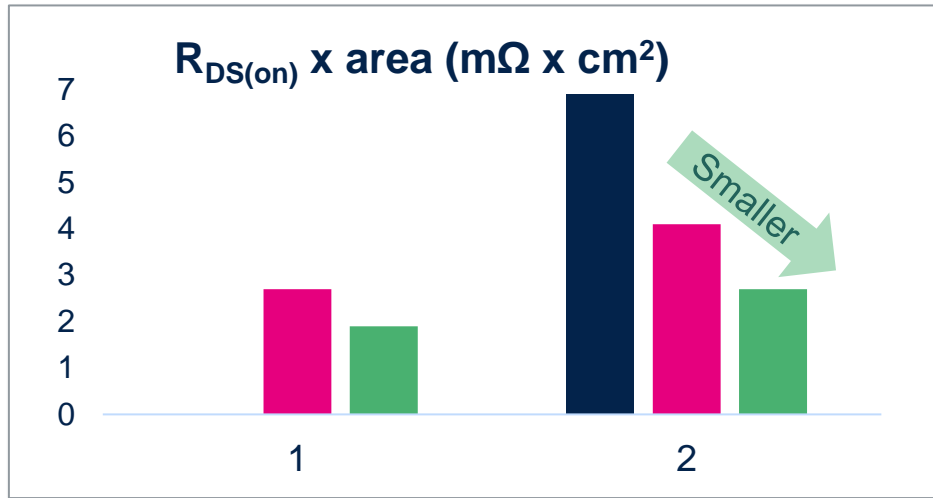


SiC vs Si MOSFET



Low Ron achievable with SiC in high voltage applications

ST SiC MOSFET figures of merit



Steady improvement over generations

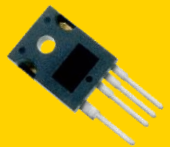
- Lower $R_{on} \times \text{area}$ → lower R_{on} in package (or same R_{on} in smaller package), higher current capability, and lower conduction losses
- Lower $R_{on} \times Q_g$ → lower switching losses, higher frequency (smaller board)



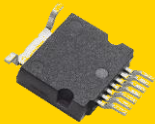
STPOWER SiC MOSFET & Diode Technologies

Market leadership in automotive
with best-in-class SiC technology

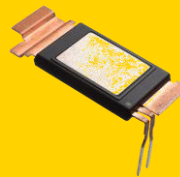
- Broad range of SiC solutions: Discrete, bare dice, module
- Proven very high reliability
- Vertical integration through Norstel AB acquisition
- Continued capacity expansion to support market demand
- Investing in advanced package technologies



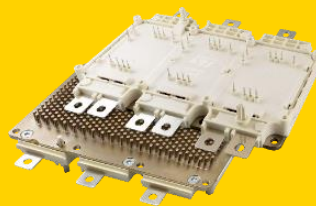
HiP247-4 leads



HU3PAK

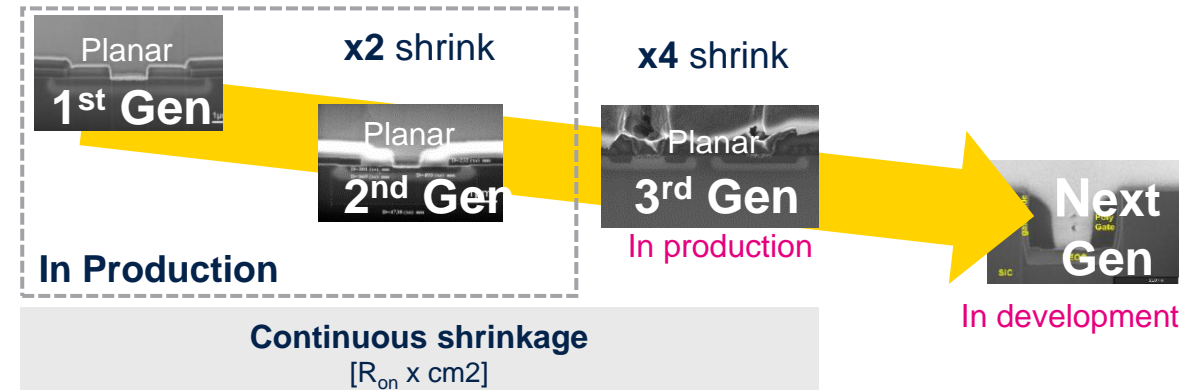


STPAK



ACEPACK DRIVE

Front-end evolution



Key advantages in automotive



Traction inverter &
On-board charger



Charging
Station



Car Weight
Reduction



Longer Range:
>600 km with SiC



Less charging time
(from 16 to 7 min)



SiC charging station
handles **2x** energy
(Fast charger: 350 kW with SiC)





STPOWER SiC MOSFET & diodes in production

The best high voltage high frequency switch for high power density applications

Gen1 SiC MOSFET: 1200V, 1700V

Gen2 SiC MOSFET: 650V, 1200V

Gen3 SiC MOSFET: 650V, 750V, 900V, 1200V

ST SiC MOSFET evolution:
steady improvement in R_{on} and switching frequency for a broad range of automotive and industrial application **increasing power density at fast pace**

Available packages



HiP247-4L
DPAK



HiP247



HiP247-LL



D2PAK- H2PAK

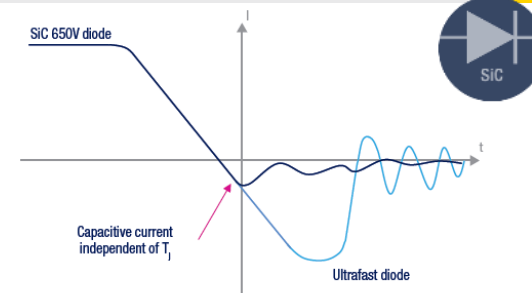


PowerFLAT



Best switching

650V & 1200V SiC diodes





Power module solutions for automotive

SLLIMM

Intelligent Power module



SLLIMM HP



ACEPACK
DMT-32



ACEPACK
SMIT

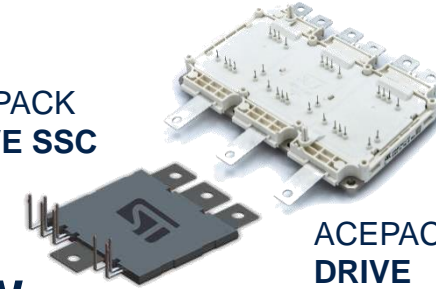


ACEPACK 1 & 2

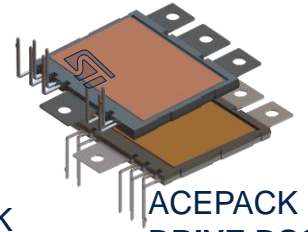


30 kW

ACEPACK
DRIVE SSC



ACEPACK
DRIVE



ACEPACK
DRIVE DSC

340 kW

5 kW

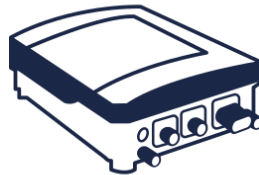
10 kW

150 kW

HVAC-on-board charger-DC-DC converter



HVAC



OBC



DC-DC
converter

Traction inverter

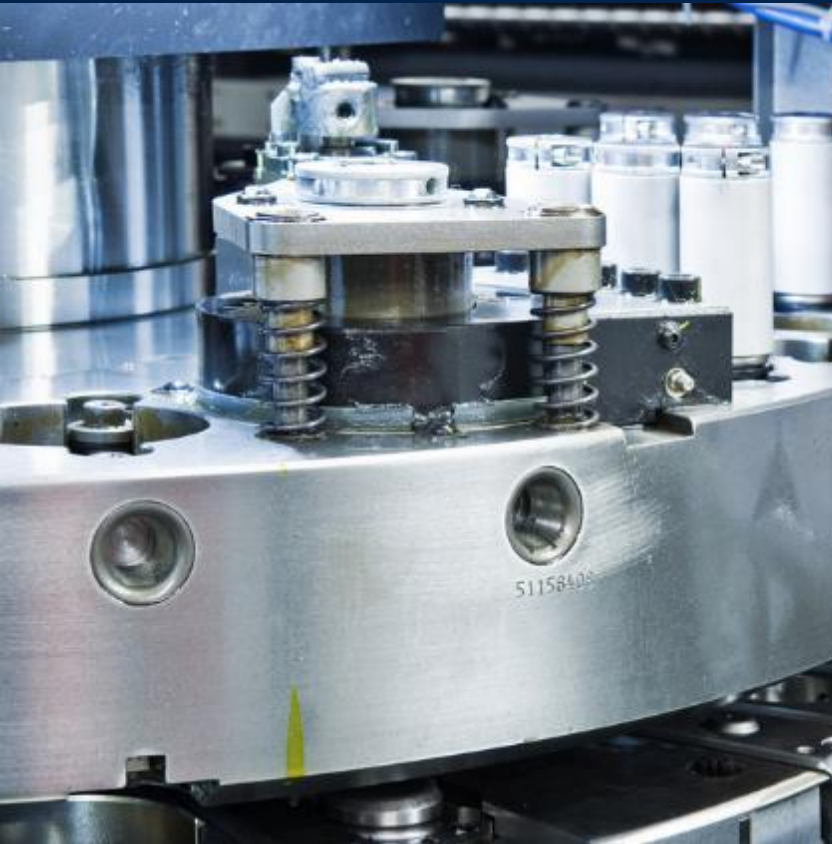


Traction
inverter



Key benefits of ACEPACK 1 & 2

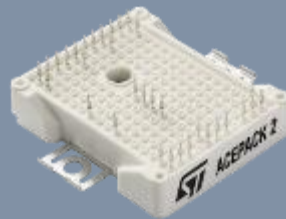
Industrial drives, motor control, UPS, and automotive EV ecosystems



ACEPACK 1 & 2



33.8 x 48 mm



48 x 56.7 mm

- Press fit and solder pin options, configuration flexibility
- Up to 1200V breakdown voltage
- Integrated screw clamps
- All power switches in a module including NTC
- Several current ratings available
- Several configurations (CIB, six-pack, ...) available
- Low stray inductance
- High reliability and robustness, miniaturized power side board occupation
- Compact design and cost-effective system approach
- Very high power density



ACEPACK Drive

Direct liquid cooled high performance power module For (H)EV, truck, and bus traction inverters

Press fit connections for high reliable
and long lasting connection

Si & SiC-MOS based, 750V & 1200V

Pin-fin for direct cooling

Dedicated NTC for each single
substrate

Unequaled $R_{DS(on)}$

ACEPACK DRIVE



Internal layout optimized for minimized stray
inductance

High reliability and robustness

Different bus bar available to fit welding or
screwing connection methods

AMB substrates for better thermal
management

Extremely high-power density

ACEPACK DRIVE for 400V battery

IGBT&Diode based

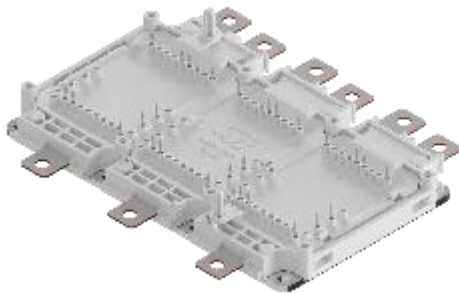


ADP660S75EM(*)

120kW

160kW

ADP820S75EM(*)



SiC MOSFET based



ADP61075W3

175kW

220kW

ADP46075W3



POWER



(*) IGBT& diode power modules to be pin-to-pin compatible to market reference

Date: May 2022 (timeline information can be subject to variations without advance notification)

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ACEPACK DRIVE for 800V battery



SiC MOSFET based



SixPack topology

SiC MOSFET Gen2 based:

For first customers electrical evaluation only

ADP300120W2-L

180kW

ADP280120W3

230kW

ADP360120W3

300kW

ADP360120W3

Power

SiC MOSFET Gen3 based:

Tailored for high-power traction inverters

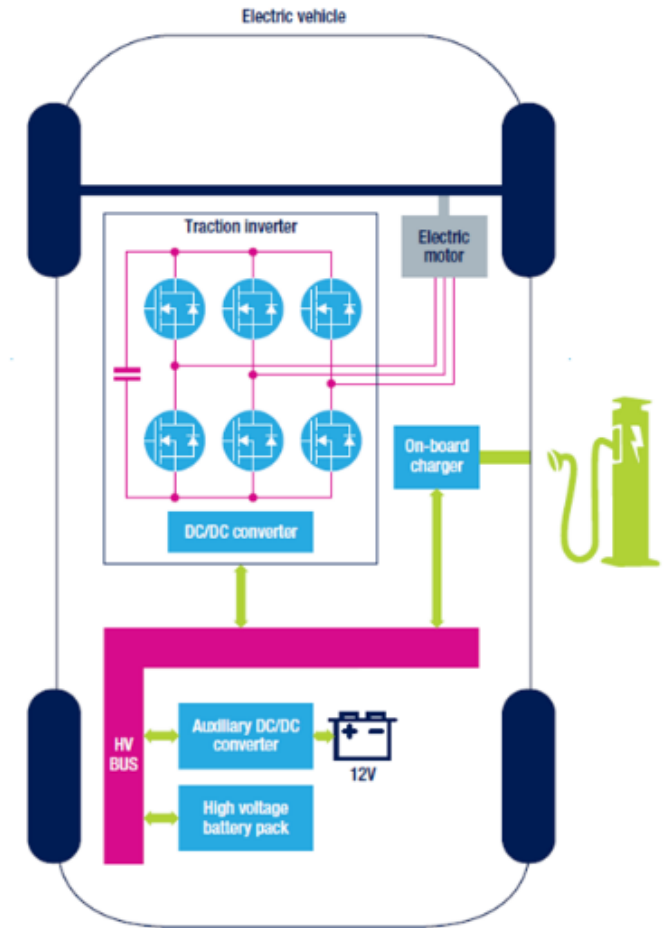
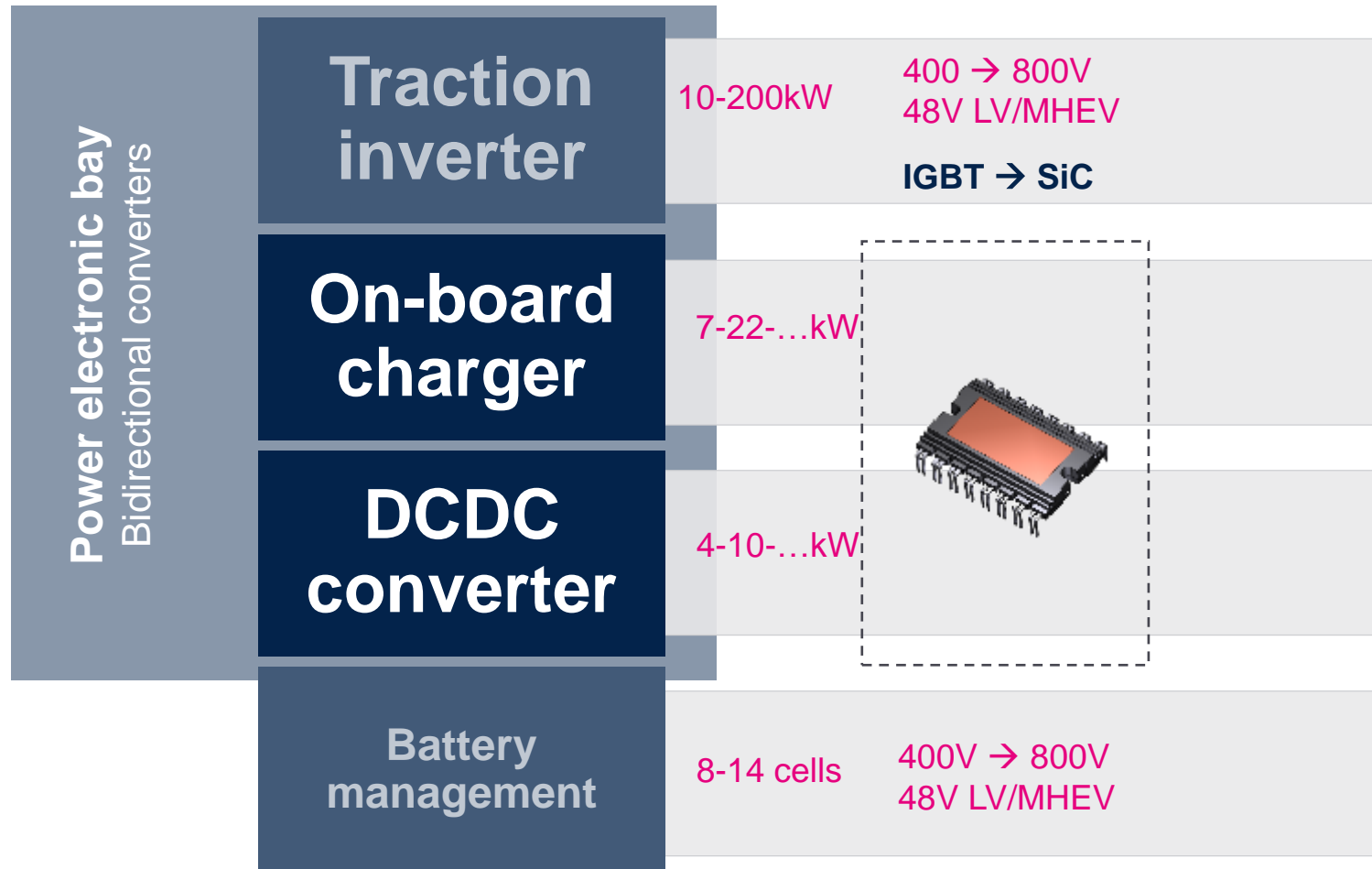


STEVAL-APD001K1 eval board for SiC-based devices

STEVAL-APD001K1 is fully compatible with ACEPACK DRIVE power press fit pins and requires a dedicated pressing tool to mount it.



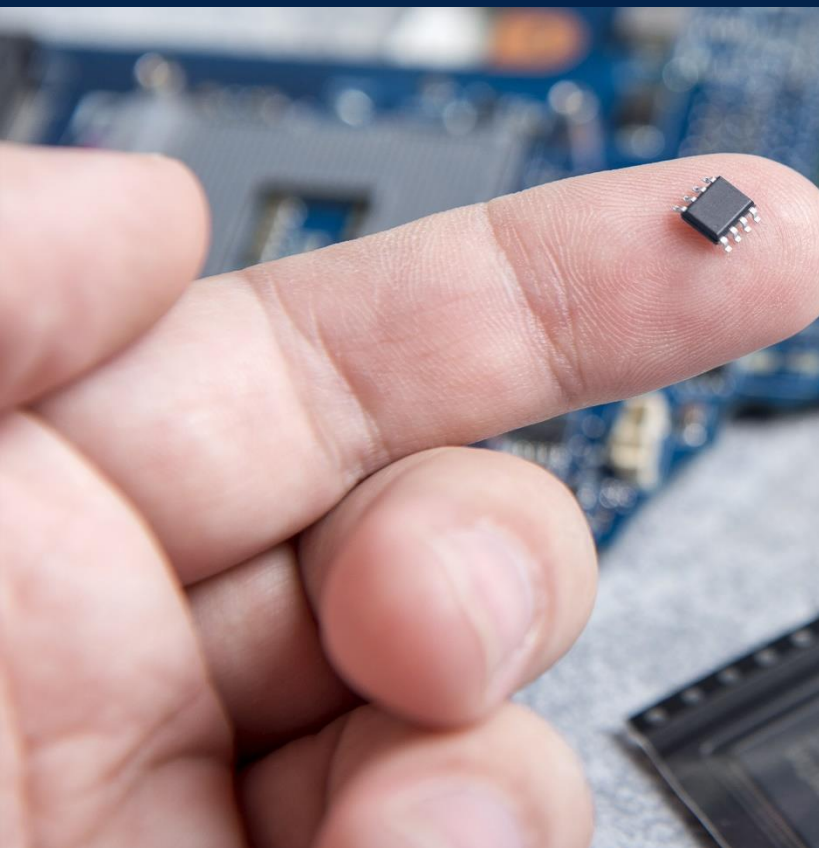
ACEPACK DMT-32 power module for electric vehicles





ST power packaging technologies

Investing in advanced package technologies



Lead-less packages

Pervasion of lead-less packages enablers for miniaturization

Leaded packages

Standard packages benefitting from economy of scale

Top side cooling SMD package

SMD packages that allow direct connection to heatsink

Multisintering package

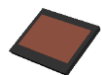
Highly reliable, high power density, sintering on heatsink

Modular package

Multipurpose configurations, high power, top side cooling

Bare die

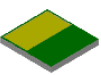
For high-temperature or customer in-house assembly



PowerFLAT



TO-LL



2SPAK



SOT223-2L



DPAK



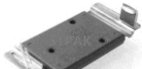
TO247-4L



H2PAK



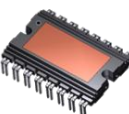
HU3PAK



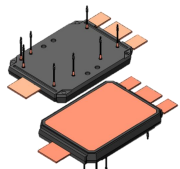
STPAK



SMITPAK



DMT-32



HB Sirius



ACEPACK 2



Tested cut/uncut
wafer



Tested dice in
T&R

