New MOSFET technologies

3rd Generation Silicon Carbide

Gallium Nitride

M9 600V to 650V Super Junction

K6 >800V Super Junction
Power semiconductor positioning vs. key applications

- **Si IGBT**
- **Si MOSFET**
- **SiC (Silicon Carbide)**
- **GaN (Gallium Nitride)**

### Key Applications
- **P_{OUT} (W)**
  - 100k
  - 10k
  - 1k

- **f_{SW} (Hz)**
  - 1k
  - 10k
  - 100k
  - 1M

- **Si IGBT**
- **Si MOSFET**
- **SiC**
- **GaN**

- **Traction Inverter**
- **DC-DC Converter**
- **Power Supply**
- **OBC**
- **Power supply & DC-DC Converter**
The best high voltage and high frequency switch for high density applications

STPOWER SiC MOSFET overview

Gen1
1200V-1700V

Very good Ron vs. Tj behavior: very suitable for motor drive applications

Gen2
650V, 1200V

Very Good Ron vs. Qg trade-off: highly suitable for a broad range of automotive and industrial applications

Gen3
650V, 750V, 900V, 1200V

An ultra-fast series with the best Ron vs. Qg trade off: highly suitable for very high frequency applications & AG qualified
SiC MOSFET advances in technology

MOSFET Figure of Merit

Steady improvement in MOSFET generations

- Lower Ron x Area $\rightarrow$ lower Ron in package (or same Ron in smaller package), higher current capability and lower conduction Losses

- Lower Ron x Qg $\rightarrow$ lower switching losses, higher frequency (reduced board)

Unrivaled $R_{DS(on)} \times A$ and $R_{DS(on)} \times Q_g$ FOM
### Breakdown Voltage

<table>
<thead>
<tr>
<th>Voltage</th>
<th>650V</th>
<th>750V / 900V</th>
<th>1200V</th>
<th>1700V</th>
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</table>

### Series

<table>
<thead>
<tr>
<th>Series</th>
<th>G2</th>
<th>G3</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G1</th>
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### On-state resistance

<table>
<thead>
<tr>
<th>Voltage</th>
<th>18 mOhm to 55 mOhm</th>
<th>14 to 55 mOhm</th>
<th>11 mOhm (750)</th>
<th>12 mOhm (1200)</th>
<th>52 mOhm to 520 mOhm</th>
<th>25 mOhm to 75 mOhm</th>
<th>8 to 69 mOhm</th>
<th>1 Ohm and 65 mOhm</th>
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### Focus Applications

**OBC & DC-DC**
- Renewable energy
- Power Supply
- Industrial drives

**Traction**
- OBC & DC-DC
- High density
  - Power Supply

**Traction Inverter**
- OBC & DC-DC
- High density
  - Power Supply

**Photovoltaic**
- Power supply

**OBC & DC-DC**
- Inverter
- Charging stations
- HF Power Supply

**Traction Inverter**
- OBC & DC-DC
  - HF Power Supply

**DC-DC**
- Power Supply
- Renewable energy
# SiC MOSFET package roadmap

<table>
<thead>
<tr>
<th>Package</th>
<th>PowerFLAT 8x8 STD &amp; DSC</th>
<th>H2PAK-7L</th>
<th>HU3PAK</th>
<th>ACEPAK SMIT</th>
<th>HiP-247 (3 &amp; 4 leads)</th>
<th>STPAK</th>
<th>Bare Dice</th>
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<tbody>
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<td>Special Package Solutions</td>
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## Characteristics

- **Very Thin (< 1mm)**
- **Well accepted in power conversion**
- **Dual side cooling option**
- **Leadless**
- **Industrial domain**

### PowerFLAT 8x8 STD & DSC

- AG qualified at 175dC
- Kelvin Source for optimized driving
- High runner for Automotive customers

### H2PAK-7L

- AG qualified at 175dC
- **Top side cooling**
- Kelvin Source for optimized driving
- Very good thermal dissipation

### HU3PAK

- AG qualified at 175dC
- **Isolated Top side cooling**
- Suitable for different configurations (HB, Dual die, etc.)
- High Power
- Modular Approach

### ACEPAK SMIT

- AG qualified at 200dC
- **Very common Industry standard**
- Kelvin Source option for optimized driving
- High creepage version (1700V) in development
- High Power
- Modular Approach

### HiP-247 (3 & 4 leads)

- AG qualified at 200dC
- **Very common Industry standard**
- Kelvin Source option for optimized driving
- High creepage version (1700V) in development
- High Power
- Modular Approach

### STPAK

- Unique Solution for traction Inverter
- AG qualified at 200dC
- **Very High thermal dissipation efficiency**
- Sense pin for optimized driving
- Multi-sintered package

### Bare Dice

- WLBI & KGD T&R or RWF options
- Compliant with the most stringent Automotive Quality Requirements
ST GaN technologies platforms

From EXAGAN acquisition
- 8-inch wafers GaN-on-Si
- Normally-off structure based on Cascode approach
- 650V & 900V technologies
- GaN power discrete & Integrated with Silicon technologies

From TSMC Partnership
- 6-inch wafers GaN-on-Si
- 100V & 650V Normally-off structure based on p-gate (p-GaN) process
- 100V & 650V GaN-on-Si process
- GaN Power Discrete & GaN IC platform

From CEA-Leti Partnership
- 8-inch wafers GaN-on-Si
- 650V Normally-off structure based on recessed approach
- 100V Normally-off structure based on p-gate (p-GaN) process
- GaN Power Discrete

• Partnership with TSMC to accelerate the GaN qualification and to guarantee a strong manufacturing capability.

• CEA-Leti partnership and Exagan acquisition aim to create an ST GaN ecosystem with the final goal to get an ST proprietary technology (100V & 650V e-Mode)
**STPOWER GaN**

**PowerGaN product family overview**

**GaN: a serious contender of Silicon in power conversion applications**

**G-FET**
650V D-MODE

- Very fast, ultra-low Qrr, **robust GaN cascode FET** with **standard silicon gate-drive** for a wide range of power.

**G-HEMT**
650V and
100 V E-MODE

- Ultra-fast, **zero Qrr** e-mode HEMT, easily parallelable, well suited for **very high frequency** and power **applications**.

**G-DRIVE**
650V D-MODE

- Ultra-fast GaN switch with **embedded gate drive** to simply board design and minimize parasitic inductance.

(**) For industrial application only
PowerGaN product portfolio overview

**G-FET™**

- **650V**
  - Rds(on) typ - mΩ: 25, 35, 190, 250

- **900V **
  - Rds(on) typ - mΩ: 50, 75, 220

- TO-247, PQFN 8x8 BSC, PQFN 5x6 BSC, LFPAK 12x12 TSC

- For first prototypes only

**G-HEMT™**

- **100V**
  - Rds(on) typ - mΩ: 1.2, 1.8, 2.6

- **650V**
  - Rds(on) typ - mΩ: 16, 22, 30, 42, 80

- LFPAK 8x8 TSC, PowerFLAT8x8 DSC, 2SPAK PowerFLAT5x6 TSC, PQFN 8x8 BSC

**G-DRIVE™**

- **650V**
  - Rds(on) - mOhm: 75, 135, 190

For industrial application only

*) = ES H2-2023
### Packages for PowerGaN

<table>
<thead>
<tr>
<th>Package</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| QFN 5x6 / PowerFLAT 5x6 | 1mm max thickness  
Fixed form factor  
Well accepted in power conversion  
Easy to drop in vs standard solution |
| 2SPAK                 | 0.585mm max thickness  
Form factor tailored to the die  
No wires  
Kelvin Source for optimized driving  
Top side cooling technology  
Die attach on cavity lead frame  
Available in 5.9x7.9 mm² and 6x6.4 mm² |
| PowerFLAT 8x8 DSC     | 0.77mm max thickness  
Fixed form factor  
No wires. Flip chip die technology  
Kelvin Source for optimized driving  
Dual side cooling technology |
| LFPAK 8x8 / 12x12 TSC | Exposed metal on top side  
Low package profile  
Cu clip technology  
Lower operating temperature  
8*8 G-Hemt  
12*12 G-Fet |
The most complete product portfolio for High power and efficiency systems

- Best $R_{\text{DS(on)}} \times \text{area}$
- Step forward in Hard switching and Soft switching
- DM9 FAST diode embedded version available
- Wide product portfolio

**Why choose M9/DM9?**

- Only one technology for hard (PFC) and soft switching (LLC)
- Higher power level and better efficiency with the same packages
- Increasing power density providing smaller packages
- Improved system ruggedness applying new production processes
- Better electrical parameters, giving more safety to the system
STPOWER MOSFET M9/DM9 main features

Reliability
- Increasing Humidity ruggedness
- Increasing mechanical performances
- Increasing the guard band

Process
- Reduced BVdss spread <70V
- Reduced Vth spread <1V
- Ruggedness (UIS test)

Robustness
- Static dv/dt up to 120V/ns
- Dynamic dv/dt up to 50V/ns (M9)
- Dynamic dv/dt up to 120V/ns (DM9)

- Worldwide best $R_{ds(ON)}$ per area
- Suitable for Hard switching topologies
- Best choice for Resonant high power density system
Superjunction MDmesh M9 vs M5 $R_{DSon}$ comparison

Main packages comparison

<table>
<thead>
<tr>
<th>Package Type</th>
<th>MDmesh M9</th>
<th>MDmesh M5</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO-220</td>
<td>220</td>
<td>63</td>
<td>-32%</td>
</tr>
<tr>
<td>TO247</td>
<td>150</td>
<td>45</td>
<td>-28%</td>
</tr>
<tr>
<td>PowerFLAT 8x8 HV</td>
<td>69</td>
<td>23</td>
<td>-26%</td>
</tr>
<tr>
<td>DPAK</td>
<td>29</td>
<td>44</td>
<td>-36%</td>
</tr>
</tbody>
</table>

*$m\Omega$ values

Wider product range

- **34** P/N (M9) 650V - **10** packages
- **27** P/N (M9) 600V - **8** packages
- **32** P/N (DM9) 450V/600V/650V Automotive Grade
- **48** P/N (DM9) 600V/650V Industrial Grade

- 23 mΩ
- 33 mΩ
- 44 mΩ
- 45 mΩ
- 150 mΩ
- 630 mΩ

Best 650V in TO247
Best 650V in TO-LL
Best 650V PF 8x8
Best 650V in TO220
Best 650V in DPAK
Best 650V PF 5x6
High Voltage power MOSFETs
Current Mature Package

ACEPACK SMIT package
- Top side cooling package
- Several topologies can be realized
- Very high thermal dissipation
- Kelvin source pin enables higher efficiency
- Automotive grade

HU3PAK package
- Top side cooling package
- Higher creepage distance
- Very high thermal dissipation
- Kelvin source pin enables higher efficiency
- Automotive grade

TO-LL package
- Compactness
- Higher power density
- Reliability at high VDSS rating
- Kelvin source pin enables higher efficiency
High performing super-junction very high voltage MOSFETs technology to boost efficiency

Very high voltage range > 800V

$R_{DS(on)}$ and $BV_{dss}$ with the right mix to reach high efficiency and compactness

Increased Power Density with better $R_{DS(on)} \times$ area
MDmesh K6 - Key Features

Benefits:
• More compactness solution
• Height board reduction

Benefits:
• Lower driving voltage
• Idle reduced losses
• Tighter tolerance

Benefits:
• Higher efficiency
• Lower power losses

Gate Charge comparison

-60%
MDmesh product plan - K6 800V

Best 800V in DPAK

- 220 mΩ
- 340 mΩ
- 450 mΩ
- 600 mΩ

Best 800V in SOT223-2L

- 4.5 Ω

Package options

- SOT223-2L
- DPAK
- IPAK
- D2PAK
- TO-220
- TO-220FP

Street Lighting
Outdoor Lighting
Indoor Lighting
Adapter

15W – 200W

5W – 15W

Indoor Lighting
Adapter