Power Modules Packaging Technologies & Market

May 28th – ECTC 2012

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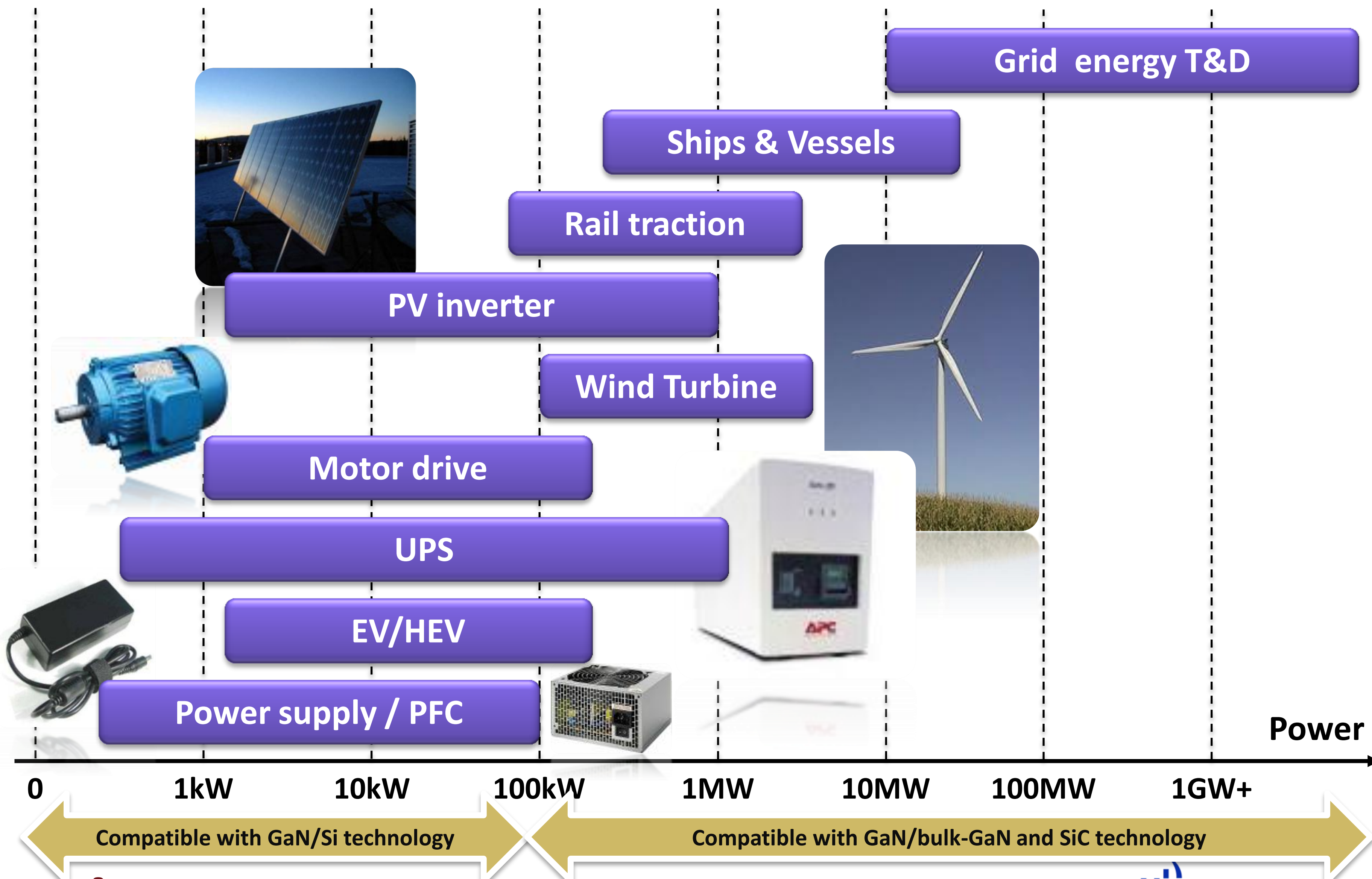
Power is everywhere !

Power Range of the targeted applications



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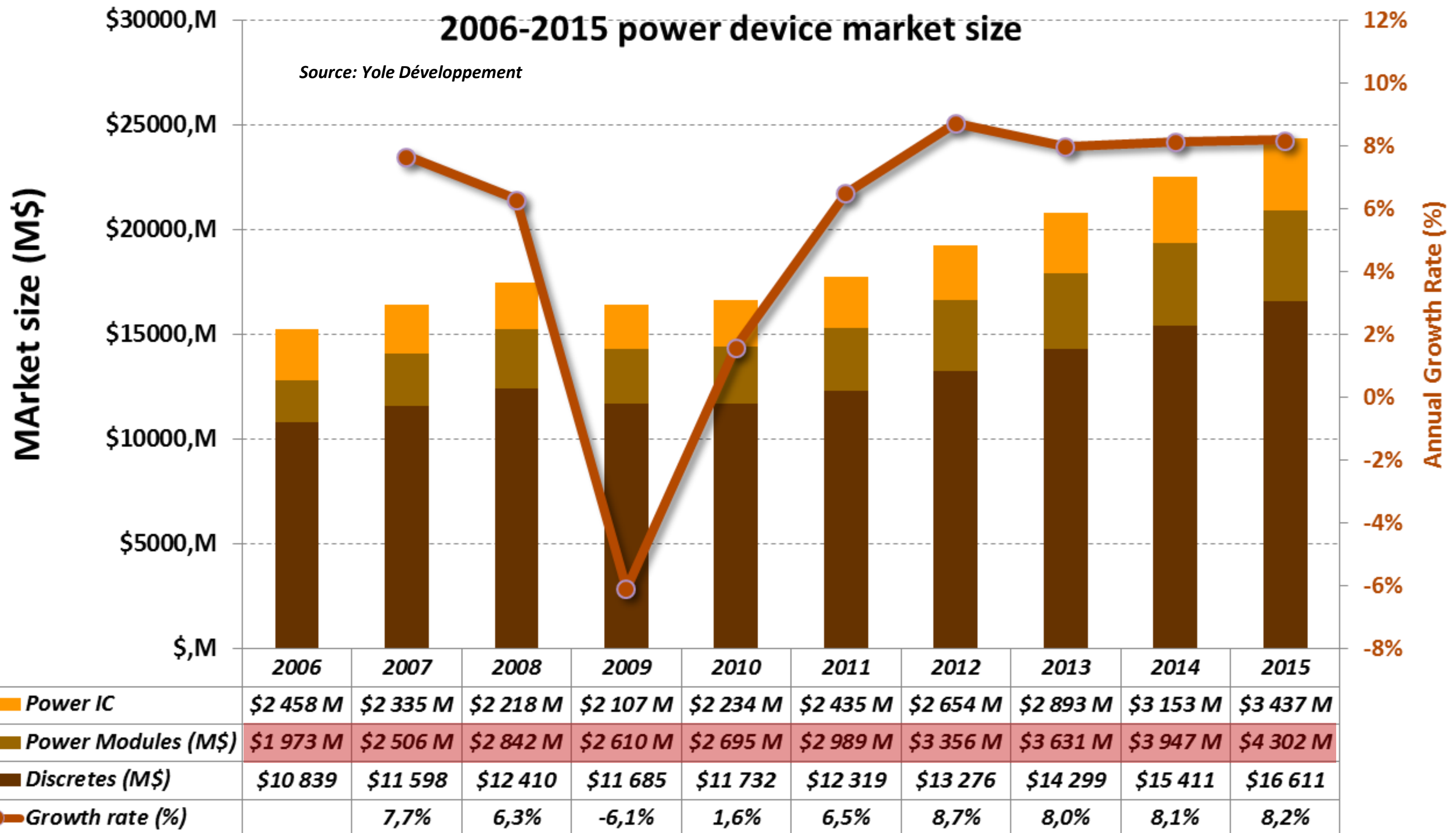
Power Electronics Market

Breakdown by device type (M$)



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Power IC	*$2 458 M*	*$2 335 M*	*$2 218 M*	*$2 107 M*	*$2 234 M*	*$2 435 M*	*$2 654 M*	*$2 893 M*	*$3 153 M*	*$3 437 M*
Power Modules (M$)	*$1 973 M*	*$2 506 M*	*$2 842 M*	*$2 610 M*	*$2 695 M*	*$2 989 M*	*$3 356 M*	*$3 631 M*	*$3 947 M*	*$4 302 M*
Discretes (M$)	*$10 839*	*$11 598*	*$12 410*	*$11 685*	*$11 732*	*$12 319*	*$13 276*	*$14 299*	*$15 411*	*$16 611*
Growth rate (%)		*7,7%*	*6,3%*	*-6,1%*	*1,6%*	*6,5%*	*8,7%*	*8,0%*	*8,1%*	*8,2%*

- Power discretes = MOSFET, rectifier, IGBT, Bipolar….
- Power modules = IGBT, diode or MOSFET modules, IPM
- Power IC = power management IC: mainly voltage regulators (POL) and drivers

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Power Electronics Value Chain

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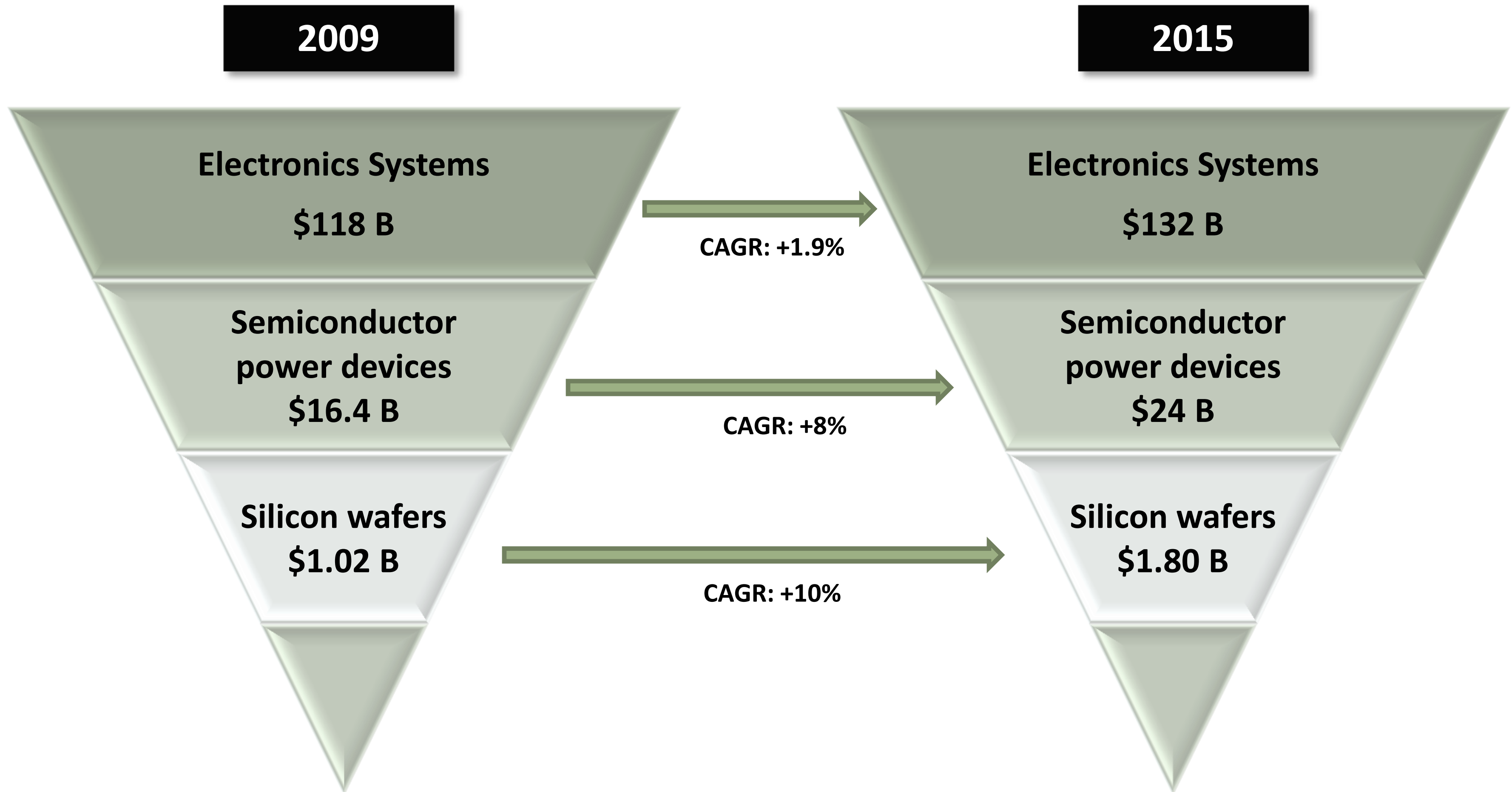

Source: SIA + SEMI + Yole

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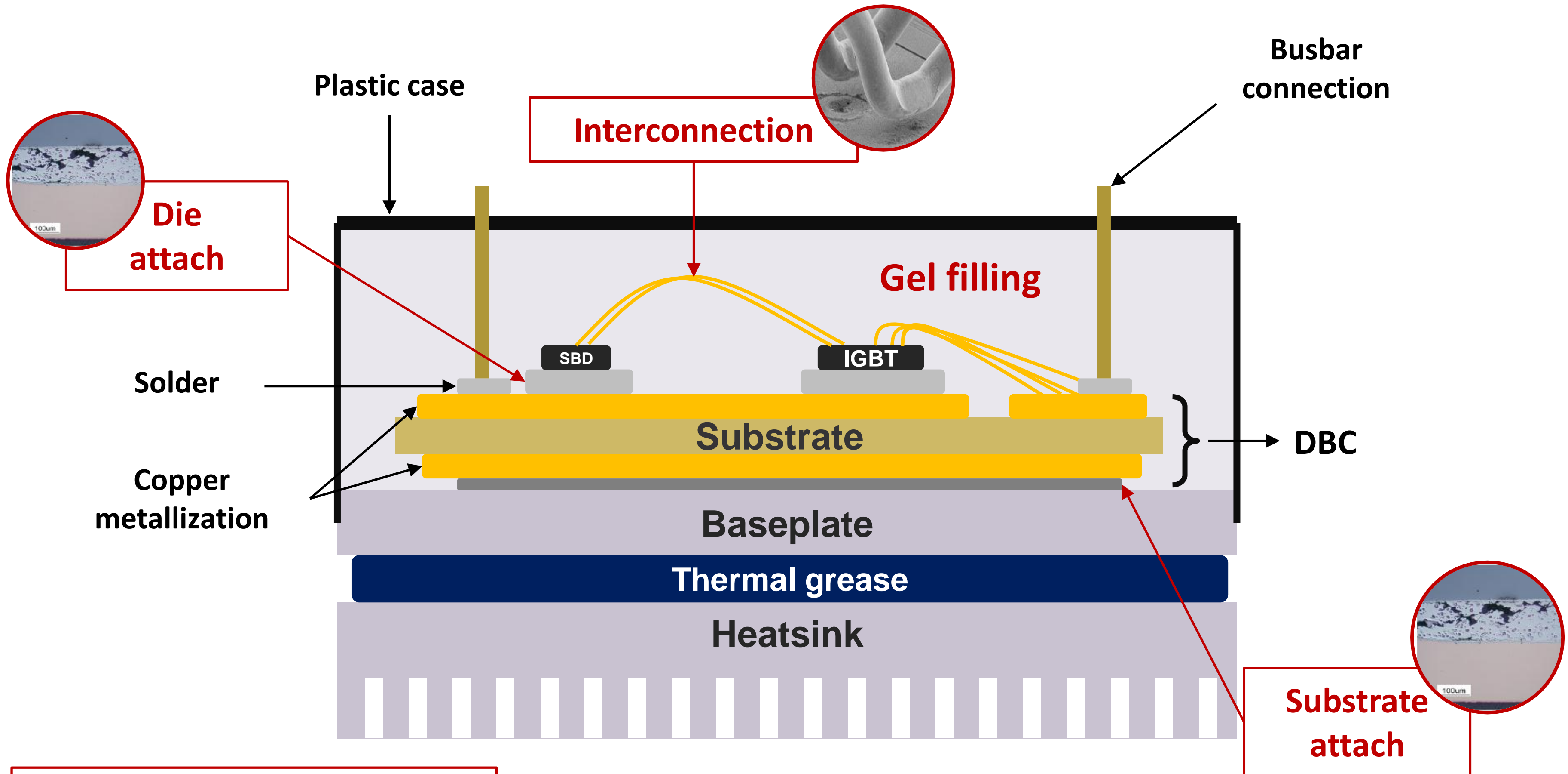
Introduction to power module packaging

- Common failure in a power module is caused by thermal cycling
- Mismatching CTE make layers to detach one from the other
- Some gel filling also cannot handle high temperature



In red: Common failure locations

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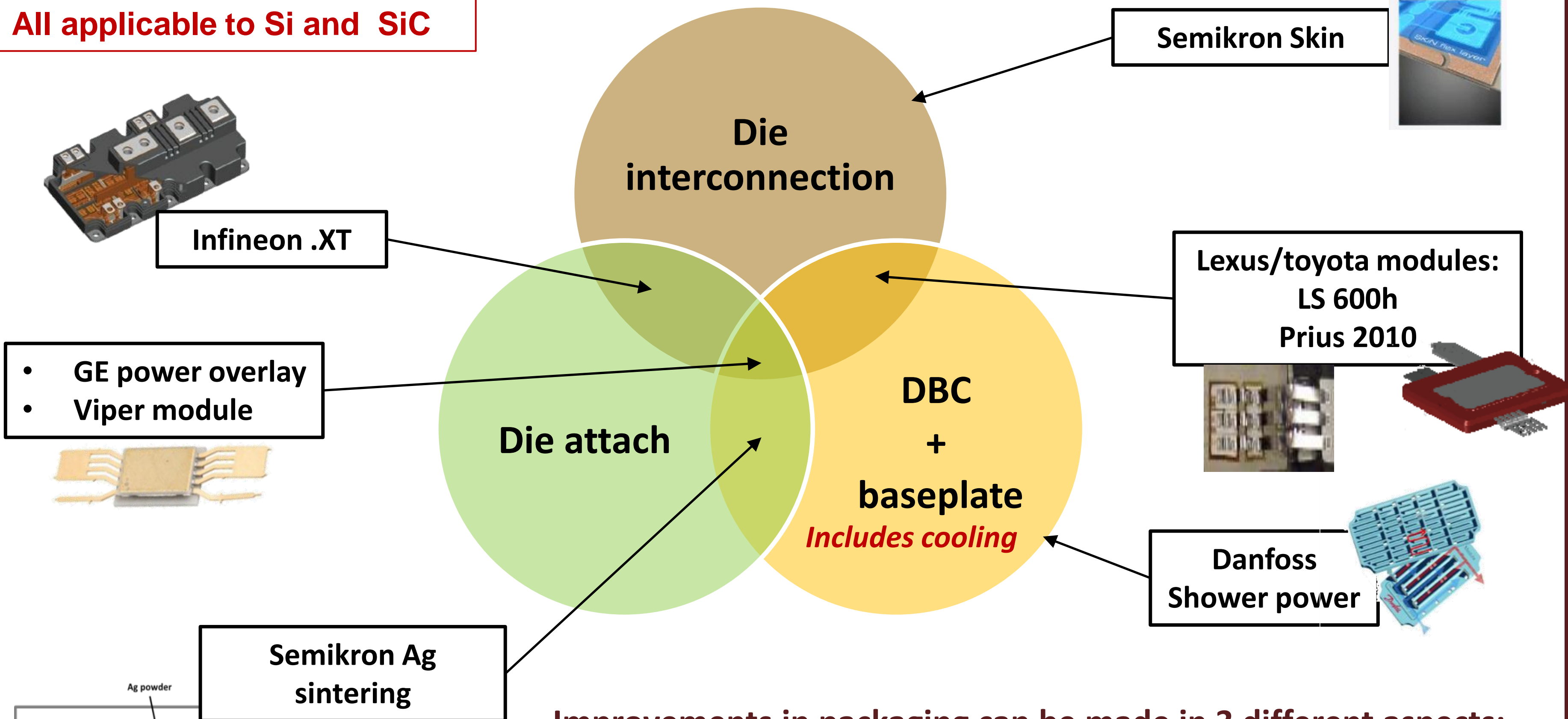
Improvement aspects in packaging

All applicable to Si and SiC



Improvements in packaging can be made in 3 different aspects:

- **Die interconnection,** which is searching for innovative wire bonding or no-wires connection for better lifetime and reliability
- **Die attach**, which uses new materials for better lifetime
- **DBC+baseplate**, which uses new materials and suppress layers for improved cooling and smaller size

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Analysis of innovation trends in packaging for power modules

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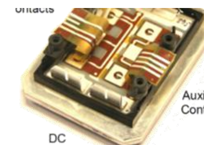
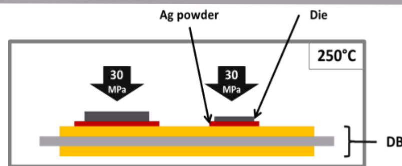
	Current solutions *Widely used by all players*	*Emerging technos* *At mass production and growing in market shares*	*Potential breakthrough* *At R&D stage. Still too expensive*
Interconnection	 Al wire bonding	Al ribbon bonding Copper wire bonding	 Foil sintering Foil ultrasonic wedge bonding
Die attach	Pb/Sn alloy Or SAC alloy	 Silver micro powder sintering	Nano powder sintering (no heating and pressure for attach process)
Baseplate Cooling	Baseplate + heatsink AlSiC for long lifetime Al_2O_3 for cost	**Thermal exchange improvements:** • Shower power • DBC to heatsink (no baseplate) 	 Micro-channel cooling

DBC on both sides:
flip chip
+ Sintering on both sides
+Cooling on both sides

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Power module packaging trend in EV/HEV

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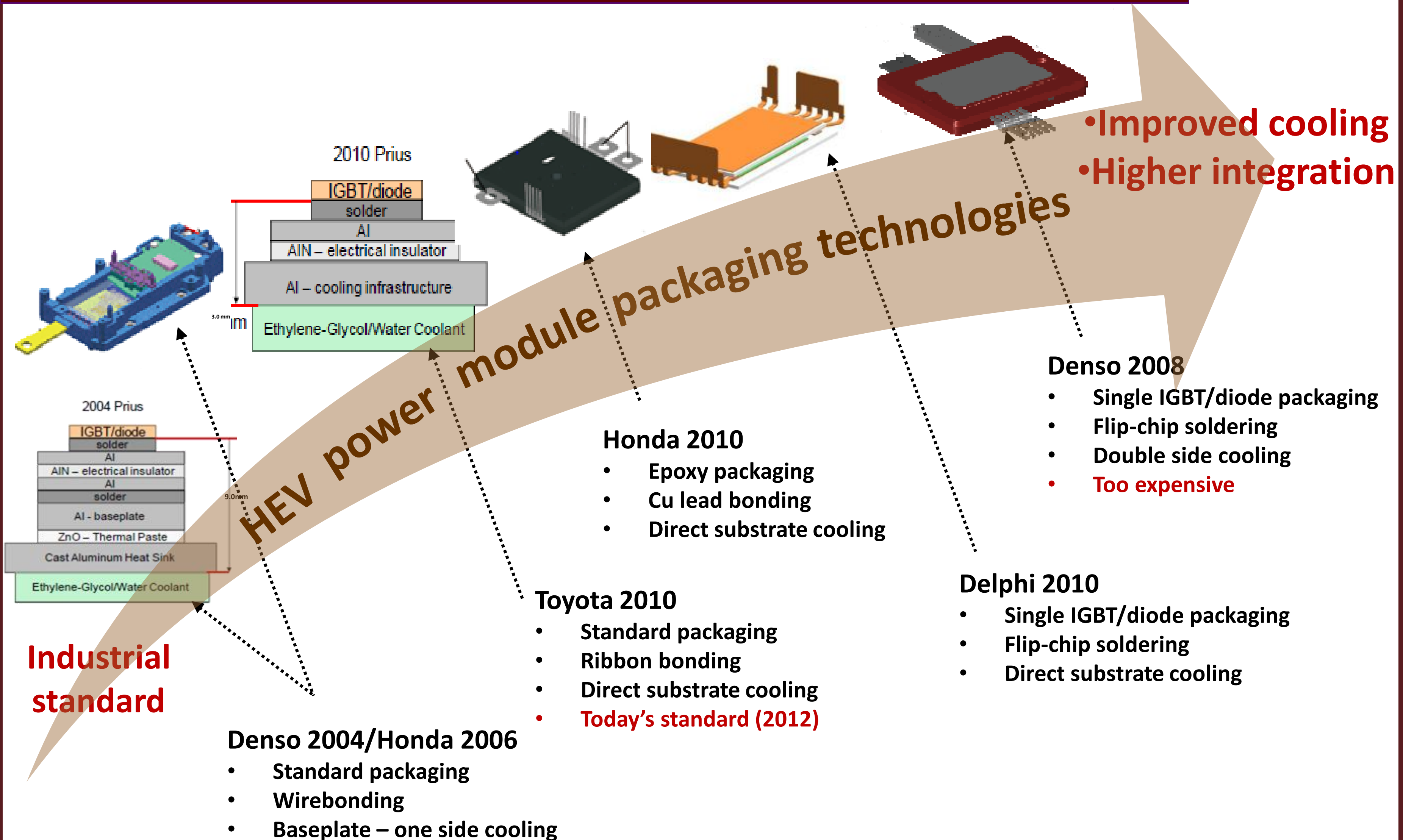
- EV/HEV is one of the biggest market for power electronics in 2020, according to all forecast
- The main challenges will include **manufacturability, reliability** and **lifetime**, but also **integration** and **weight**
- Module packaging is already a great challenge in EV/HEV:
  - *The market is potentially large enough to involved huge developments founds*
  - *The level of integration will lead to custom solutions and all integrated inverter*
  - *Footprint, size, weight and cost and are all strong technical drivers*

•Improved cooling
•Higher integration

Industrial standard

Power module packaging trend in EV/HEV



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Analysis of innovation trends in packaging for power modules

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- **The main improvements aspects are each leading to different technologies, but breakthrough technologies are solving all these issues at the same time:**
  - Using double side DBC, with integrated cooling solves all the potential issues at the same time. But no production process is cost effective, and no standard is being studied yet
- **Several technologies are closer in time or already used in high-end packaging:**
  - Direct cooling is becoming a standard and widely used. The most showing example is EV/HEV. There is no clear trend in wirebonding:
    - Copper wires seems on its way to become a standard, being developed by several players including Infineon and Danfoss
    - Semikron pushes for Ag sintering applied to interconnection, but we have to wait and see for the results
    - Denso is putting ribbon Al bonding in Toyota Prius modules
  - Die attach solutions are on the same trends, between copper and Ag sintering
- **The innovation is going to be pushed forward by EV/HEV players. They need better power electronics conversion systems to gain in added value. Smaller and easier to cool are the two drivers**

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- **Yole Développement is currently launching a brand new offer dedicated to power packaging including**
  - Technological analysis
  - Market metrics and supply chain analysis
  - IP and patent analysis