CooliBlade®

Key Requirements and Innovations for increasing Power Densities

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CooliBlade®

THERMAL MANAGEMENT EXPO EUROPE

CooliBlade definition of Power Electronics

Power Electronics Overview:

Focused on controlling and converting electric power with semiconductor devices.

Common Applications:

Frequency Converters & Industrial Drives: Control motor speeds and power levels. Power levels: 1 kW – 100 MW+

EV Charging: Manage power in fast, efficient EV charging stations. Power levels up to 500 kW or even 1,5 MW

Inverters & Converters: Convert DC to AC or adjust voltage levels for renewable energy, UPS, and power supplies. Power levels 1 kW – 100 MW+

Modern applications for power electronics

Renewable Energy

E-mobility

Industrial engines

Telecommunication

Lighting

Data centers

Defence

Medical

The most important component of Power Electronics - IGBT

- Professor Bantval Jayant Baliga is electrical engineer who has been recognized as the person with the world's largest negative carbon footprint.
- He is the inventor of the IGBT (Insulated Gate Bipolar Transistor), a groundbreaking innovation developed in the 1980s that has revolutionized power electronics.
- IGBT has greatly improved the efficiency of electrical devices. It has also accelerated the breakthrough in renewable energy production
- His invention has led to a remarkable reduction in global CO_2 emissions, estimated at 82 gigatons over the past three decades, equivalent to offsetting three years of human-generated carbon emissions.

In 2024, Prof. Baliga received the Millennium Technology Prize for his contributions to sustainable technology.

The evolution of power electronics

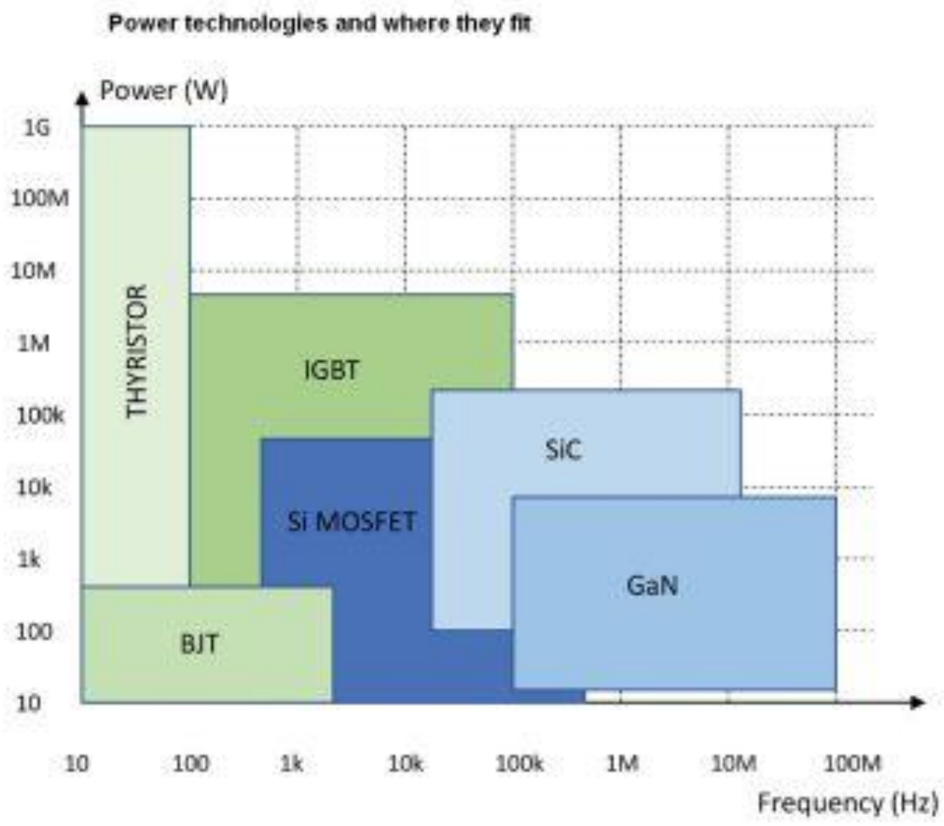
From Silicon to Next-Generation Semiconductors:

IGBTs (Insulated Gate Bipolar Transistors):
Traditional solution in high-power applications; handles high voltages but has slower switching speeds and limited thermal management capabilities.

SiC (Silicon Carbide): Faster switching and higher temperature tolerance, improving efficiency.

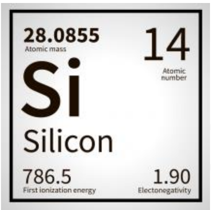
GaN (Gallium Nitride): Ideal for high-frequency applications (e.g., consumer electronics and compact converters); efficient with lower power loss.

Key Applications and Impacts:
Applications are shifting toward smaller, faster, and more energy-efficient devices.



https://www.macnica.co.jp/en/business/semiconductor/articles/qorvo/136866/

The evolution of power electronics: Cooling Needs



IGBT Cooling:
Traditionally managed with air or liquid cooling

- higher power densities and switching frequencies now demand improved heat management.

SiC and GaN Cooling:
Compact designs with higher power density need advanced cooling. SiC often requires liquid or phase-change cooling, while GaN demands even more precise thermal management.

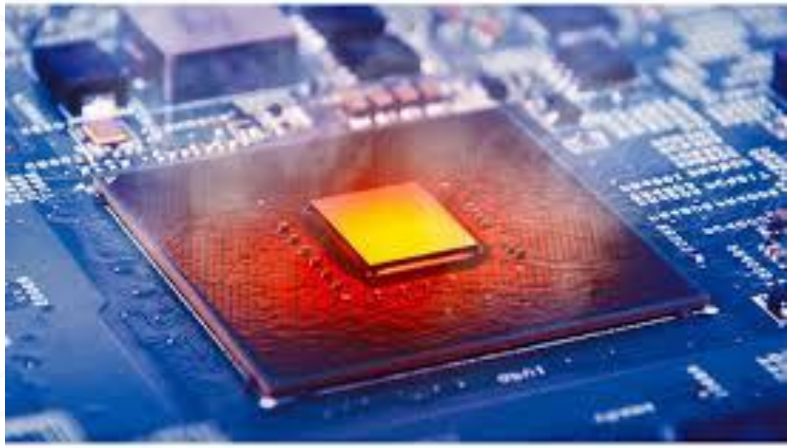
- Both new technologies face higher thermal stress and require efficient hot spot control.

Silicon Carbide
SiC

Future Trends:

- Focus on phase-change cooling to avoid liquid cooling.
- Advanced TIMs for better thermal bonding.
- Ultimate goal is to use fully passive cooling solutions

Overheating Causes 55 % of All Electronics Failures



Thermal Management Challenges

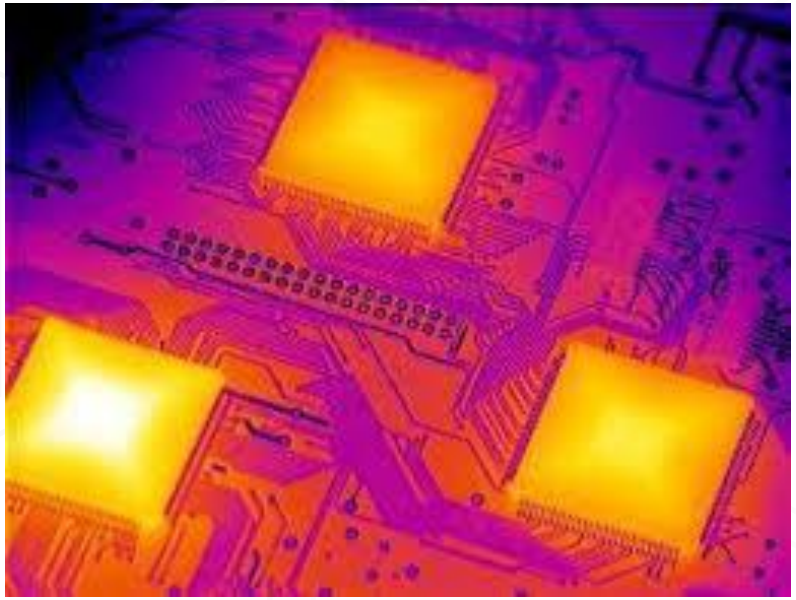
Power level and Heat
Higher power level generates more heat to manage.

Miniaturization and higher Power Densities
As devices shrink, heat flux intensifies.

Reliability and Lifetime
Typical device lifetime expectation 20 - 30 years in industrial applications.

Cost and Space Constraints
Optimizing cost and thermal performance in limited space.

Complex Systems
Efficient cooling in multi-component systems.



Different applications require different cooling solutions

COMPONENTS

PCBs

FR4 / MCPCB

MODULES

IGBT / SiC / GaN

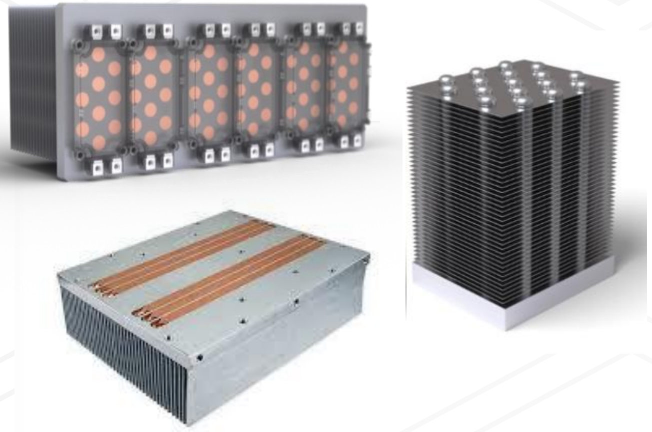
THYRISTORS

POWER STACKS

CABINS

Commonly used Thermal Management technologies

Aluminium heat sink



Phase change systems

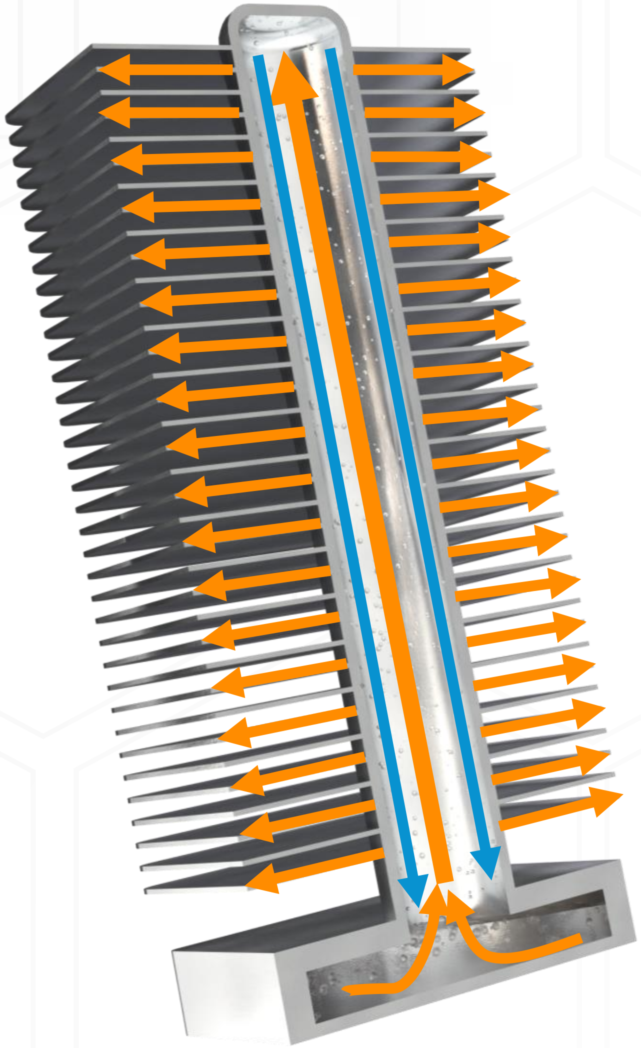
Liquid cooling and cold plates

NEOcore – New generation for phase change cooling

1000 times higher thermal conductivity compared to traditional aluminum heat sinks.

NEOcore integrates an evaporator, thermal channel, and condenser into one structure.

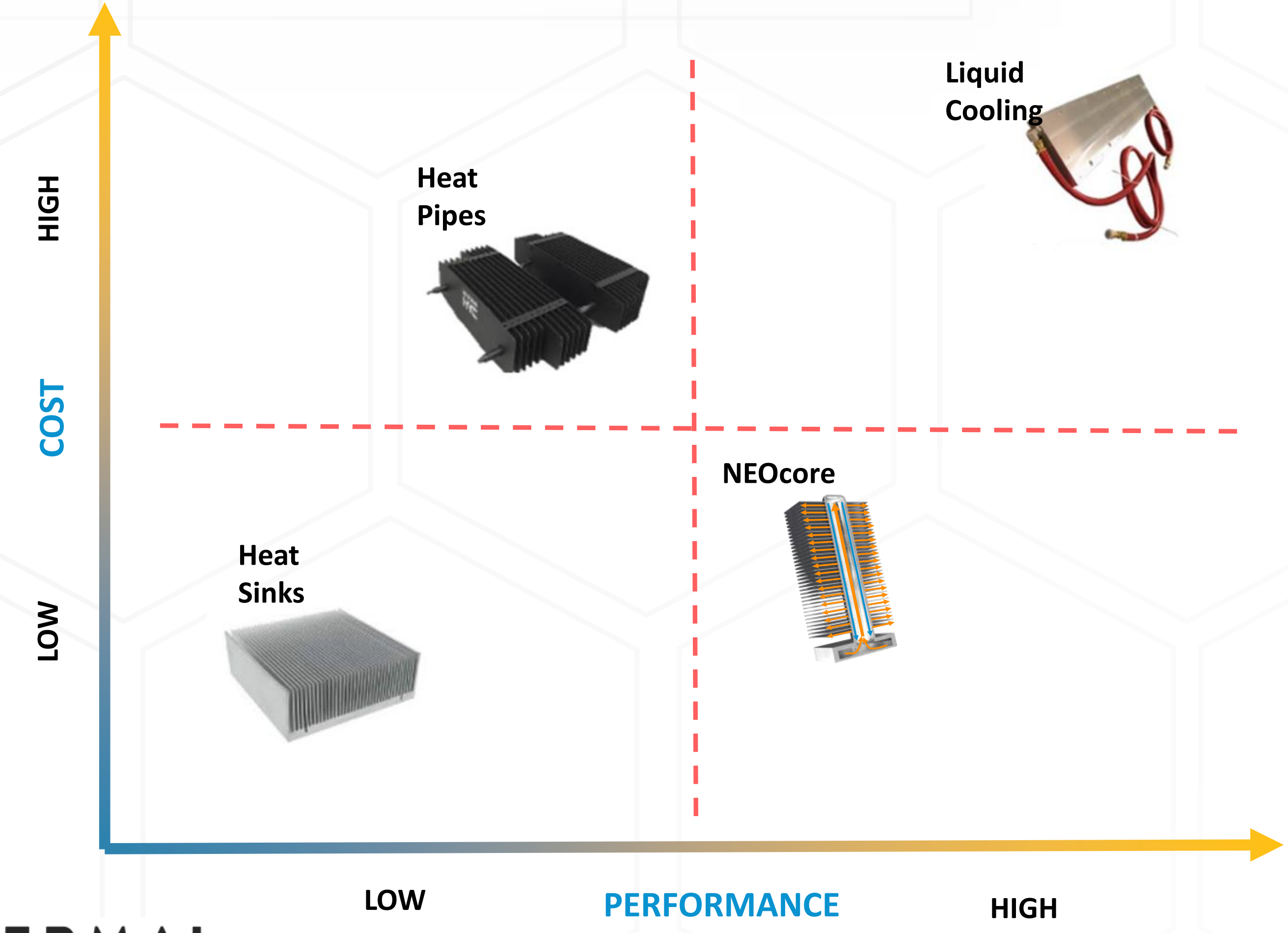
Integrated structure removes additional thermal interfaces and enables mass-manufacturing.



Performance - Cost matrix of the cooling solutions

Thermal Management is always cost and performance optimization

- Aluminum heat sink, Common cooling solution for low heat loads and power densities
- Heat pipe heat sinks, solution when the thermal conductivity of pure aluminum is not enough
- NEOcore, High performance air cooling for high power levels and power densities
- Liquid Cooling, High heat transfer capacity, complex system level solution, high cost impact



NEOcore vs heat pipe technology

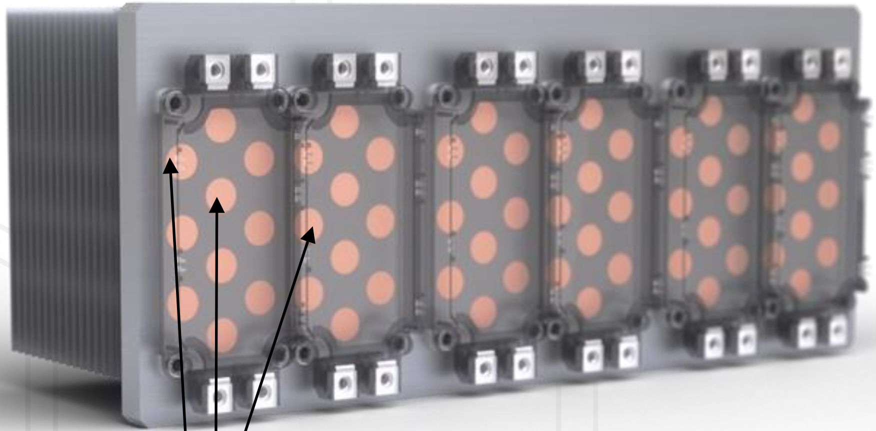
Large NEOcore evaporators remove heat and hot spots efficiently over the whole heat sink structure enabling higher power levels.

HEAT PIPE

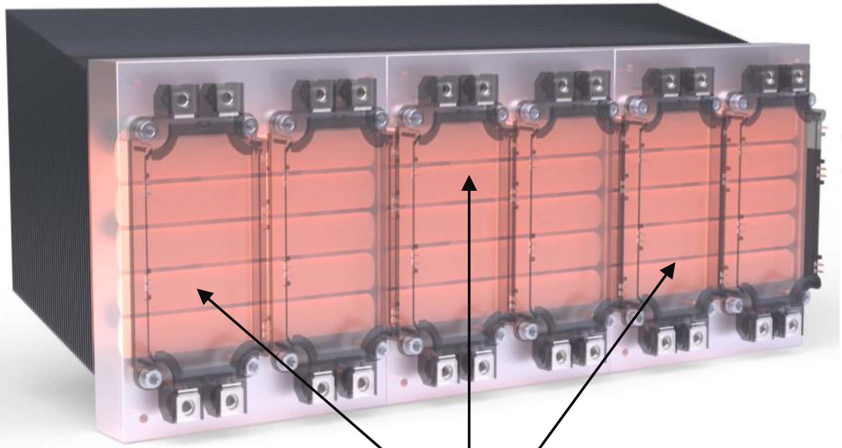
6 x IGBT
6 x 0.8 kW = 4.8 kW
60 Heat Pipes

NEOcore ULTIMA

6 x IGBT
6 x 1.0 kW = 6.0 kW
15 Integrated evaporators connected to the Thermal Channels



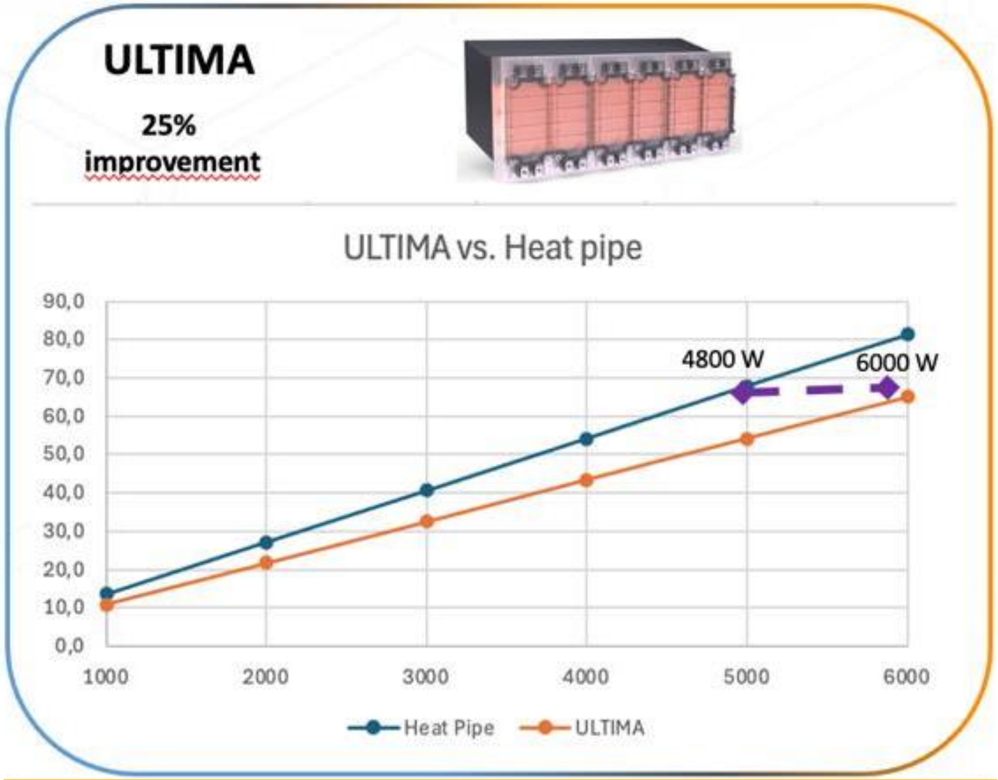
Identical footprint

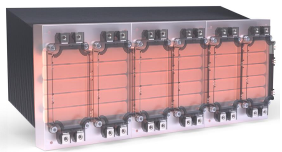


Performance comparison: CooliBlade ULTIMA and Heat pipe heat sink

Large NEOcore evaporators provide more efficient heat transfer especially with high power levels

- Heat sink surface temperature difference at 5 kW is about 15 K.
- Heat pipe heat sink with power of 5kW provides ΔT = 68K above ambient
- NEOcore heat sink with the same ΔT = 68K provides 1.2 kW more cooling power

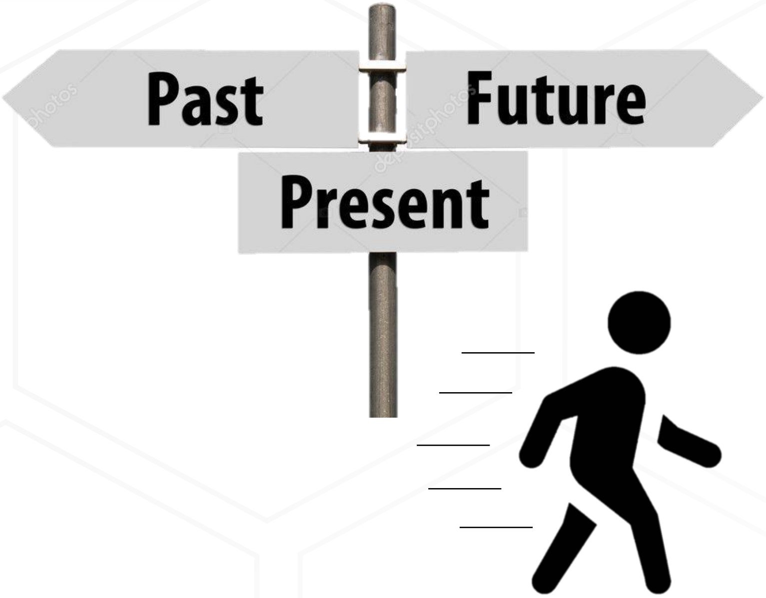




Power increasing example: e.g, 192 kW to 240 kW in electrical power (98% efficiency of the modules)

Conclusions

- Efficient thermal management improves energy efficiency and sustainability.
- **Smaller and cost-efficient systems** needed to fulfill industry requirements.
- There is growing need for innovative solutions to reduce energy use and enhance efficiency.
- Challenges in heat management are increasing, despite the new component technologies.
- Investing in heat management leads to long-term savings and environmental benefits.



THANK YOU

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