evs 27

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Fuji Electric
Innovating Energy Technology

Ultra-Compact and Light Weight Intelligent Power Semiconductor Module for Hybrid System

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Fuji Electric Co., Ltd.
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Required Performance of Power Module for HEV

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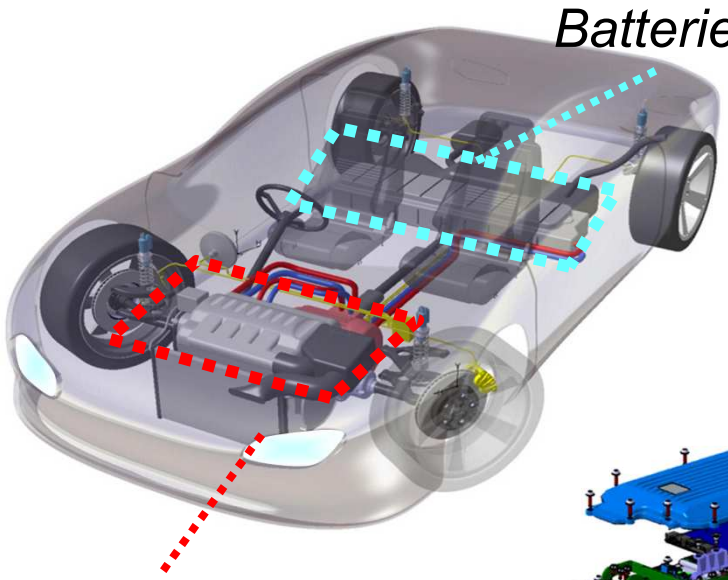
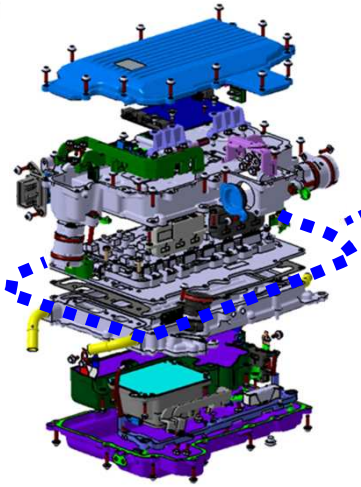
Intelligent Power Module for Hybrid Electric Vehicles

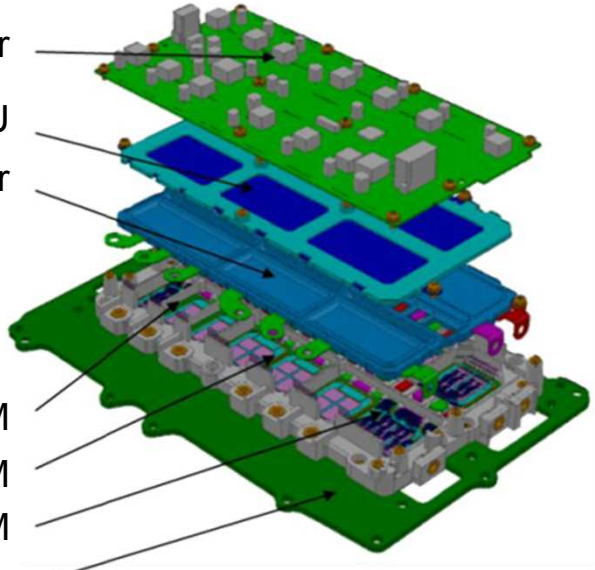


Engine Room of HEV

- PCU
- Motors
- Engine & other



Power Module



■ Requirements for power module
1.High Efficiency, 2. Downsizing, 3. Lightweight

Trend of Fuji Electric Power module

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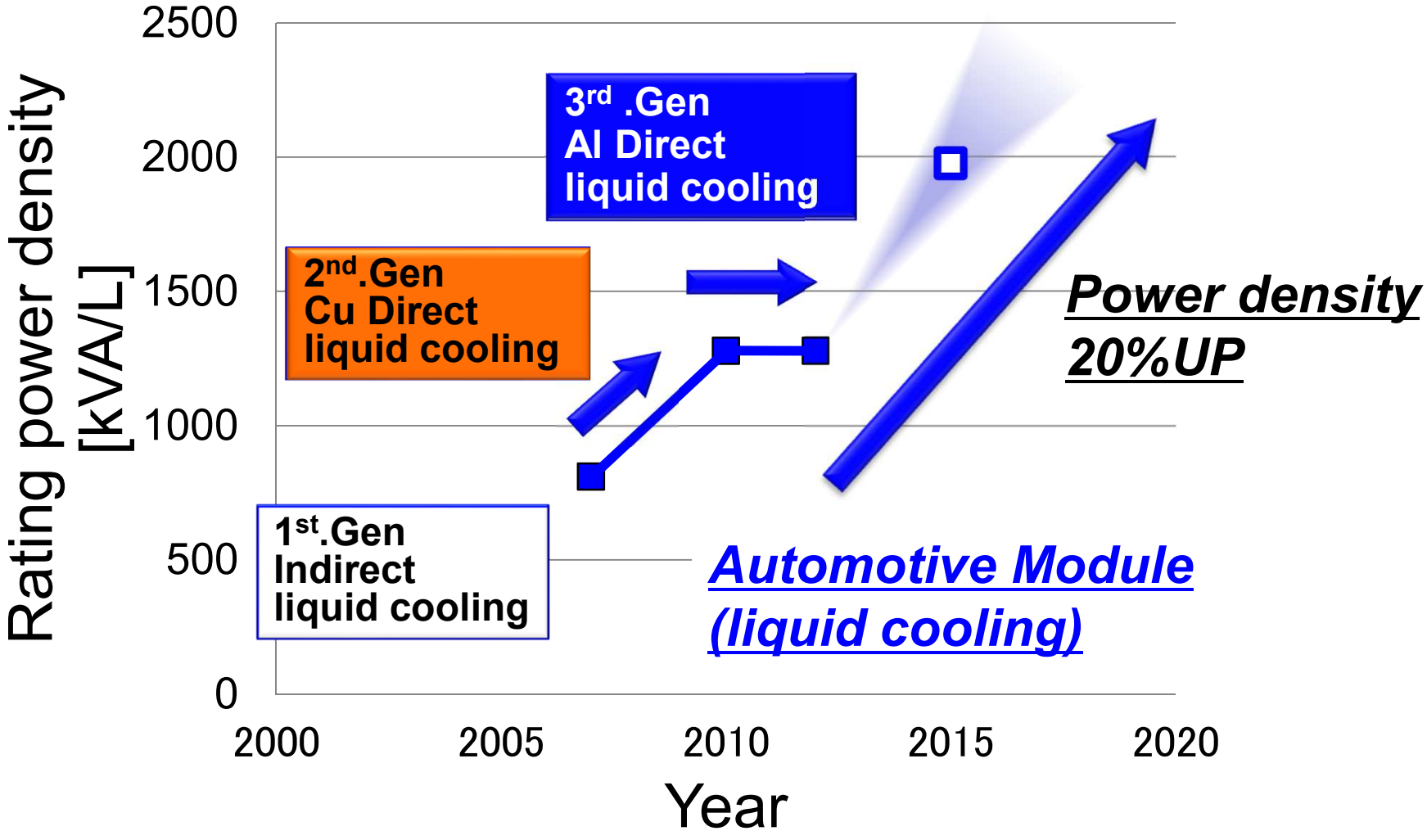
kVA/L ＝ Rated voltage [kV] × rated current [A] / product volume [L]



- High power density is required for automotive module
- Direct liquid cooling with aluminum fin is key technologies for 3rd gen.

Subject of Conventional Power Module Structure

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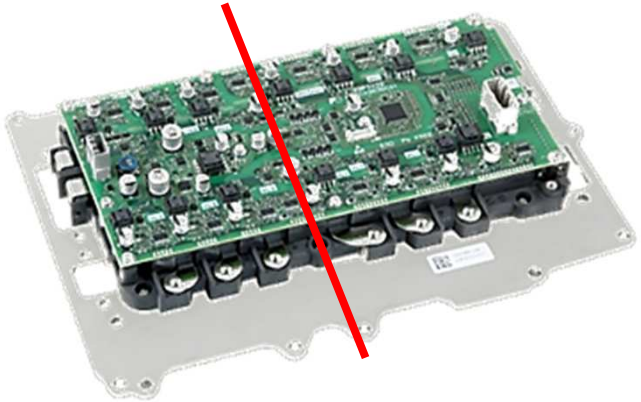
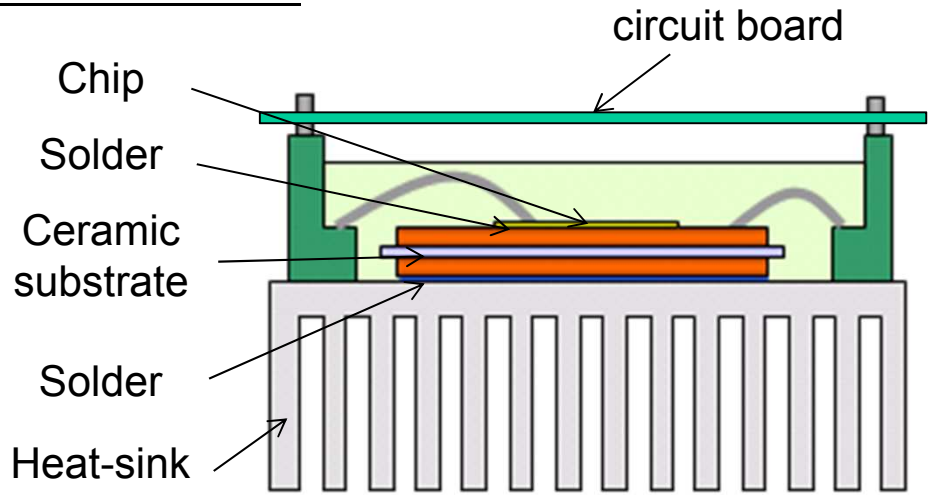
Direct liquid cooling module structure

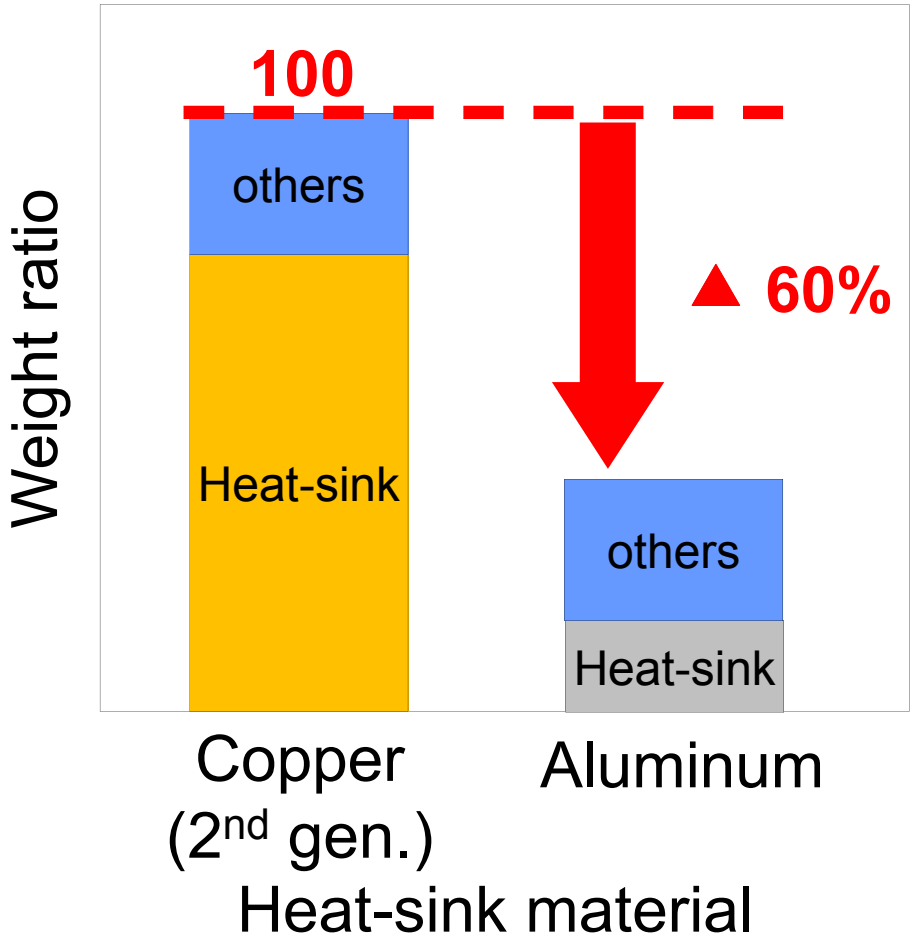


Cross section



Aluminum is

- *Light weight*
- *Good corrosion resistance*



■ Aluminum heat sink can reduce module weight by 60%

Subjects of Aluminum heat sink structure

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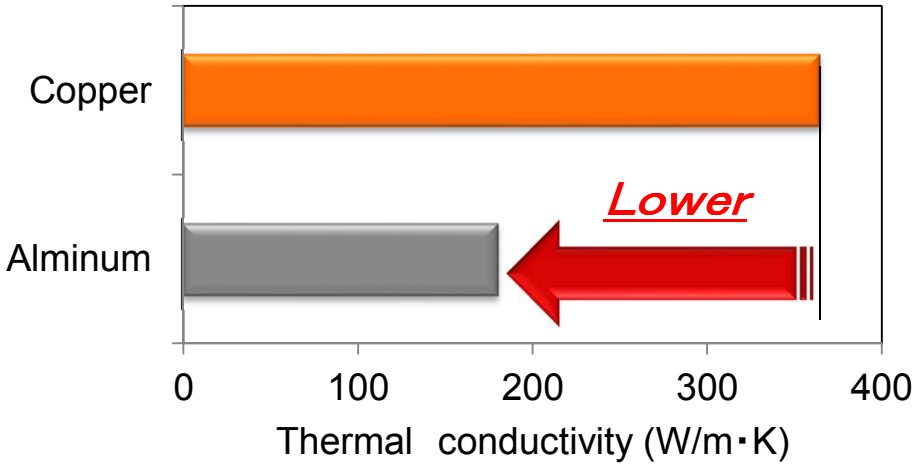
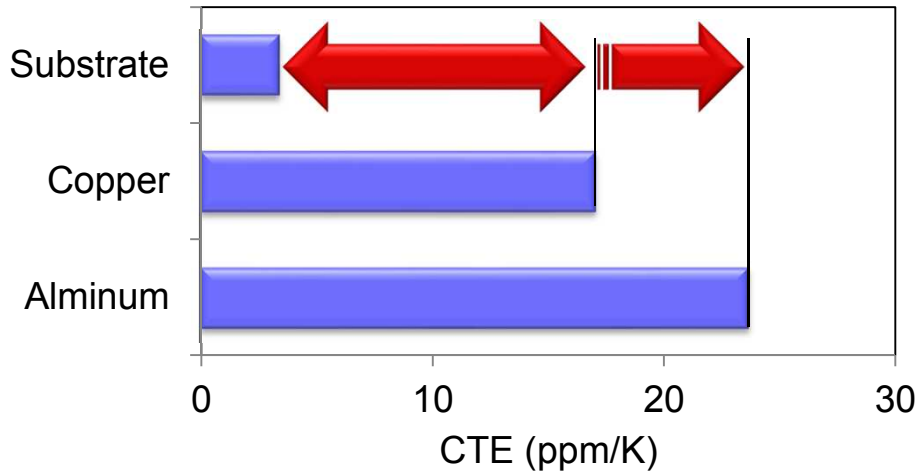
Ⅰ. Low thermal conductivity

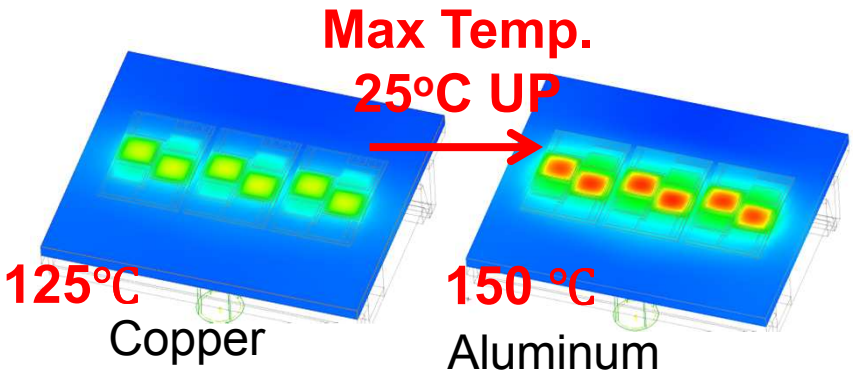


Ⅱ. Large CTE mismatch

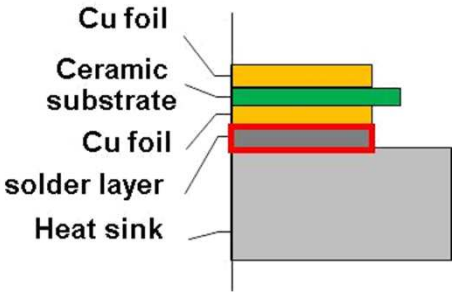
ΔCTE 1.4 times Higher



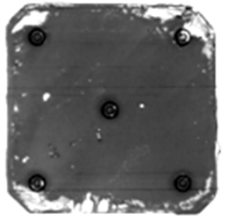
Temperature of semiconductor



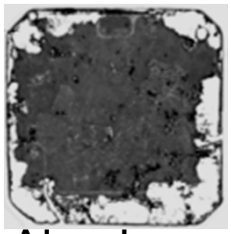
Reliability of joint layer



Thermal cycle at 1500cyc.



Copper heat sink



Aluminum heat sink

■ Thermal design and high strength joint layer are needed

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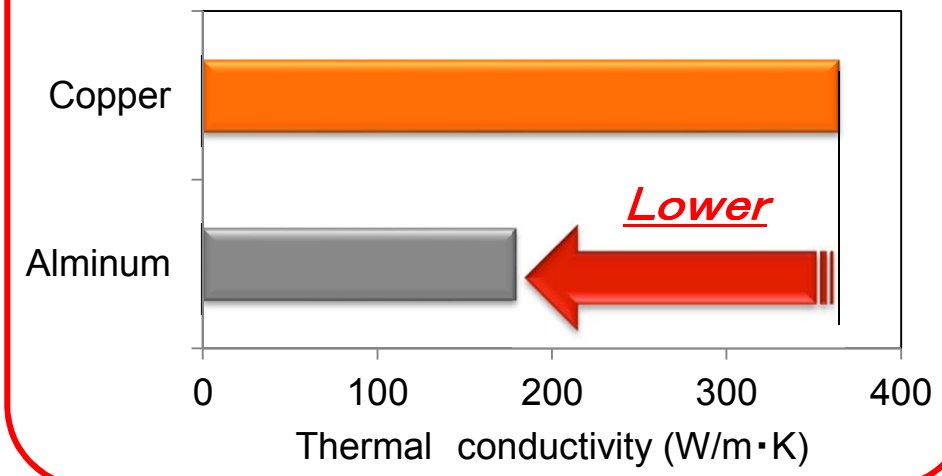
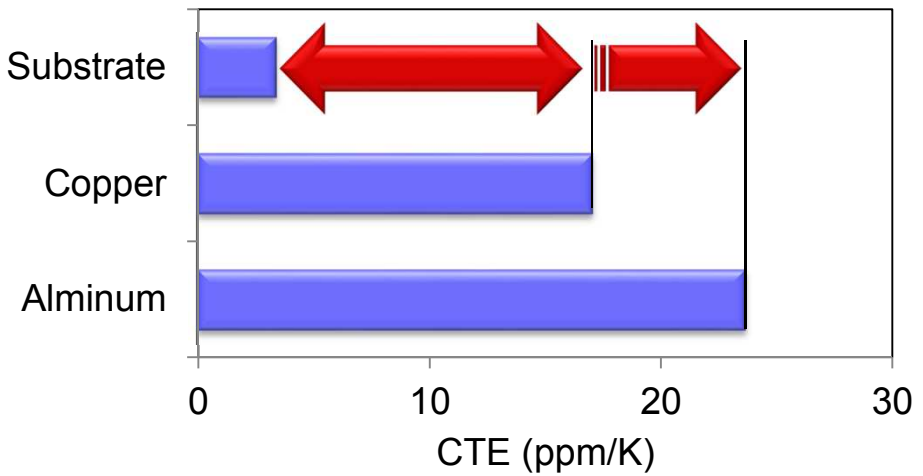
Ⅰ. Low thermal conductivity



Ⅱ. Large CTE mismatch

ΔCTE 1.4 times Higher



Subject for the design of aluminum heatsink

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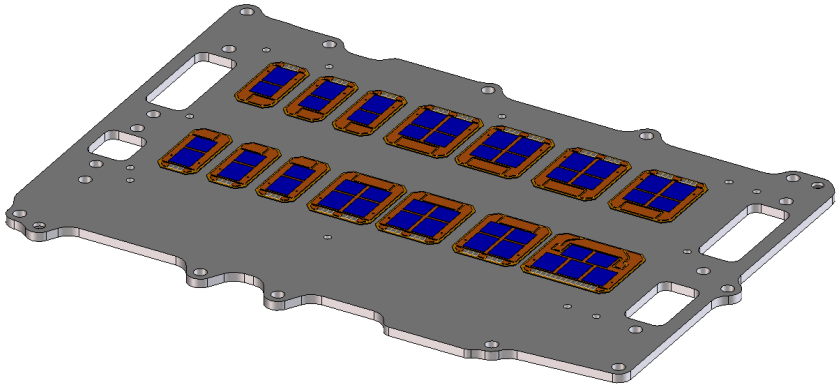
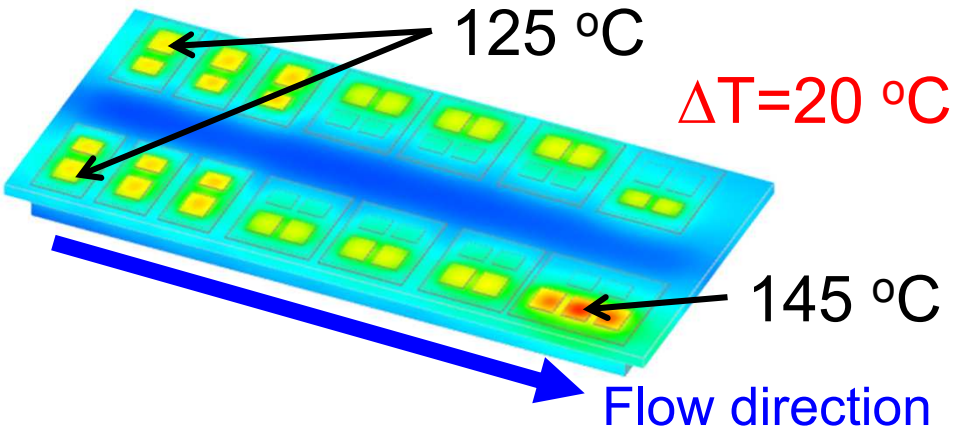
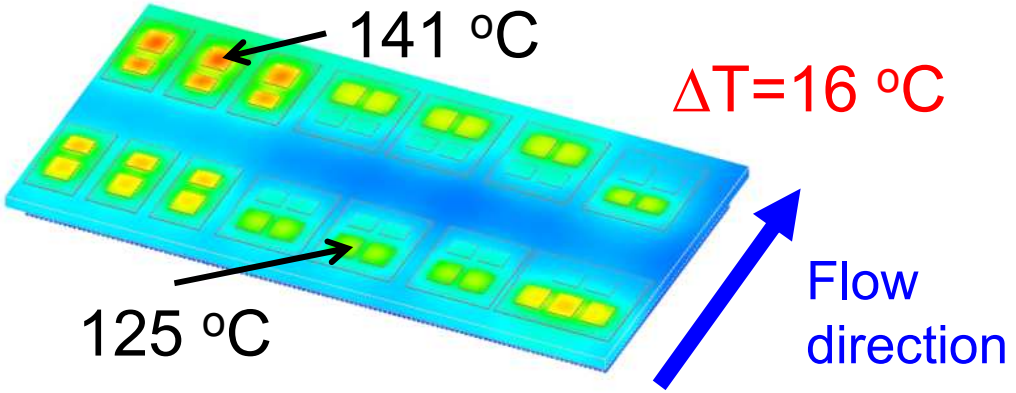
Simulation model (real product)

Size	: 320x170 mm
Inlet	: 60 °C
Flow speed	: 10 l/min.
Chip operation	: maximum



Temperature distribution of coolant





- Optimization is necessary to reduce temperature distribution

Optimization of flow distribution

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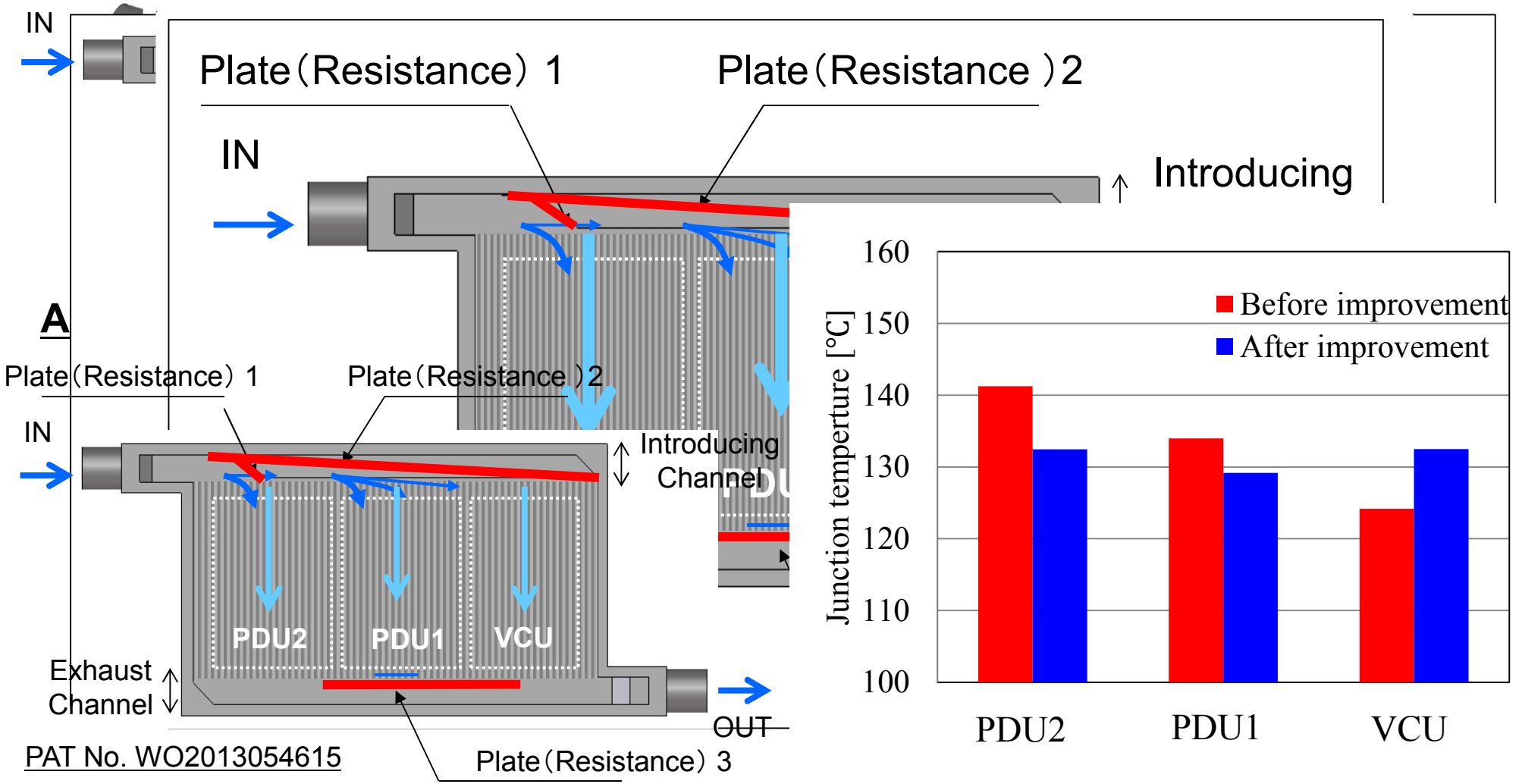
Before Optimization



- With this design, we have a almost the same performance with Aluminim heat sink as Copper heat sink.

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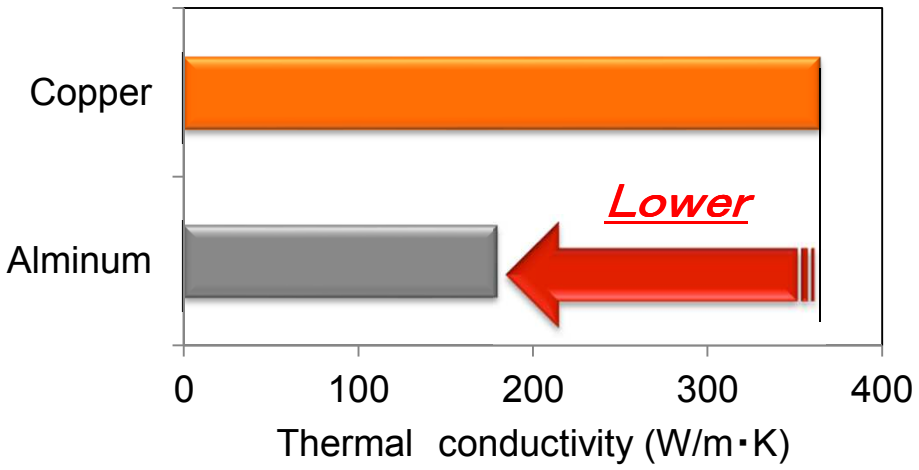
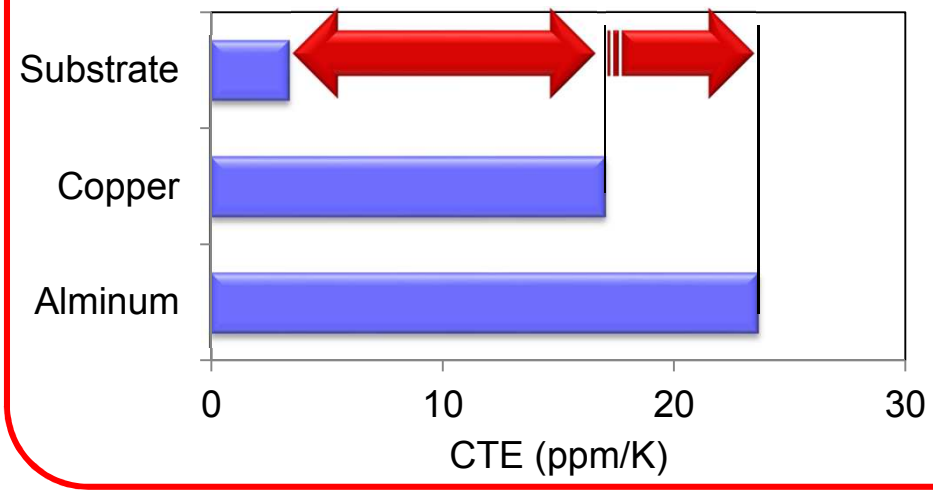
Ⅰ. Low thermal conductivity



Ⅱ. Large CTE mismatch

ΔCTE 1.4 times Higher



Strengthening Mechanism of Solder Alloy

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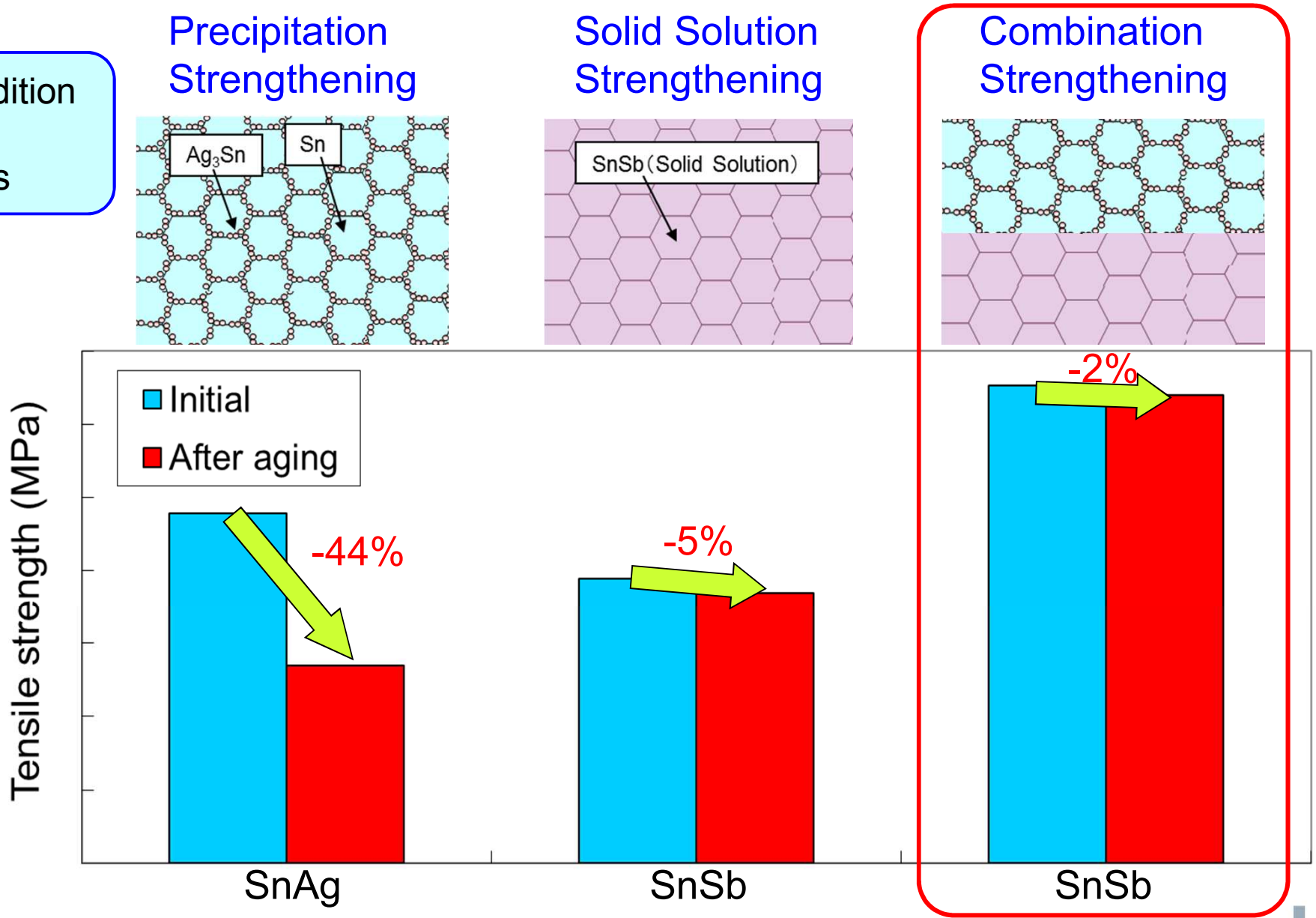
Aging condition
175 °C
1000 hours



Effect of Thermal Fatigue Characteristics of New Solder

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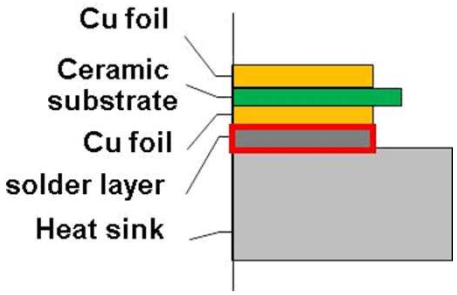
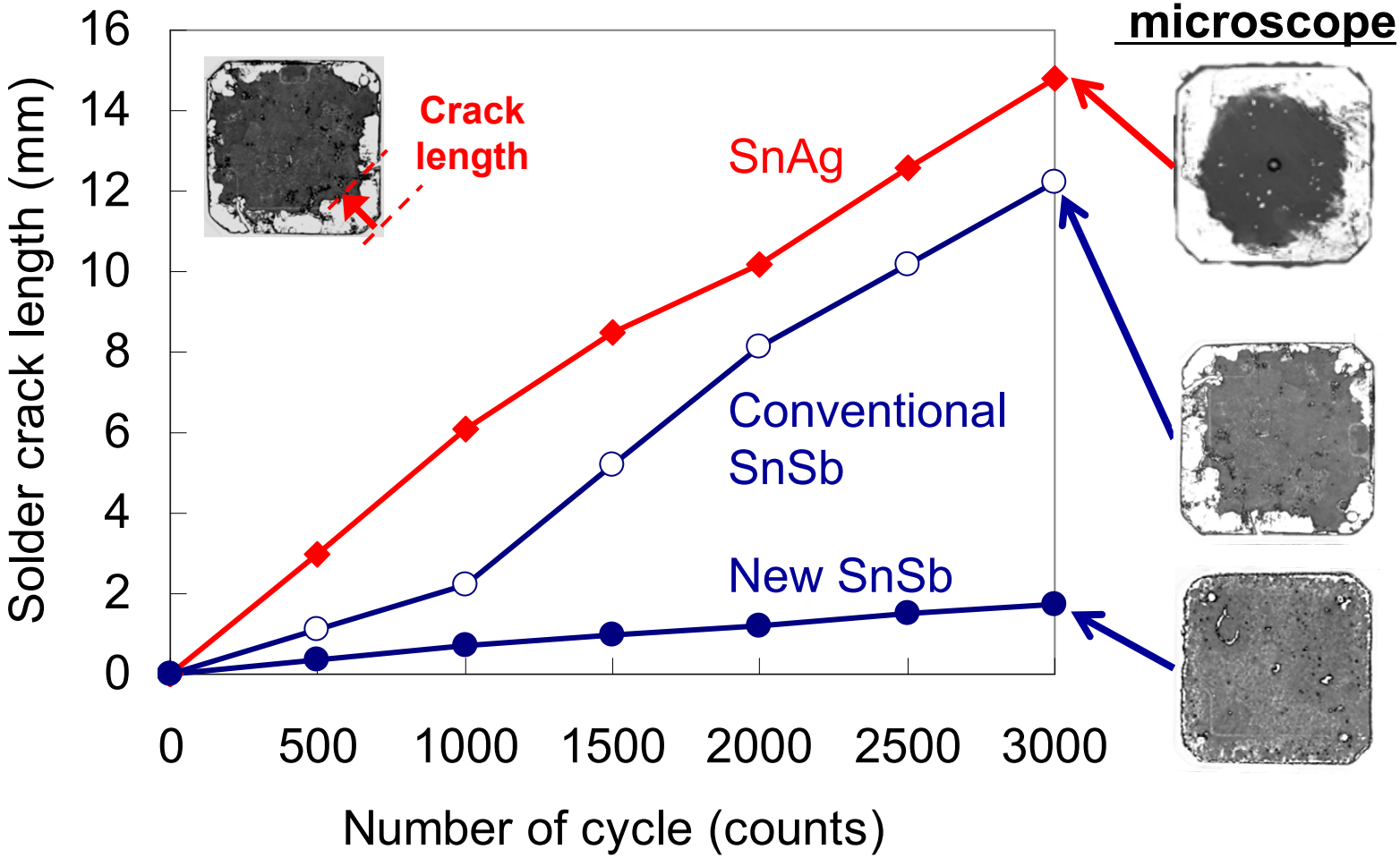


Thermal cycle test -40~105℃



Scanning acoustic microscope

■ Achieved 7 times longer lifetime against the general Sn-Ag Solder.

Product Summary of a Newly Developed IPM

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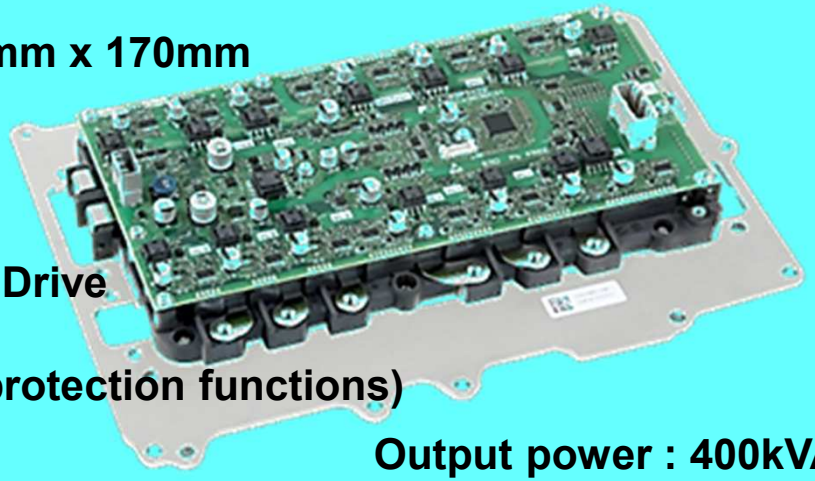
Mass Production Model

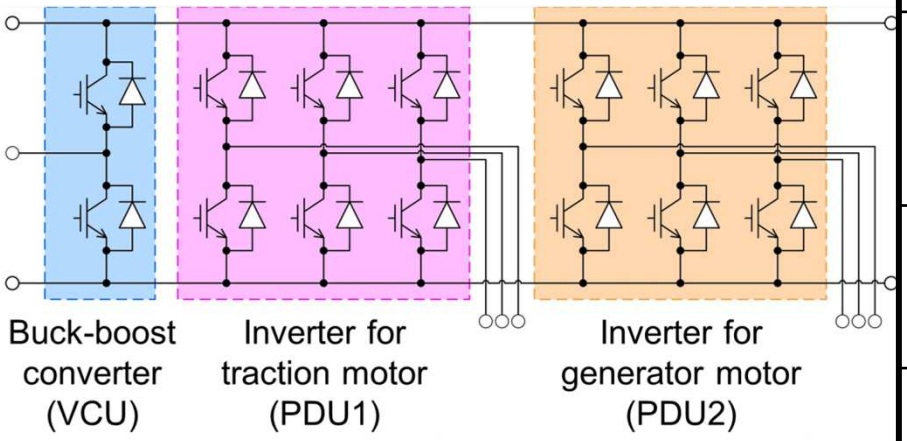
320mm x 170mm



Gate Drive ICs (for protection functions)

Output power : 400kVA

Engine Room in hybrid Electric Vehicle



Unit	Specifications
Power Module	14-in-1 unit of IGBT/FWD in total IGBT Output power : 400 kVA (in total)
IGBT chip	Fuji Electric V-series (6th generation) System voltage : 1200 V
Self Protection function	IPM status sensing (temperature, voltage and failure information) and self protection by itself. Information communication with ECU.

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Conclusions

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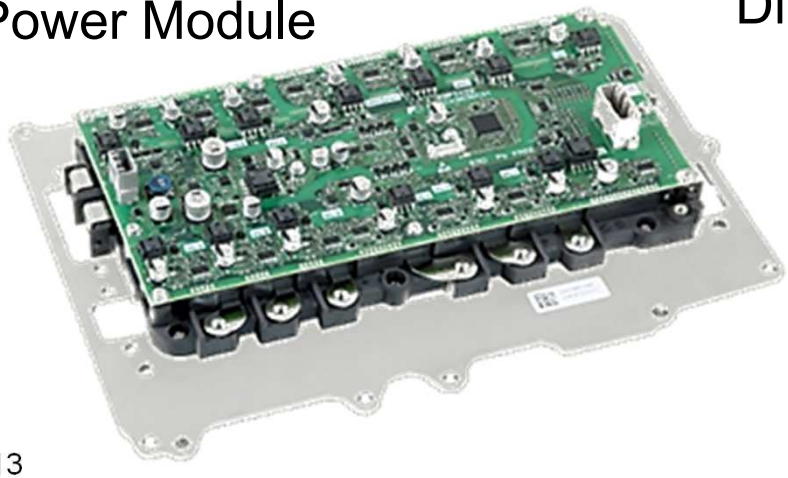
1. Design of Aluminum heat-sink
   - Developed a cooling structure that can be efficiently cooled
2. Development high reliability solder material
   - Reliability is 7times longer compared with the Sn-Ag solder
   - Achieve a automotive quality used by Aluminum heat-sink

⇒We achieved direct liquid cooling module
   -30% volume, 60% weight reduction compared to products with conventional technologies

Front side
Intelligent Power Module



Back side
Direct Liquid Cooling Fin

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Thank you for your attention !

Four Beautiful Seasons in Matsumoto City
Where Fuji Electric locates

Sagrada Familia in Barcelona
Where EVS held