3rd Generation RC-IGBT for Automotive Application

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Abstract

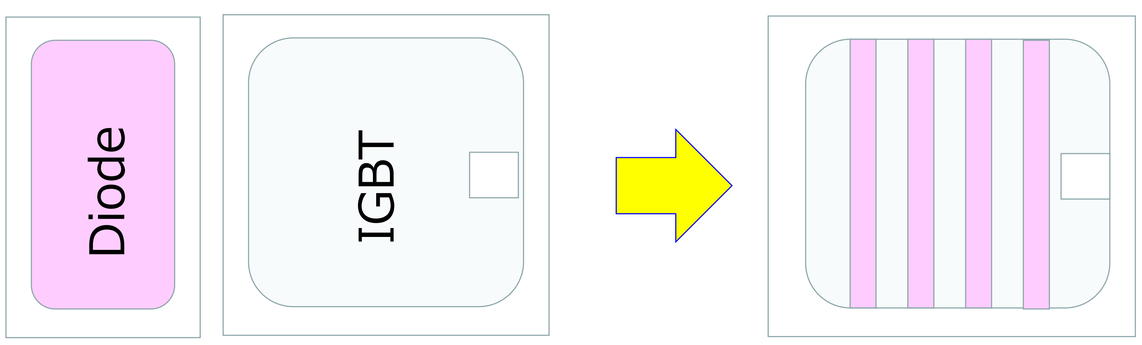
This paper presents a new 750V RC-IGBT (Mitsubishi 3rd generation RC-IGBT) dedicated for automotive power module which is used for xEV including BEV power-train inverter and E-Axle applications. The new chip demonstrated 30% reduction in thermal resistance while achieving electric characteristics lower than that of 7th generation (7th Gen.) IGBT/FWD chipset. Simulation result verified that the RC-IGBT is applicable to a wide range of inverter operation of various xEVs.

1. Introduction

- RC-IGBT is a good option for small size and large capacity power module.
- Our benchmark result confirms that our RC-IGBT outperforms those of other companies.
- Further productivity improvement by increasing the wafer diameter and reducing the manufacturing processes.
- Our automotive RC-IGBT has been mass produced since 2019.

①Integration of IGBT and Diode

☞Chip downsizing by sharing a guard ring

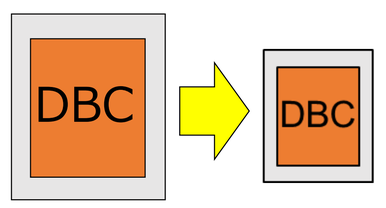


②Shorten the interval between IGBT/Diode

☞Material reduction/Number of chip reduction

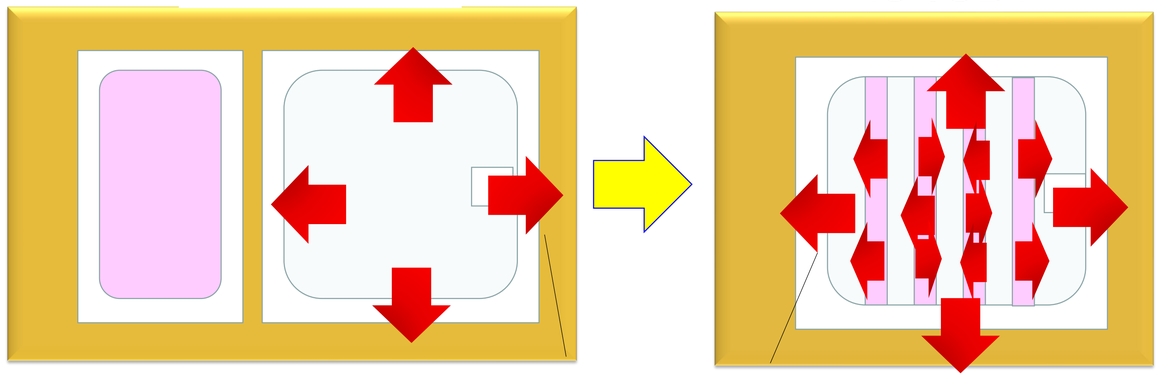
☞Reduction of assembly cost by reducing connection

Downsizing DBC

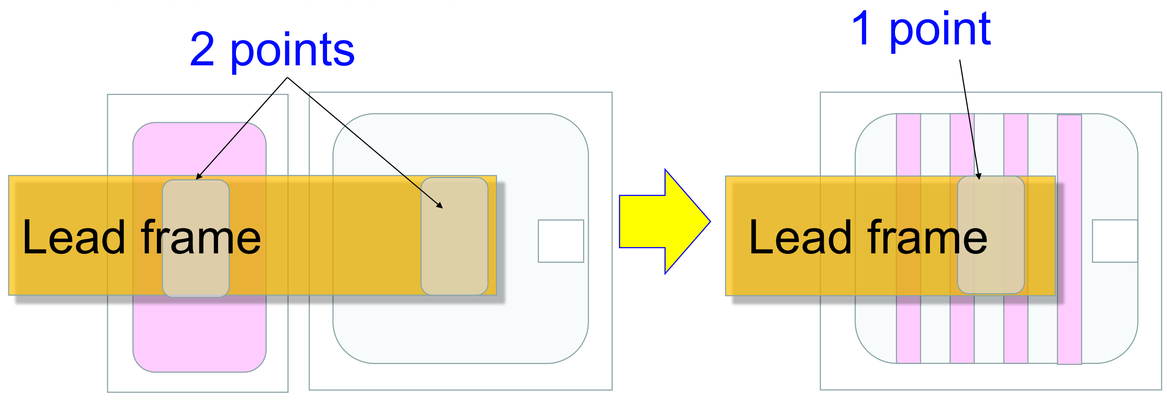


③ Increased heat dissipation path and area

☞Reduced thermal resistance, Chip downsizing

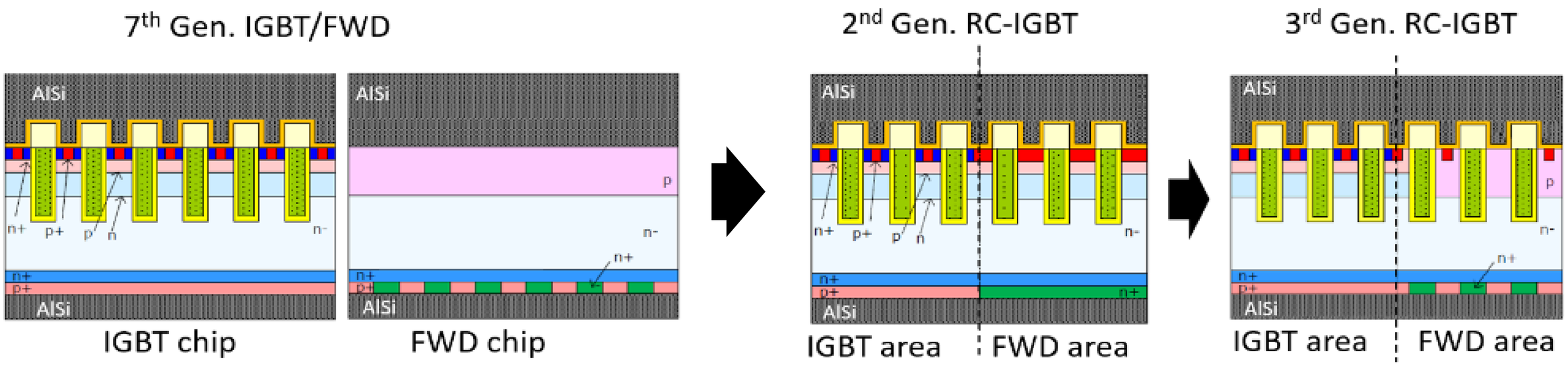


Die - direct lead connection



2. Chip technology

- 3rd Gen. RC-IGBT is based on Mitsubishi thin wafer process and the 7th Gen. CSTBT™ chip technology
- Low V_{CEsat} adopting micro fabrication technology to achieve better cell pitch and improved carrier storage effects
- High frequency FWD characteristics by optimizing the anode concentration and cathode pattern ratio in the FWD area.
- 34% reduction in chip size compared to 7th Gen. separated IGBT/FWD chips assuming the same current rating



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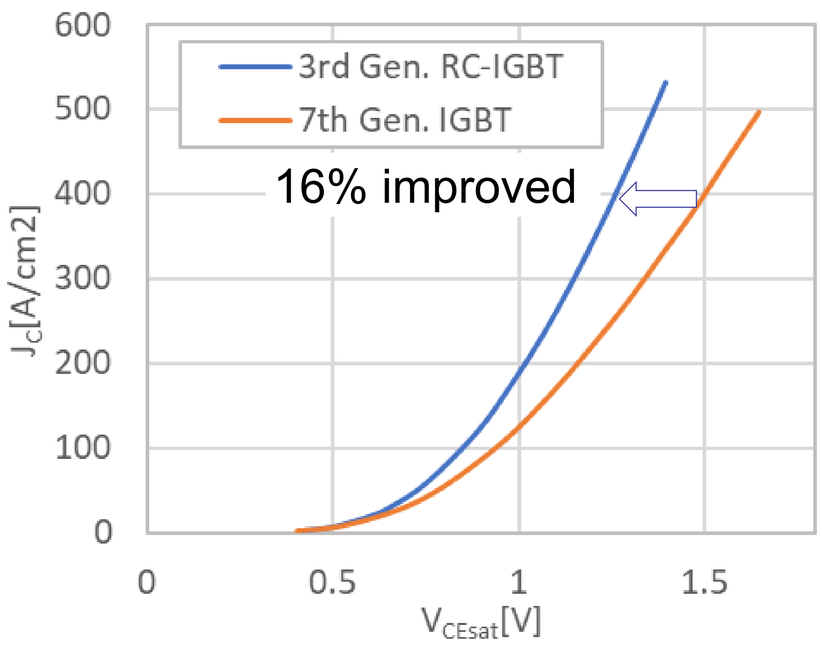
Changes for the Better

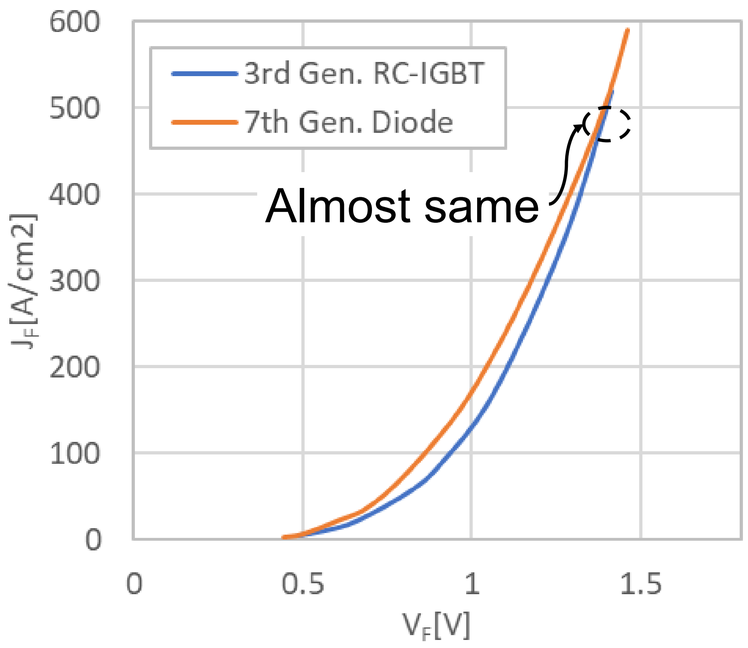
3. Evaluation result

- VCEsat of 3rd Gen. RC-IGBT is 16% lower than that of 7th Gen. IGBT.
- VF of the 3rd Gen. RC-IGBT is the almost same as that of 7th Gen. FWD.
- Switching loss is also better than that of 7th Gen. IGBT/FWD chipset.

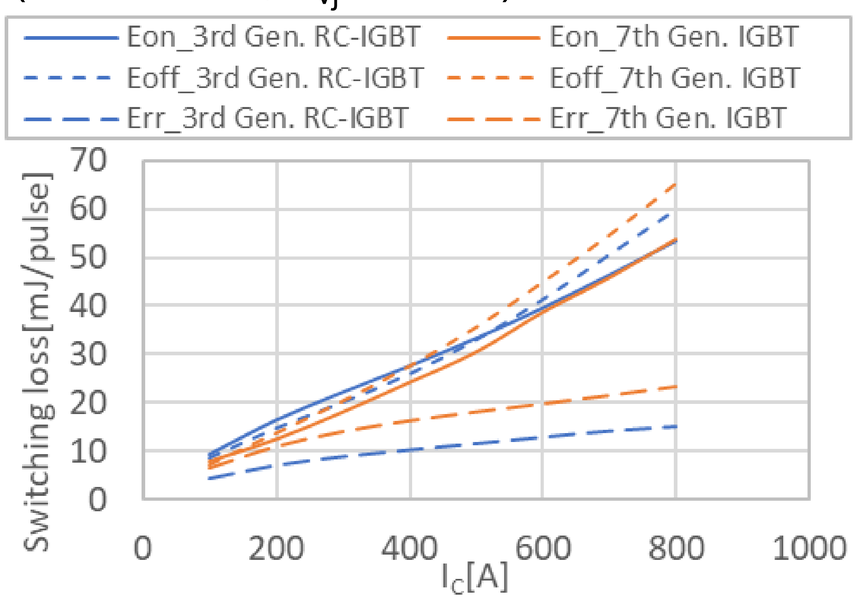
・ V_{CEsat} characteristics(T_{vj}=150°C)



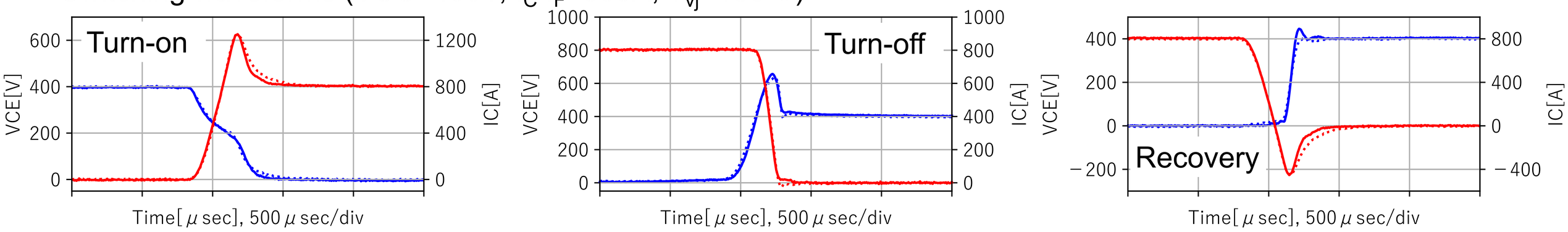
・ V_F characteristics(T_{vj}=150°C)



・ Switching loss characteristics (VCC=400V, T_{vj}=150°C)



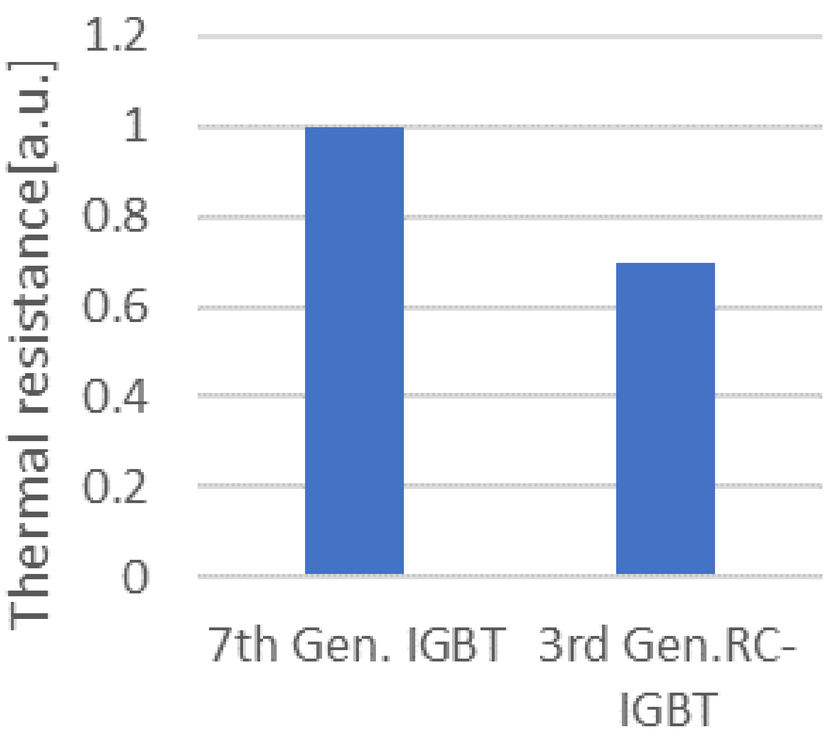
・ Switching waveforms (VCC=400V, I_C/I_F=800A, T_{vj}=150℃)



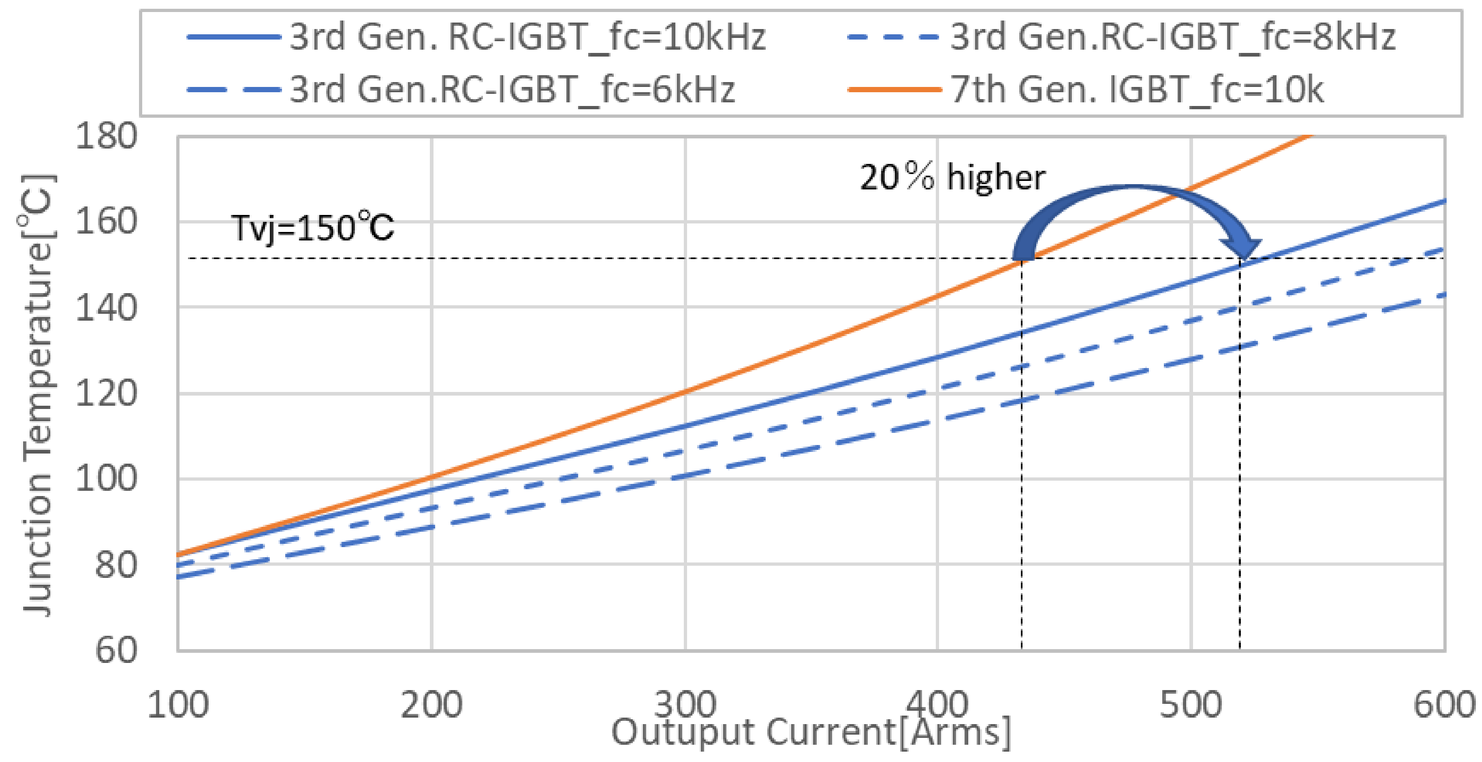
4. Simulation result

- Thermal resistance and current handling capability of both 7th Gen. chipsets and 3rd RC-IGBT mounted on automotive pin-fin package are calculated by CAE.
- The active area of 3rd Gen. RC-IGBT is 20% less than that of 7th Gen. chipset. However, its thermal resistance is 30% better.
- The inverter output current can exceed 500Arms (more than 150kW output power) at a maximum junction temperature of below 150°C, and the current handling capability is improved by 20%.

・ Thermal resistance



・ T_{vj} simulation(VCC=400V, fc=6,8,10kHz, Tw=65℃, flow rate=10L/min)



5.Conclusion

The new automotive 3rd Gen. RC-IGBT has been developed to meet the evolving automotive market requirements. RC-IGBT consists of IGBT and FWD in one chip, and it has been confirmed that it has excellent electric and thermal characteristics. Therefore, the total chip area can be reduced, and it is possible to reduce the size of power modules for automotive. In conclusion, the 3rd Gen. RC-IGBT can realize a wide range of inverter operation and meet various demands of xEV applications including BEV. It also contributes to material reduction and resource conservation. Through this technology, we will promote carbon-neutral efforts and contribute to the protection of the global environment.