

車載パワートレイン&パワートランジスタ調査レポート(日本対象) Si IGBT sと SiC MOSFETs の使用状況と今後の動向予想

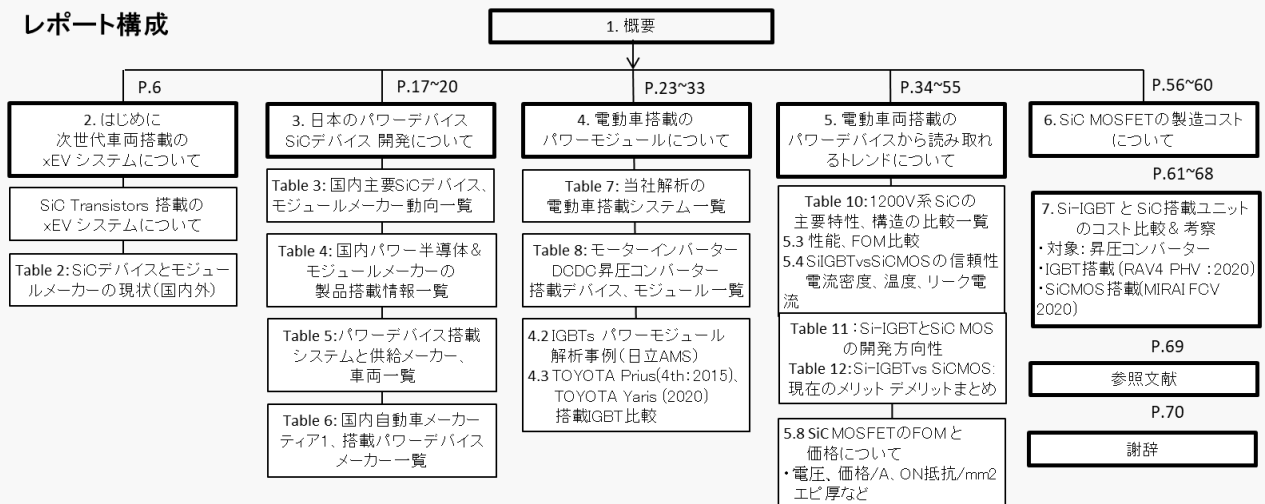
背景

地球温暖対策、カーボンニュートラルの実現に向けて、自動車の電動化が進み、各社実用化、市場競争が活発になっている。
電動化に際して「低損失」、「高信頼性」、「コスト」を決定する重要な部品のひとつとして、高耐压パワーデバイス(IGBT、RC-IGBT、SiC)があげられる。

エルテックでは、2015年から50以上の車載パワートレインを解析しており、それらの解析結果を元に、自動車メーカー、ティア1、半導体、モジュールメーカー動向、搭載情報、国内パワーデバイスについて、各社デバイス性能、コスト比較、IGBTからの置き換えによるメリット、コスト試算などをレポートしています。

レポート構成(目次)

レポート構成



【レポート抜粋】

Table 6: 国内自動車メーカーティア1、搭載パワーデバイスメーカー一覧

| No | Car Manufacturer | Electronics Parts Suppliers | Semiconductor Manufacturers | | | | | | | | | |
|----|----------------------|--|-----------------------------|----------|-----|--------------|-----------|---------|------|---------|---------|-------|
| | | | Infinion | ST-Micro | BYD | Mitsumi Elec | Fuji Elec | HITACHI | ROHM | Toshiba | Renesas | Denso |
| 1 | TOYOTA | Tier 1 DENSO AJSIN TOYOTA GOSEI TDK (DCDC) TOYOTA INDUSTRIALS (DCDC) In-house | | | | | | | | | | |
| 2 | HONDA | Tier 1 HITACHI Axiator (KEIHIN) HITACHI Axiator (HITACHI AMS) Mitsubishi Elec (DCDC) SHindengen In-house (Zama) | | | | | | | | | | |
| 3 | NISSAN | Tier 1 Marvell (CALSONIC KANSEI) Marvell (Magneti Marelli) TDK (DCDC) | | | | | | | | | | |
| 4 | MITSUBISHI | Tier 1 Mitsubishi Elec DENSO | | | | | | | | | | |
| 5 | MAZDA | Tier 1 DENSO | | | | | | | | | | |
| 6 | SUBARU | Tier 1 Mitsubishi Elec | | | | | | | | | | |
| 7 | SUZUKI | Tier 1 Mitsubishi Elec | | | | | | | | | | |
| 8 | VW | Tier 1 Bosch | | | | | | | | | | |
| 9 | AUDI | Tier 1 HITACHI Axiator (HITACHI AMS) | | | | | | | | | | |
| 10 | Daimler Benz | Tier 1 ZF HITACHI AMS | | | | | | | | | | |
| 11 | BMW | Tier 1 Delphi | | | | | | | | | | |
| 12 | Jaguar | Tier 1 Continental | | | | | | | | | | |
| 13 | Peugeot | Tier 1 Continental | | | | | | | | | | |
| 14 | TESLA | In house In house | | | | | | | | | | |
| 15 | Ford | Tier 1 HITACHI Axiator (HITACHI AMS) | | | | | | | | | | |
| 16 | GM | Tier 1 LG Electric | | | | | | | | | | |
| 17 | Guangzhou Automobile | Tier 1 Necel | | | | | | | | | | |
| 18 | Geely Automobile | Tier 1 Delphi | | | | | | | | | | |
| 19 | BYD | Tier 1 BYD | | | | | | | | | | |
| 20 | SAIC Motor | Tier 1 Fosch | | | | | | | | | | |
| 21 | Hyundai | Tier 1 Hyundai Mobis | | | | | | | | | | |

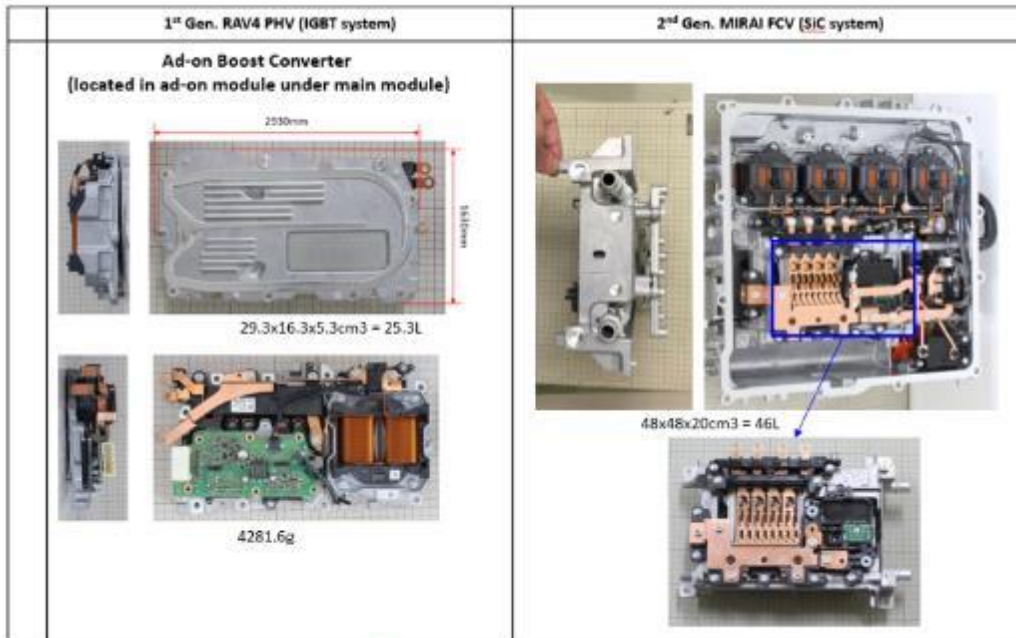
Table 8: モーターインバーター DCDC昇圧コンバーター 搭載デバイス、モジュール一覧

| | Fuji Electric | HITACHI AMS | Denso | Denso | Denso | Keihin |
|---|--|------------------------------------|--|--|---|---|
| System | Product Identification 6MSB00V-07V-01 | Audi e-tron: 55 Quattro Inverter | 2016 TOYOTA Yaris PCU Traction Motor Inverter Power-card | 2016 TOYOTA Prius e-4 PCU Traction Motor Inverter Power-card | 2016 TOYOTA MIRAI FC Boost Converter Power-card | 2020 HONDA e PCU Traction Motor Inverter |
| Configuration | 3-Phase Inverter | 3-Phase Inverter Half-Bridge 3相 | 3-Phase Inverter Half-Bridge 3相 | 3-Phase Inverter Half-Bridge 3相 | 4-Phase Inverter DC/DC Boost Converter | 3-Phase Inverter Half-Bridge 3相 |
| VCC / C | -500 V, IC=500A | 300 V | 500 V | -500 V | 500 V, I=200A | 570 V |
| Power / Spec of Motor's Power | | Front: 125 kW Rear: 140 kW | 55 kW | 55 kW | 125 kW | 80 kW |
| Power Semiconductor Device | | | | | | |
| Transistor configuration per Half-Bridge Switch | | | | | | |
| Transistor chip size (mm ²) | | | | | | |
| Transistor Area per Switch (mm ²) | | | | | | |
| Free-wheeling Diode (FWD) chip size (mm ²) | | | | | | |
| Total System size (100 Y + 4 FWD) (mm ²) | | | | | | |
| VCE, VFS (V) / C-E saturation voltage @ Tj=25°C and IC = 2 A (ns) / VCE+FSV | | | | | | |
| Power Semiconductor Supplier | | | | | | |
| Module | | | | | | |
| Module Size | | | | | | |
| Cooling | | | | | | |
| 3-Phase (Half-Bridge) package size | | | | | | |
| Transistor Size per Switch (mm) | | | | | | |
| Thermal Resistance per Switch (Rth,jc @ 25°C) (K) | | | | | | |
| Cooling Configuration | | | | | | |
| Cooling fluid | | | | | | |
| Cooling structure | | | | | | |
| Pressure drop @ 30 L/min (Total) | | | | | | |
| Specific Thermal Resistance per Switch (Rth,jc) (K/A) | | | | | | |
| 部品名集 部品名集 | | | | | | |



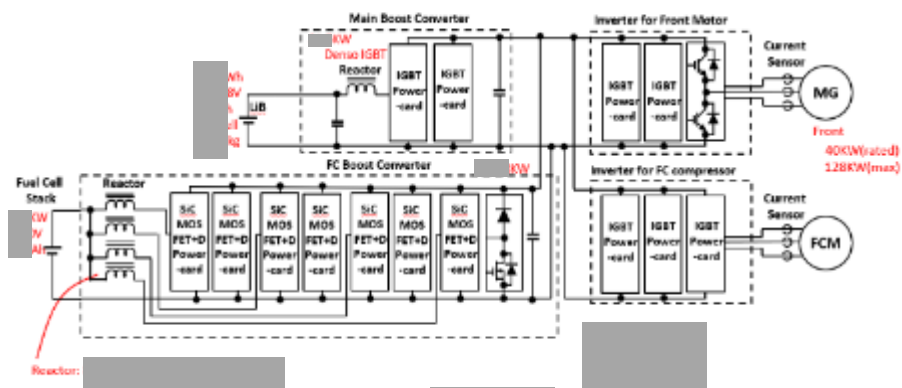
【レポート抜粋】

7.1 Analysis result of RAV4 and MIRAI



7.2 The 2nd Gen. MIRAI FCV, Boost Converter and Inverter Block Diagram

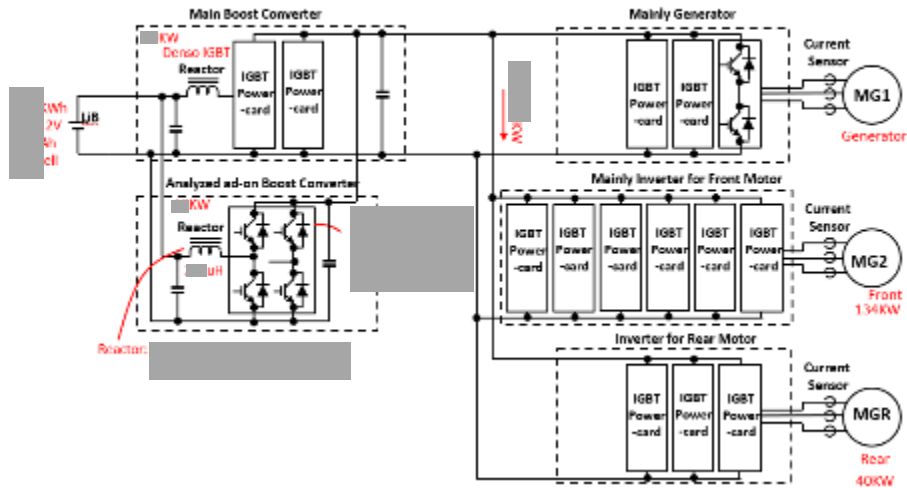
- PCU has 8 IGBT power-cards in main module portion, FC Boost module has 8 SiC MOSFET power-cards



【レポート抜粋】

7.3 The 1st Gen. RAV4 PHV, Boost Converter and Inverter Block Diagram

■ PCU has 14 IGBT power-cards in main module partition



IGBT has absolutely advantage in the simple cost comparisons. However, it is estimated that the case using SiC will increase in order to reduce the size due to space limitation.

| | SiC | | | SiC | |
|-------------------------|----------------------------------|-------------------------------|-----------------------------|--------------------------------|--------------------------------|
| | 1 st Gen. RAV4 PHV | 2 nd Gen. RAV4 PHV | MIRAI FCV when use IGBT | 2 nd Gen. MIRAI FCV | 3 rd Gen. MIRAI FCV |
| | Main converter + Ad-on Converter | Main converter | Built in the main converter | FC boost converter | Built in the main converter |
| Vbus | 355V | 355V | 650V | 650V | 650V |
| Transistor Vds | | | | | |
| Power Device | | | | | |
| Gate Driver | | | | | |
| Boost Controller | | | | | |
| Reactor | | | | | |
| Film Capacitor | | | | | |
| Current Sensor, Bus Bar | | | | | |
| AI Chassis | | | | | |
| Total cost | | | | | |

Note 1: It is quite difficult to use 1200V Si-IGBT due to speed drop and rise of switching losses in high voltage and high current condition. We think that this is one of the reason MIRAI uses SiC instead of IGBT.

