Automotive Power Module Packaging Comparison 2018

A Cost Oriented Technical Analysis Review

Power Semiconductor report by Farid Hamrani

July 2018 - Sample
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Executive Summary

The most recent market forecast by Yole Développement shows the global rise of power devices. The market for power module devices will follow that trend, with a 10.2% compound annual growth rate (CAGR) over the next five years. This will impact the power module packaging market, which will see a 9.5% CAGR, reaching a value of almost $1.8B.

The progress of electric and hybrid electric vehicles (EV/HEVs) is imposing new standards in terms of electrical equipment, pushing electronic components to work in non-conventional environments for longer. That poses the electronics industry new challenges regarding both performance and reliability. To meet these requirements, electronic systems have to be improved at both design and industrialization levels.

Power modules have come a long way since the early stages of car electrification. They are now playing a key role in the power modulation through all EV/HEVs, from inverters to bi-directional converters. Packaging these modules has become critical due to several technical aspects. They must combine good thermal and electrical efficiency while keeping low mass and volume. Also, to remain competitive in an open market, power module makers must deliver high reliability while remaining cost efficient.

In this report we analysed the physical composition and cost of ten modules for automotive applications from seven different manufacturers. We reviewed the different topologies and techniques used for the module packaging in such applications. We describe opening the modules, provide measurements and cross-sections, along with scanning electron microscope (SEM) and optical pictures. We analyse and simulate the cost of manufacturing and compare it to a summary panel.

This report includes comparison of the structures and costs of the different technological choices made by key manufacturers of the automotive industry.
The components analyzed are listed against.

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<td></td>
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<td>SKiM SKiM306GD12E4</td>
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<tr>
<td>STMicroelectronics</td>
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<td>Toshiba</td>
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<td>Toyota</td>
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This Market forecast by Yole Developpment is showing the rise of the global power market devices.

It also shows that the market for the Power Module devices will follow that trend with an estimated XXXincrease in the next five years.
Inverter Module – Views and Dimensions

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Introduction

Physical & Cost Analysis
- Bosch
- Infineon
- Mitsubishi
- Semikron
- ST Microelectronics
- Toshiba
- Toyota

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Infineon Hybridpack 2 – Cross Section

- With two \( \text{xxxx} \)\( \mu \text{m} \) thick copper plates and an \( \text{xxxx} \)\( \mu \text{m} \) layer of \( \text{xxxx} \)\( \mu \text{m} \) the total thickness of the DBC is \( \text{xxxx} \)\( \mu \text{m} \).
- We can see that the copper baseplate and the DBC are connected together by with solder joint of \( \text{xxxx} \)\( \mu \text{m} \).
# HybridPACK DSC – Assembly Cost Analysis

## Module Assembly Process Flow

<table>
<thead>
<tr>
<th>Process Operation</th>
<th>TOTAL COST</th>
<th>Breakdown</th>
</tr>
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<tbody>
<tr>
<td><strong>MODULE ASSEMBLY</strong></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Die placing</td>
<td>$0.06561</td>
<td></td>
</tr>
<tr>
<td>$0.05942</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>Spacers pick &amp; place</td>
<td>$0.31297</td>
<td>33%</td>
</tr>
<tr>
<td>Reflow</td>
<td>$0.31503</td>
<td>10.8%</td>
</tr>
<tr>
<td>Solder deposition</td>
<td></td>
<td>2.4%</td>
</tr>
<tr>
<td>Post Mold Cure</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$5.00</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Module Steps Cost

- Baseplate Cleaning + rinsing +...
- Solder screen printing on...
- Die placing
- Reflow on DBC
- Visual Inspection...
- Unpacking terminals
- Solder screen printing on DBC
- Leadframe pick & place
- Spacers pick & place
- Reflow
- Solder deposition
- Emitter plate placing
- X-Ray inspection
- Wire Bonding on DBC
- Transfer molding press
- Post Mold Cure

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CoolIR – Assembly Cost Analysis

- The total price for the parts & assembly of this module adds to a grand total of $XX.
- This includes $XXX of external parts (XX% of final price) and $XX of assembly. The losses during the assembly operations come down to $XX.
Case Module – Cross-Section

Module detail - cross-section view
Above is a representation of the cost breakdown evolution for each studied module packages classified by packaging technologies. We can see the impact of external parts (housing leadframes...) the added value (labor, machine cost...) and the cost of losses. The impact of the external parts have can interfere with the final prices. Especially the PinFin baseplate on the modules from Infineon. But this choice from the German manufacturer is to combine this baseplate/radiator for the best thermal efficiency. An additional cost that as to be added at system level for the other configurations.
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