In 2016, the power module market was worth almost $3.2B and from there it will grow steadily for the next five years. As of 2016, almost 40% of the power module cost concerns raw materials used for packaging. Materials for die-attach, substrate-attach, substrate, baseplate, encapsulation, interconnections and casings constitute a $1.1B market in 2016. This market will grow and reach $1.8B by 2021. Yet the growth will not be even across all raw material markets. Die-attach materials have the highest forecast compound annual growth rate (CAGR) for 2016-2021, at over 13%. Casings and encapsulation have the lowest CAGR, at 5-7% for 2016-2021. The main differences arise from technology choices for those materials and their impact on the each market segment. For instance, the greater presence of epoxy resin will reduce the cost of encapsulation in power modules.

Substrates and baseplates account for half of the packaging raw material market, and together are worth over $550M. Therefore, the choice of technology in ceramic substrates or baseplates can have a great impact on final power module cost. Around 25% of the cost is related to die-attach or substrate attach material. The rest of the cost is divided between encapsulation, interconnections and the casing.

Industrial applications remain the biggest part of the power module market. However, the electric and hybrid car market, with its double digit growth forecast for the period 2016-2021, will represent around 40% of this market by 2021. Moreover, the automotive industry is leading in technological innovations in packaging, helping and accelerating the implementation of these new technologies thanks to high manufacturing volumes.

THE POWER MODULE MATERIAL MARKET WILL GROW AT 9.5% PER YEAR FROM 2016-2021, REACHING ALMOST $1.8B

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In recent years, several new power module designs have emerged, principally driven by the severely challenging requirements for high power density and integration from the automotive industry. Indeed, electric and hybrid cars are the best example of technology innovation in the design of power modules. The Toyota Prius’ fourth generation double-sided cooling power modules might be the most well-known example. Yet today many other module manufacturers are also proposing new designs that move away from conventional power module layers and technologies. In this report, Yole Développement shows the latest power module designs with their cross sections, explanations about materials used, etc.

The innovations in power module design will not be made without impacting the materials and processes used in power module packaging. The role of the ceramic substrate and baseplate is being rethought, as in order to achieve smaller and better integrated power modules. A trend towards layer suppression has clearly been adopted in those industries where size, weight and integration is a must. Again, principally in the automotive industry, direct cooled baseplates using pin-fins have become common. They avoid the use of Thermal Interface Materials (TIMs) that are responsible for a considerable part of the thermal resistance and form voids over time, deteriorating the thermal conductivity and reliability even more. IGBT dies directly soldered to leadframes have also appeared, enabling a highly conductive substrate, but still requiring some sort of electrically insulating layer. Power modules designed for double-sided cooling will use epoxy resin encapsulation and wire-bond-free interconnections. On the substrate side, both ceramic and leadframe options could be used. Yole Développement has also analyzed the other industries where the classical power module design will persist. However, even in those cases very interesting advanced material technologies will come to enhance their reliability, robustness and thermal/electrical efficiency. Silver sintering is obviously one of the big stars, as a growing number of players are being seduced by this technology as a replacement for soldering in die attach. The report highlights the advantages of sintering, but also the remaining manufacturing barriers that it must overcome to be widely adopted by the industry. The differences between Al2O3, AlN and Si3N4 ceramics and the expansion of the highly thermally conductive AlN and Si3N4 over coming years will be explained. AlN will continue its growth in industrial and renewable energy markets, while a strong push for Si3N4 could come from the automotive industry.

The arrival of wide-band gap devices using SiC and GaN semiconductor materials calls for specially-adapted packaging solutions. Encapsulation technologies must...
evolve to handle high operating temperatures. Standard silicone gel and epoxy are limited in terms of temperature, and new materials such as parylene are being developed, although still struggling with high costs. Low-inductance interconnections, and die attach compatible with high operating temperatures are also needed.

All these technology trends are creating opportunities for some material suppliers, but at the same time, they are threatening some of today’s businesses for power packaging. The most obvious case is the risk for TIM suppliers that direct cooled baseplates could result in no need for TIMs. Also, the largely used aluminum wire bonding solution can be supplanted by top leadframe connections, flexible interconnection foils or copper and gold wire bonding. Meanwhile, double sided cooling technology will open a second market for top die-attach connection for solder and sintering solution suppliers. Thereby, it is crucial to understand the synergies and impacts of the technology choices on the other materials or technology solutions.

Yole Développement’s report summarizes these synergies with illustrative visual figures.

COMPANIES CITED IN THE REPORT (non exhaustive list)

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REPORT OBJECTIVES
• Provide power module packaging market analysis and forecasts
• Provide a deep insight into state-of-the-art package designs and materials
• Describe actual discrete devices packaging and innovations
• Identify the key technology trends that will shape the market in the future
• Understand the main challenges and proposed innovations
• Provide supply chain analysis and trends

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ABOUT YOLE DEVELOPPEMENT

Founded in 1998, Yole Développement has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole Développement group has expanded to include more than 50 collaborators worldwide covering MEMS, Compound Semiconductors, LED, Displays, Image Sensors, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Nanomaterials, Power Electronics and Batteries & Energy Management.

The “More than Moore” company Yole and its partners System Plus Consulting, Blumorpho, KnowMade and PISEO support industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to develop their business.

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