Headline: Delivering the automotive quality IC packaging technology solution that is helping to define the shape of the automotive industry

Standfirst: The benefit of consistent and predictable growth in the automotive market comes with demanding performance and quality requirements. The challenge of meeting the demand for new enabling technologies can be managed through strategic partnerships with specialist suppliers.

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The growth in demand for semiconductors designed to service the automotive industry has been consistent for a decade and it shows no indication of abating. In fact, the expansion is even more stable than in other markets thanks to the continued electrification of the automobile, driven in no small way by the adoption of ADAS (Advanced Driver Assistance Systems) and autonomy, along with increasing demand for safety, connectivity (in part to support autonomy) and the appeal of greater comfort.

Thanks to these continued trends, analysts predict the automotive semiconductor market will grow by around 6% per year through to 2022. And while this represents total growth, the strongest application areas within the automotive market will be electrification (19%) and ADAS (15%) (source: Prismark).

This includes the electrification of existing functions, from the drivetrain to seat adjustment, and is responsible for the consistent demand for new and improved solutions as the automotive industry strives to deliver greater efficiency. However, the emerging opportunity is also to deliver new solutions, developed specifically to support the features that will help stimulate the growth in autonomy. Examples here include the use of vision systems to provide guidance, navigation and safety features. In the same category, the industry is experiencing the rapid uptake of Image sensors (cameras), RADAR and, more recently, LiDAR systems that are used almost exclusively by the vehicle’s own systems, rather than the human driver, to support greater levels of autonomous driving.

Figure 1: *Overview over automotive applications and components*

The Automotive Market Leaders
Like most other semiconductor sectors, the automotive semiconductor supply chain is dominated by companies that fall into four broad groups: Foundries, Tier 1s, IDMs (Integrated Device Manufacturers) / Fabless and OSATs (Outsourced Semiconductor Assembly and Test). While foundries provide the main wafer manufacturing services for the wafers, OSATs provide the required assembly and test services, deferring these critical stages to specialist suppliers such as UTAC who are better placed to make the ongoing investments needed to develop the leading-edge solutions and provide the highest quality now demanded by the automotive industry. Of course, IDMs still sustain a certain percentage of their own fabrication, assembly and test functions, but they too are increasingly turning to OSATs for packaging and test solutions and services.

The total available market for automotive semiconductors is dominated by ten companies who, together, account for around 70% of all sales. Their relative position in the league table may change over time, but the companies at the top of this list remain steadfast and include NXP Semiconductors, Infineon Technologies, Renesas Electronics, Texas Instruments, ST Microelectronics and ON Semiconductor. While there are many OSATs around the world, the outsourced assembly and test services for the automotive market is dominated by only three OSATs, including UTAC.

OSATs in automotive
Due to the proliferation of package types now being utilized in automotive applications, more IDMs are turning towards OSATs to help them develop products faster while still meeting the requirements for safety, quality, reliability and overall design integrity.

OSATs that are already qualified to the International Automotive Task Force's (IATF) ISO/TS 16949 standard are well placed to provide the right services. This is one of the global automotive industry’s most widely applied quality management standards, based on ISO 9001:2015. As such, it forms a supplement to what would otherwise be a more general quality management system, adding requirements developed specifically for the automotive market.

The main challenges that OSATs now face include ratifying “zero defect” quality levels with the mindset of ever lower cost. Additionally, the need for increased performance is creating demand for packages that can combine lower conduction losses and inductances with greater thermal conductivity. This is influenced by the existing and emerging applications for semiconductors within vehicles. The cost of investing in the development and the equipment needed to produce some of these advanced packaging solutions is causing more foundries and IDMs to use OSATs that are proven to deliver the right solutions.

Additionally, it can take anywhere between two to four years to qualify and realize meaningful revenue from automotive business. In contrast, one can realize revenue for some consumer products in six months. Given the stringent qualification requirements and the long road to realize revenue, many OSATs cannot or do not want to participate in automotive assembly and test. However, once qualified the reward can be steady flow of revenue for ten years or more.

Packaging technologies for the automotive industry

Digital processing forms a large part of the next phase in automotive operation and, here, the trend is towards higher pin count packages, including BGAs. The use of QFP continuous to rise, as it offers greater pin density. Analog components continue to favor leadframe, with demand for QFN type packages growing significantly.

The high-power requirements associated with motor control has historically seen the use of ceramic boards, however, there is a shift towards the use of molded packages and metal insulated board mounting solutions. Leadframe remains the preferred packaging for power devices, although the demands being put onto these semiconductor devices, including lower on-resistance and higher frequency operation, is creating demand for new types of packaging that can minimize parasitic capacitance and inductance, such as Copper Clip Interconnect.

One of the drivers for these trends is the increased demand for processing power that is associated with ADAS, autonomy and general electrification. The microprocessors used in the automotive industry are now much more powerful, moving from simple 8-bit devices that could be accommodated in TSSOP packages with pin counts in the region of 100, to 32-bit processors with as much as 600 pins or more. The Flip-Chip Ball Grid Array (FCBGA) is an example of the type of package now used for these devices.

The AEC-Q100 specification provides five grades differentiated by their operating temperature excursions. Grade 0 offers the widest window of -40℃ to +150℃, while Grade 4 covers 0℃ to +70℃. In general terms, components associated with chassis electronics and safety, ADAS and body electronics must be qualified to Grade 1 (-40℃ to +125℃), while components in the powertrain are typically qualified to Grade 0.

The automotive industry is increasingly calling for “Zero Defects”, that is zero failures in the field. This puts even more pressure on manufacturers who must not only ensure that the semiconductor is entirely fault-free but that the packaging and the process of soldering the package to the circuit board are achieved in a way that prohibits the potential for failure.

In general, this relates to how readily the package can be used in the manufacturing process and, here, the dominant method for quality assurance with stringent quality control involves automated inspection processes, more specifically Automatic Optical Inspection (AOI), as well as x-ray.

QFN packaging with a wettable terminal flank, designed with side lead plating (SLP), is now a requirement for automotive applications. This delivers a solder fillet that provides an inspectable joint for AOI equipment, and the use of this packaging technology has dramatically increased the adoption of QFN in the automotive industry.

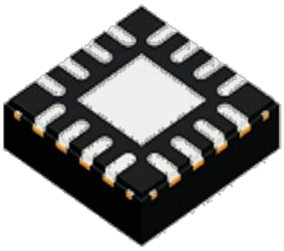

Figure 2: *SLP QFN package*

As well as SLP QFN, the development of Copper Clip Interconnect, or Cu Clip, is being used by many leading IDMs supplying power semiconductor devices to the automotive industry. Cu Clip can support higher currents than wire bond interconnects, as well as delivering lower resistance and reduced inductance. Its high-power credentials have been exploited in discrete power transistors for many years, and now the manufacturing processes exist to allow Cu Clip to be applied in multichip packages, to bring together control and power in a single device. MOSFETs, the transistor technology used in high power applications, require an additional low power transistor to drive them; the integration of the driver and power stages in a single package has many benefits for many markets, but in automotive applications it can directly result in higher efficiency, greater reliability and a smaller Bill of Materials, as well as reduced total footprint. Because of its ability to handle higher levels of power density, Cu Clip is now popular in a range of applications including regulators and converters, point of load supplies and general power modules.

Other important packaging technologies now being utilized by the automotive industry include System in Package (SiP). The value proposition here is multifarious; SiP can deliver a smaller total solution with higher overall performance levels and subsequently a more optimized end-product. As the name may suggest, SiP is a way of encapsulating several components that operate together in a single package.

Commonly this would allow a processor and its associated RAM and non-volatile memory to be mounted on a substrate alongside the power management components.

With more complex supply chains emerging to support the new features found in autonomous vehicles, a SiP approach can allow multiple semiconductor manufacturers, comprising both IDMs and fabless companies, to collaborate more easily to develop and deliver next-generation solutions. In this new model, OSATs will provide a crucial level of expertise and capabilities.

MEMS (Micro-Electro-Mechanical Systems) technology has been in use in the automotive market for years, primarily in the air-bag sensor application. However, with the significant improvement in various kinds of MEMs sensors, its use is also on the increase in other automotive applications. The type of MEMS devices now being used include oscillators, magnetometers, accelerometers and gyroscopes, as well as pressure and temperature sensors. The range of options in MEMS packaging includes conventional and cavity QFN, cavity and over-mold LGA, as well as SOIC.

Conclusion

Semiconductor packaging technologies are intrinsic in delivering the need for more efficient, more integrated and more reliable devices to enable the current trends within the automotive market. These include the continued electrification of vehicles, the adoption of more autonomy, increased connectivity and continued improvements in comfort. Meeting all demand requires innovative package solutions of high quality that require sustained investment; increasingly, OSATs are best placed in the automotive semiconductor supply chain to deliver that investment and provide the best service.

UTAC is a leading independent OSAT serving the automotive market, with certification that includes ISO/TS 16949:2016 and ISO 26262. It has expertise in the assembly and test of semiconductors across multiple vertical sectors and is particularly well placed to support IDMs and fabless semiconductor companies targeting the automotive market.

Quality is a key differentiator for UTAC, which is evident in its manufacturing processes. The fabrication process for semiconductor wafers is highly automated, not only because it provides repeatability but also because it supports the need for totally clean environments during the delicate stages of semiconductor fabrication. Assembly and test are typically less automated, relying instead on operators and while this is recognized across the industry, UTAC operates at a much higher level of automation than other OSATs. This has enabled it to achieve failure incidents measured in parts per billion. UTAC is rightfully very proud of the quality it delivers; it is a significant contributor towards achieving Zero Defect in automotive semiconductors.

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