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What can we expect from autonomous vehicles?

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There is a lot of evidence to show that ADAS (Advanced Driver Assistance Systems) can make vehicles safer, with many consumers expressing a desire to see these systems evolve into full autonomy. However, there is a degree of mystery surrounding the journey from the ADAS systems in the semi-autonomous vehicles of today to fully autonomous Level 5 vehicles.

This article will describe the ADAS systems we can expect to see in vehicles during that evolution and how the semiconductor industry is addressing this trend, in terms of the underlying technologies needed to support them.

How cars are changing, from a technology perspective

The continued electrification of the automobile means that the vehicles of today bear very little resemblance to their counterparts from a decade ago. This is largely due to the adoption of electronics in practically every aspect of vehicle management. However, the emergence of ADAS systems is another significant contributing factor that has been driven by increased demands for enhanced connectivity (in part to support autonomy), more stringent safety standards and greater comfort for both drivers and passengers.

Indeed, electronics industry analyst firm Prismark predict that the automotive electronics market will grow from $199B to $289B by 2022, as shown in Fig 1. Interestingly, this represents a 45% increase despite vehicle production being estimated to grow by 13% in the same period. One reason for that is because the amount of electronic content per vehicle is predicted to rise from approx. $2,000/vehicle in 2016 to $2,700 in 2022, with the strongest application areas being electrification (19%) and ADAS (15%).

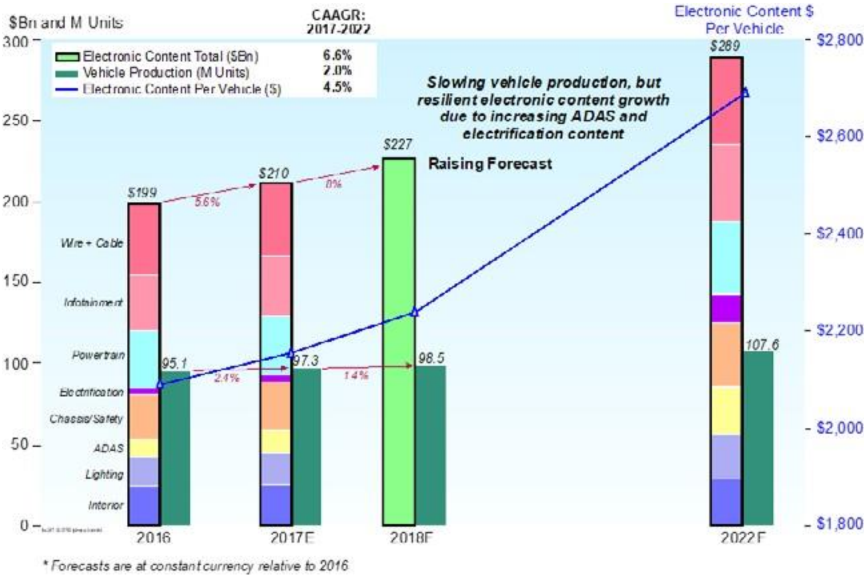

Figure 1: Automotive electronic market 2016-2022. SOURCE: Prismark Oct'18

ADAS systems in use today

Levels of autonomy in vehicles are currently graded from 0-5, with Level 0 representing traditional vehicles where the driver retains full control in all instances and standard passive sensors are used in areas such as air bags and tyre pressure measurement.

More recently, automotive manufacturers have introduced new electronic systems to enable driver assistance in vehicles, which has stimulated the growth in autonomy. This has led to the emergence of semi-autonomous vehicles featuring Level 1 and 2 ADAS systems. In turn, this has driven the requirement for a greater number and variety of sensor modules to be integrated within vehicles, such as added accelerometers and gyros, ultrasonic sensors and steering wheel angle sensors. This has been complemented with fast adoption of vision systems to enhance navigation and guidance, along with image sensors (Rear, front and surround view cameras), RADAR and blind spot detection systems to improve safety. In addition, ADAS systems are used to support automatic emergency braking systems, lane keep assist and parking assist functions.

Autonomous tomorrow

More recently, light detection and ranging (LiDAR) sensor modules have begun to be adopted to support greater levels of autonomous driving. LiDAR systems are used almost exclusively by a vehicle's own systems, rather than the human driver, and are set to be integrated in the first generation of Level 3 semi-autonomous vehicles. Level 3 vehicles are expected to feature ADAS systems to support automated driving in specific situations such as parking and highway driving. It is estimated that up to 10 million Level 3 vehicles will be produced per year between 2020-2025 as the automotive industry moves towards Level 4 adoption.

LiDAR systems are also deemed essential for fully autonomous Level 4 vehicles, which are predicted to be introduced in volumes of 5 million vehicles per year between 2025-2030. Indeed, many IDMs, as well as design houses, are already working on solid-state LiDAR technology that requires a fully customised packaging solution utilising advanced technology and materials.

As the industry moves towards Level 3 adoption and beyond the number of sensor modules required to support ADAS systems is expected to grow significantly. This is particularly true at Levels 4/5 as shown in Fig 2., which shows the estimated growth in the number of Camera, RADAR and LiDAR sensor modules required per vehicle at each level of automation.

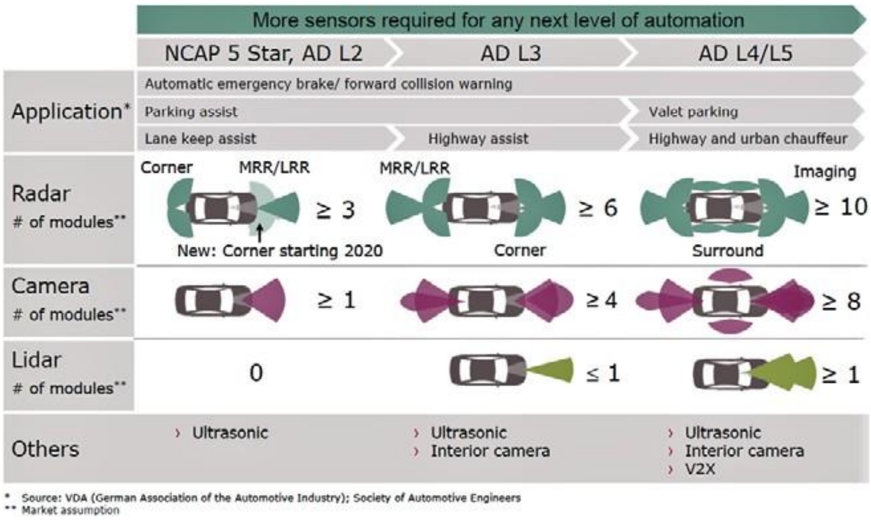

Figure 2: Number of radars, camera and LIDAR modules per vehicle per level of automation.
SOURCE: © Infineon Technologies AG.

Ultimately, it is anticipated that Level 4/5 vehicles will include ADAS systems that monitor or control practically every aspect of the driving environment. From a technological perspective, this will encompass the likes of system networking and sensor fusion. Meanwhile, from a guidance and navigation point of view it will likely see ADAS systems directly influence and implement distance measurement, traffic sign recognition, lane reconstruction, precise positioning, and real-time mapping functions. Perhaps most importantly, it may also take away all manual decision-making from drivers with respect to critical arbitration in potential collisions and driving rules implementation.

How the semiconductor packaging industry is preparing

Semiconductor packaging technologies are intrinsic in enabling the current trends within the automotive market, with OSATs (Outsourced Semiconductor Assembly and Test) already gearing up to support the move towards more advanced ADAS systems and greater levels of autonomy in vehicles.

One area that is expected to form a major part of the next phase in automotive operation is digital processing. The trend here is towards higher pin count packages, including BGAs. The use of QFPs with finer pitch continues to rise because they provide greater pin density and it is a well-established automotive packaging solution. It is also anticipated that analog devices will continue to rely on leadframe, with QFN type packages increasing in demand as a result.

Furthermore, while ceramic boards have traditionally been used, because of the high-power requirements of motor control applications, there is now a move towards using molded packages and metal insulated board mounting solutions. Although leadframe remains the preferred packaging for power devices, the demand for higher frequency operation and lower on-resistance has led to the introduction of new packaging types that can minimize parasitic inductance and capacitance. One example of this is Copper Clip Interconnect, or Cu Clip for short, which enables lower RDSon and improved switching performance.

The move towards greater autonomy and electrification in vehicles has also created demand for greater processing power. As a result, the automotive industry is now using far more powerful microprocessors. This has led to a move away from basic 8-bit devices, with pin counts of approx. 100, to 32-bit processors in excess of 600 pins. An example of the type of package now used for these devices is the Flip-Chip Ball Grid Array (FCBGA).

Another major trend in the automotive industry is the demand for zero failures in the field. This call for “Zero Defects” has placed a greater onus on semiconductor packaging companies, who need to ensure their devices are completely fault-free. As a result, the packaging and process of soldering the package to the circuit board must be carried out in a way that eliminates any potential failures.

This primarily relates to how easily a semiconductor package can be applied in the manufacturing process. To ensure stringent quality control and assurance it is now standard practice to follow automated inspection processes, more specifically Automatic Optical Inspection (AOI).

On a related note, QFN packages with wettable terminal flank, featuring side lead plating (SLP) is the standard for automotive application. It delivers a solder fillet that provides an inspectable joint for AOI equipment, with the adoption of this packaging technology significantly increasing the use of QFN in the automotive industry.

Along with SLP QFN, Cu Clip technology is being used by many suppliers of semiconductor devices to the automotive industry as Cu Clips enable higher current-carrying capacity than wire bond interconnects, as well as providing reduced inductance and resistance. The high-power credentials of Cu Clip have already been utilised in discrete power transistors, and the manufacturing processes now exist to allow it to be applied in multichip packages, to combine power and control in a consolidated device.

Conclusion

As the automotive industry introduces greater levels of autonomy in vehicles, semiconductor packaging technologies will prove crucial in delivering more integrated, reliable, and efficient devices that will enable the adoption of more advanced ADAS systems. The move from the semi-autonomous vehicles of today up to full autonomy at Levels 4 and 5 is predicted to continue at an ever-faster pace, with ADAS systems integral to delivering enhanced navigation, increased safety, greater connectivity and continued improvements in comfort. Meeting all these challenges requires innovative package solutions of high quality and OSATs are ideally positioned in the automotive semiconductor supply chain to deliver that service.

UTAC is the third largest OSAT among the automotive OSAT suppliers. With its state-of-the-art automotive assembly and test service, UTAC's automotive quality is one of the highest in the industry. 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.

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