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The automotive electronics market: A view from a material supplier

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With the increasing sophistication of future vehicles, new and more advanced semiconductor technologies will be used and vehicles will become technology centers.

Large efforts are being deployed in the car industry to transform the driving experience. Electrical vehicles are in vogue and governments are encouraging this market with tax incentives. Cars are becoming smarter, capable of self-diagnostics, and in the near future will be able to connect with each other. Most importantly, the implementation of safety features has greatly reduced the number of accidents and fatalities on the roads in the last few decades. Thanks to extensive computing power, vehicles are now nearing autonomous driving capability. This is only possible with a dramatic increase in the amount of electronic devices in new vehicles.

Recent announcements regarding acquisitions of automotive electronics specialists by semiconductor giants and strategic plans from foundries highlight the appetite from a larger spectrum of semiconductor manufacturers for this particular market. Automotive electronics has become a major player in an industrial transformation.

Automotive electronics is, however, very different from the consumer electronics market. The foremost focus is on product quality, and the highest standards are used to ensure the reliability of electronics components in vehicles. This has also an impact on the quality and supply chain of materials such as gases and chemicals used in the manufacturing of these electronics devices.

Automotive electronics market: size and trends

When you include integrated circuits, optoelectronics, sensors, and discrete devices, the automotive electronics market reached around USD 34 billion in 2016 (**FIGURE 1**).

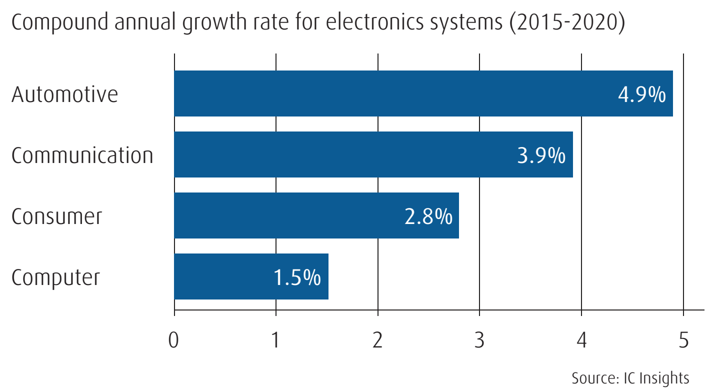

FIGURE 1. Compound annual growth rate for electronics systems (2015-2020).

While this represents less than 10% of the total semiconductor market, it is predicted to be one of the fastest growing markets over the next 5 years.

There are several explanations for such growth potential:

- The vehicle market itself is predicted to steadily grow on an average 3% in the coming 10 years and will be especially driven by China and India, although other developed countries will still experience an increase in sales.
- The semiconductor content in each car is steadily increasing and it is expected that the share of electronic systems in the vehicle cost could reach 50% of the total car cost by 2030 (**FIGURE 2**).

While it is clearly challenging to describe what the driving experience will be in 10 to 15 years, some clear trends can be identified:

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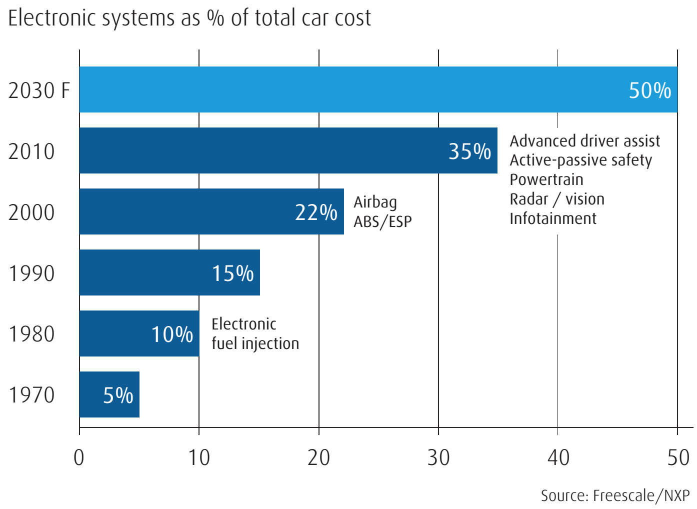


FIGURE 2. Electronic systems as % of total car cost.

- **Safety:** The implementation of integrated vision systems, in connection with dozens of sensors and radars, will allow thorough diagnoses of surrounding areas of the vehicles. Cars will progressively be able to offer, and even take decisions, to prevent accidents.

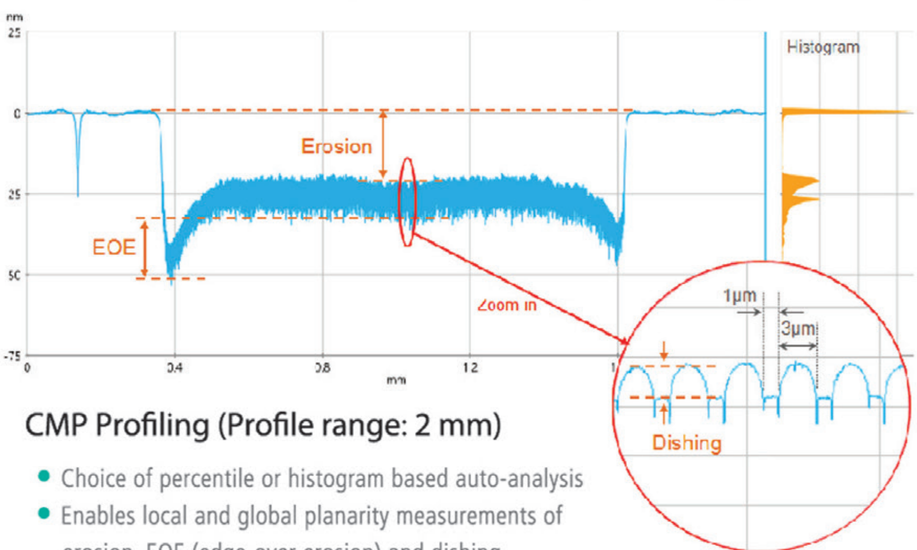
- **Fuel efficiency:** The share of vehicles equipped with (hybrid) electrical engines is expected to steadily grow. For such engines, the electronics content is estimated to double in value compared to that of standard combustion engines.

- **Comfort and infotainment:** Vehicle drivers are constantly demanding a more enhanced driving experience. The digitalization of dashboards, the sound and video capabilities, and the customization of the driving and passenger environment should heighten the pleasure of time spent in the vehicle.

In order to coordinate all these functions, communication systems (within the vehicle, between vehicles, and between vehicles and infrastructures) are critical and large computing systems will be necessary to treat large amount of data.

Quality really makes automotive electronics different

Automotive electronics cannot be defined by specific technologies or applications. They are currently



Typical operating conditions for different electronics market segments

	Consumer	Industrial	Automotive
Temperature	0 to 40°C	-10 to 70°C	-40 to 160°C
Operation time	2 to 5 years	5 to 10 years	Up to 15 years
Humidity	Low	Environment	0% to 100%
Supply	Average 1 year	2 to 5 years	Up to 30 years
Tolerated failure rate	<10%	<<1%	Target: 0% failure

FIGURE 3. Typical operating conditions for different electronics market segments.

characterized by a very large portfolio of products based on mature technologies, spanning from discrete, optoelectronics, MEMS and sensors, to integrated circuits and memories.

Until now, the automotive electronics market has been the preserve of specialized semiconductor manufacturers with long experience in this field. The reason for this is the specific know-how required for quality management.

A component failure that appears harmless in a consumer product could have major safety consequences for a vehicle in motion. Furthermore, operating conditions of automotive electronics components (temperature, humidity, vibration, acceleration, etc.), their lifetime, and their spare part availability are differentiators to what is common for consumer and industrial devices (**FIGURE 3**).

Currently, some of the most technologically advanced vehicles integrate around 450 semiconductor devices. As they become significantly more sophisticated, the semiconductor content will drastically increase, with many components based on the most advanced semiconductor technology available. Introducing artificial intelligence will require advanced processors capable of computing massive amount of data stored in high-performance and high capacity memory devices. This implies that not only the most advanced semiconductor devices will be used, but that these will need to achieve the highest degree of reliability to allow a flawless operation of predictive algorithms.

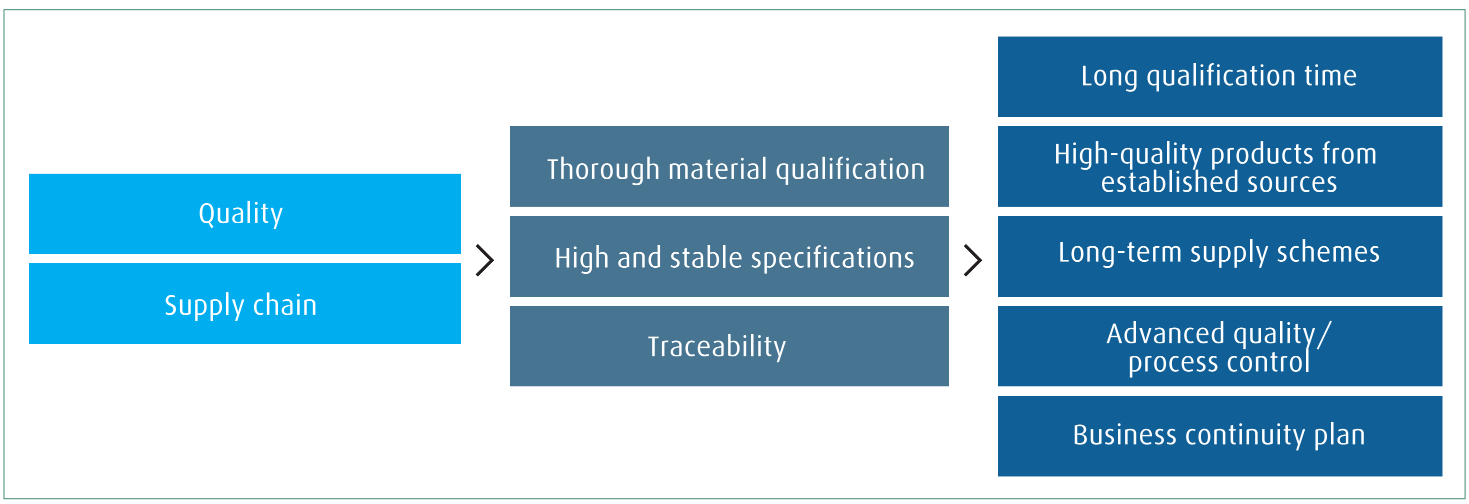


FIGURE 4. There are essentially two fields where the material supplier can support its customer: quality and supply chain.

It is expected that smart vehicles capable of fully autonomous driving will employ up to 7,000 chips. In this case, even a failure rate of 1ppm, already very low by any standard today, would lead to 7 out of 1,000 cars with a safety risk. This is simply unacceptable.

The automotive electronics industry has therefore introduced quality excellence programs aimed at a zero defect target. Achieving such a goal requires a lot of effort and all constituents of the supply chain must do their part.

The automotive electronics industry is one of the most conservative in terms of change management. Long established standards and documentation procedures ensure traceability of design and manufacturing deviations. Qualification of novel or modified products is generally costly and lengthy. This is where material suppliers can offer competence and expertise to provide material with the highest quality standards.

What does this mean for a material supplier?

As a direct contact to its customer, the material supplier is responsible for the complete supply chain from the source of the raw material to the delivery at the customer's gate. The material supplier is also accountable for long-term supply in accordance with the customer's objectives.

There are essentially two fields where the material supplier can support its customer: quality and supply chain (**FIGURE 4**).

Given the constraints of the automotive electronics market, material qualification must follow extensive procedures. While a high degree of material purity is a prerequisite, manufacturing processes are actually much more sensitive to deviations of material quality, as they potentially lead to process recalibration. Before qualification starts, it is critical that candidate materials are comprehensively documented. This

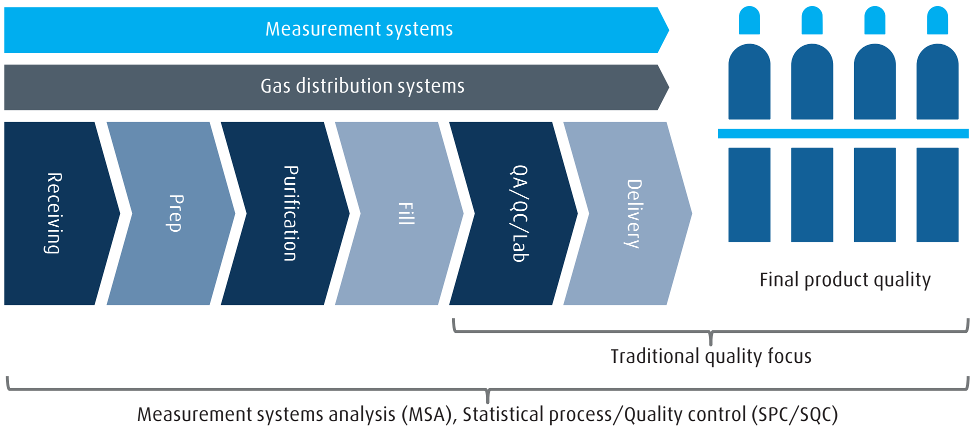


FIGURE 5. Several tools must be implemented in order to maintain a reliable supply chain of high-quality products.

includes the manufacturing process, the transport, the storage, and, where appropriate, the purification and transfill operations. Systematic auditing must be regularly performed according to customers' standards. As a consequence, longer qualification times are expected. Any subsequent change in the material specification, origin, and packaging must be duly documented and is likely to be subject to a requalification process.

Material quality is obviously a critical element that must be demonstrated at all times. This commands the usage of high-quality products with a proven record. Sources already qualified for similar applications are preferred to mitigate risks. These sources must show long-term business continuity planning, with process improvement programs in place. Purity levels must be carefully monitored and documented in databases. State-of-the-art analysis methods must be used. When necessary, containment measures should be deployed systematically. Given the long operating lifetime of automotive electronic components, failure can be related to a quality event that occurred a long time before.

Because of the necessary long-term availability of the electronics components and the material qualification constraints, manufacturers and suppliers will generally favor a supply contract over several years. Therefore, the source availability and the supply chain must be guaranteed accordingly.

Material suppliers are implementing improved quality management systems for their products in order to fulfill the expectations of their customers, in terms of quality monitoring and traceability. Certificate of analysis (COA) or consistency checks are not sufficient anymore; more data is required. In case deviation is detected, the investigation and response time must be drastically reduced and allow intervention before delivery to the customer. Finally, the whole supply chain must be monitored.

Several tools must be implemented in order to maintain a reliable supply chain of high-quality products (**FIGURE 5**): statistical process and quality controls (SPC/SQC), as well as measurement systems analysis (MSA), allow systematic and reliable measurement and information recording for traceability. Implementing these tools particularly at the early stages of the supply chain allows an "in-time" response and correction before the defective material reaches the customer's premises. Furthermore, some impurities that were ignored before may become critical, even below the current detection limits. Therefore, new measurement techniques must be continuously investigated in order to enhance the detection capabilities.

Finally, a robust supply chain must be ensured. It is imperative for a material supplier to be prepared to handle critical business functions such as customer orders, overseeing production and deliveries, and other various parts of the supply chain in any situation. Business continuity planning (BCP) was introduced several years ago in order to identify and mitigate any risk of supply chain disruption.

Analyzing the risks to business operations is fundamental to maintaining business continuity. Materials suppliers must work with manufacturers to develop a business continuity plan that facilitates the ability to continue to perform critical functions and/or provide services in the event of an unexpected interruption. The goal is to identify potential risks and weakness in current sourcing strategies and supply chain footprint and then mitigate those risks.

Because of the efforts necessary to qualify materials, second sources must be available and prepared to be shipped in case of crisis. Ideally, different sources should be qualified simultaneously to avoid any further delay in case of unplanned sourcing changes. Material suppliers with global footprint and worldwide sourcing capabilities offer additional security. Multiple shipping routes must be considered and planned in order to avoid disruption in the case, for instance, of a natural disaster or geopolitical issue affecting an entire region.

Material suppliers need to be aware and monitor regulations specific to the automotive electronics industry such as ISO/TS16949 (quality management strategy for automotive industries). This standard goes above and beyond the more familiar ISO 9001 standard, but by understanding the expectations of suppliers to the automotive industry, suppliers can ensure alignment of their quality systems and the documentation requirements for new product development or investigations into non-conformance.

Future of automotive electronics

With the increasing sophistication of future vehicles, new and more advanced semiconductor technologies will be used and vehicles will become technology centers. These technologies will allow communication and guidance computing. Most of these components (logic or memory) will be built by manufacturers relatively new to the automotive electronics world—either integrated device manufacturers (IDM) or foundries.

In order to comply with the current quality standards of the automotive industry, these manufacturers will need to adhere to more stringent standards imposed by the automobile industry. They will find support from materials suppliers like Linde that are capable of delivering high-quality materials associated with a solid global supply chain who have acquired global experience in automotive electronics.

For more information about this topic or Linde Electronics, visit www.linde.com/electronics or contact Francesca Brava at francesca.brava@linde.com. ◈