High Reliability Semiconductor Devices: The Engine of Modern Automotive Capability

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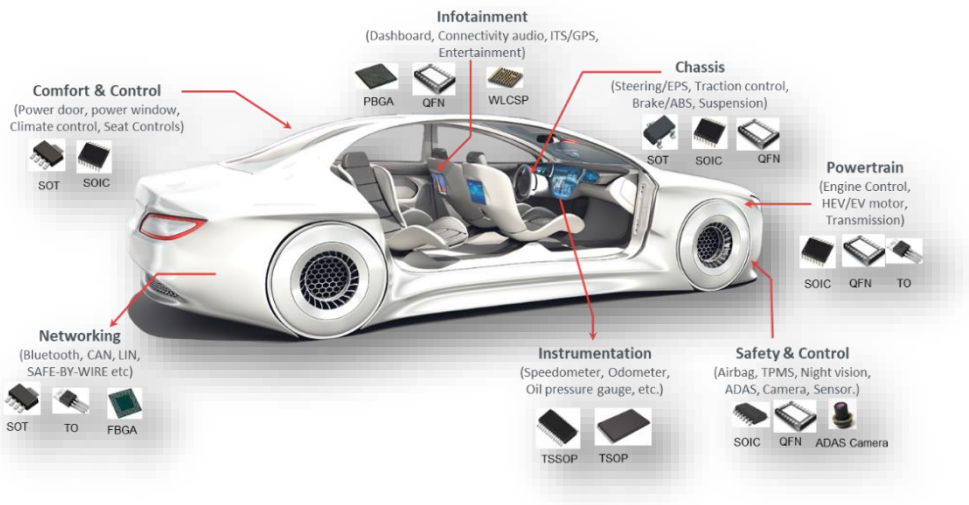
Applications across market sectors are integrating smaller, thinner devices that must operate reliably in demanding environments. One of the most challenging of these ecosystems is automotive, where electronic functionality is increasing exponentially and where passenger safety drives non-negotiable reliability standards. Within vehicles, massive infotainment functionality, fuel efficiency, and safety-enabling advanced driver assistance systems (ADAS) must operate in harmony and electronics – namely semiconductors – are making this all possible. In fact, the further electrification of vehicles, along with connectivity and mobility trends have the potential to increase the semiconductor content in automobiles by as much as ten-fold. [(1)] However, the convergence of miniaturization with expanded function within the automotive industry is challenging reliability and processing norms.

Semiconductors Fueling Automotive Innovation



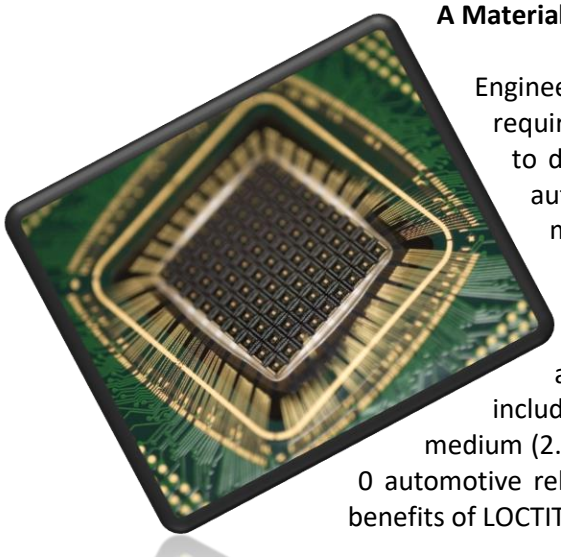
The automotive market is one of the major growth areas for microelectronics. Over the past decade, the average vehicle has gone from a few controllers and components to today's more than 3,500 semiconductors in some cases. By certain estimates, the next 20 years could see automotive semiconductor sales reach US $200 billion US. [(2)] The factors influencing this electronic acceleration are widely understood and include autonomous driving, ADAS, electrification (eMobility), improved safety features, and robust infotainment devices. ADAS, for example, which enables autonomous vehicle capability and includes everything from radars and lidars to blind spot detection, is among the fastest-growing segments in the automotive sector, with a projected CAGR of more than 20% from 2019 to 2027.[(3)] All of these emerging automotive devices, systems, sensors, controllers, and processors require semiconductor technology to support advanced functionality. And, because they are in a safety-critical environment, reliability is among the highest manufacturing and performance priorities.

For automotive semiconductor components, the two most important reliability tests are thermal cycling (TCT) and high temperature storage (HTS). **Table 1** illustrates the automotive grade levels based on meeting specific conditions for these two tests, with Grade 0 being the highest reliability. Naturally, certain systems are subjected to different reliability grade expectations; safety features would fall into the Grade 0 category, whereas an infotainment component may fall into a Grade 3 classification. For the

highest, Grade 0 reliability applications and for packages such as QFNs, QFPs and SOICs that are often found within the microcontroller units (MCUs) and powertrain applications, high thermal and electrical performance are essential and are in large part, facilitated by the die attach material, which allows die to die and die to substrate connection.

AEC Grade	TCT	HTS
Grade 0	-55C to 150C for 2000 cycles or equivalent	150C for 2000 hrs or 175C for 1000 hrs
Grade 1	-55C to 150C for 1000 cycles or equivalent	150C for 1000 hrs or 175C for 500 hrs
Grade 2	-55C to 125C for 1000 cycles or equivalent	125C for 1000 hrs or 150C for 500 hrs
Grade 3	-55C to 125C for 500 cycles or equivalent	125 for 1000 hrs or 150C for 500 hrs

Table 1: Automotive Grade reliability testing requirements.



A Material that Makes the Grade

Engineering die attach materials that can achieve these stringent reliability requirements is not simple. In fact, it is a significant chemistry balancing act to develop, deploy and scale up a material that not only passes Grade 0 automotive reliability testing, but does so while simultaneously providing manufacturers with the process flexibility to achieve their manufacturing goals and cost objectives. Built on its proprietary bismaleimide (BMI) hybrid resin chemistry platform, Henkel's LOCTITE ABLESTIK QMI529HT-LV die attach paste meets the challenging performance and processing requirements of today's high-reliability applications, including automotive. The silver-filled die attach adhesive is effective on medium (2.0 mm x 2.0 mm) to large (up to 8.0 mm x 8.0 mm) die and meets Grade 0 automotive reliability standards, but that's just one of its many advantages. Other benefits of LOCTITE ABLESTIK QMI529HT-LV include:

- Compatibility with various lead frame and die backside surfaces
- Process-adaptability with excellent workability such as good dispensing and long open/stage time
- Low outgassing with minimum resin bleed out
- Low stress, high reliability
- An enabler of high-volume manufacturing with good dispensability
- High thermal conductivity of 8.0 W/m-K

Understanding in-package thermal performance versus bulk thermal conductivity is also an important distinction when evaluating die attach systems for applications which require excellent thermal control. Thermal conductivity of the material is directly related to its ability to pull thermal and electrical energy away from the die, allowing the die to operate at higher temperatures for longer periods of time. However, thermal conductivity is not the only indicator of a material's thermal capability in-package, as anywhere from 70% - 90% of the in-package thermal resistance is attributed to the material's interfacial resistance. In live package thermal testing, LOCTITE ABLESTIK QMI529HT-LV's thermal resistance

produced results close to that of soft solder. The in-package thermal resistance of soft solder is 0.43 K/W, and for LOCTITE ABLESTIK QMI529HT-LV is 0.67 K/W.

The ability to withstand environmental stress, however, may be the most important attribute of a die attach material. For this critical measure, LOCTITE ABLESTIK QMI529HT-LV also performs exceptionally well, passing MSL 1: high temperature storage of 1,000 hours and 2,000 temperature cycles with no lead frame or die backside delamination or cracking.

Combined, all of these performance and processing capabilities make LOCTITE ABLESTIK QMI529HT-LV one of the most low-risk materials for high-reliability applications. Grade 0 compliance is essential, of course, for automotive systems, but being able to meet these tough requirements indicates the formulation is also excellent for other challenging environments. For more information about high-reliability applications and Henkel's die attach solution, view a recent webinar on the subject here or visit this resource.

Sources

1.,2. https://advisory.kpmg.us/articles/2019/automotive-semiconductors.html

3. https://www.marketsandmarkets.com/Market-Reports/driver-assistance-systems-market-1201.html