Semiconductor Device Innovation Driving Automotive Advances:
High Reliability, Automotive Grade Materials Essential for Unfailing Performance

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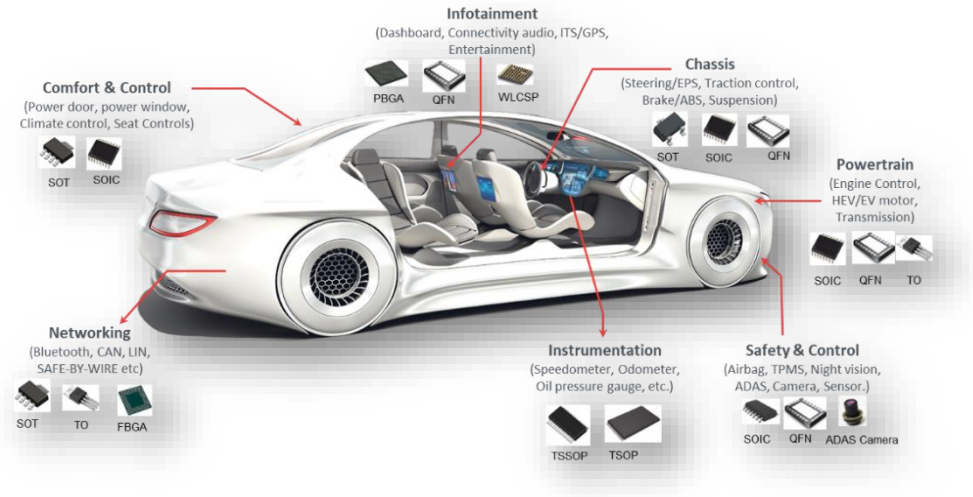
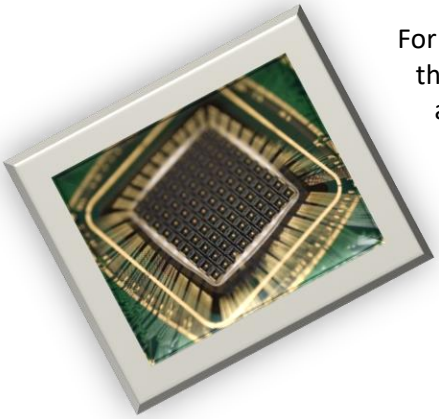
Smaller, thinner, higher performance semiconductor devices aren't just required for mobile phones and tablets. As applications across market sectors aim to expand function, semiconductor packages within numerous products are challenged to maintain – or reduce – dimensions even while capability is increasing. At the same time, integration of these devices into demanding environments such as automobiles dictates extreme reliability. In fact, the automotive ecosystem is one of the most challenging, but also one which is becoming increasingly dependent on electronics for continuous innovation. Within vehicles, 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. The increasing electrification of vehicles, along with connectivity and mobility trends have the potential to expand the semiconductor content in automobiles by as much as ten-fold. [(1)] However, the convergence of miniaturization and added function within the automotive industry is testing reliability and processing norms.

Semiconductors Fueling Automotive Innovation

The automotive market is a major growth area for microelectronics. Over the past decade, average vehicle electronics content 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

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.

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/or 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.

Materials that Make the Grade

Engineering die attach materials that can achieve these stringent reliability requirements is not simple. In fact, it takes significant chemistry balancing expertise 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 manufacturing goals and cost objectives. With several automotive Grade 0 die attach formulations, both conductive and non-conductive and in paste and film formats, Henkel's portfolio offers packaging specialists a broad range of solutions to accommodate different package types, processing preferences and performance requirements. (**Table 2**)

Material	Material Type	Thermal Conductivity W/m-k	Package Type	Die Size, mm	Lead frame Type	Wire	MSL
LOCTITE ABLESTIK 3280T	cDAP	0.5	QFN	<3x3	Std. PPF	Au	1
LOCTITE ABLESTIK 3230	cDAP	0.6	QFP	3x3 to 5x5	PPF LF / roughened	Au	3
LOCTITE ABLESTIK 8290	cDAP	1.6	SO	<5x5	Std PPF	Au	1
LOCTITE ABLESTIK CDF 515P	cDAF	1.8	QFP	6 x6	Roughened / Std Cu	Au	2
LOCTITE ABLESTIK 8200T	cDAP	2.5	QFN / QFP	<5x5	Roughened Cu	Au & Cu	1
LOCTITE ABLESTIK ABP 8920TC	ncDAP	3.0	QFN/SSOP	3 x 3	Roughened PPF	Au	1
LOCTITE ABLESTIK QMI519	cDAP	3.8	QFN / QFP/ SOIC / TSOP	1x1 to 5x5	Roughened PPF / Cu LF	Au	1
LOCTITE ABLESTIK 8600	cDAP	> 4	QFN / QFP	>3x3 to 5x5	Roughened Cu	Au & Cu	1
LOCTITE ABLESTIK QMI529HT / LOCTITE ABLESTIK QMI529HT-LV	cDAP	6.5	QFP/ TSSOP/ SOIC	3x3 to 7x7	Roughened / Std PPF	Cu	1
LOCTITE ABLESTIK ABP 8060T	cDAP	20	SOT	< 1.5 x 1.5	Ag	Au	1
LOCTITE ABLESTIK ABP 8068TD	cDAP	50	QFN	< 1 x 1	Roughened PPF	Cu	1

Table 2: Henkel has a broad portfolio of automotive Grade 0 die attach solutions.

Among Henkel's most recently commercialized materials in the automotive Grade 0 reliability class are conductive die attach paste LOCTITE ABLESTIK QMI529HT-LV, non-conductive die attach paste LOCTITE ABELSTIK ABP 8920TC and conductive die attach film LOCTITE ABLESTIK CDF 500P. No matter the application – whether a microcontroller or a camera module – Henkel's formulation range die attach materials delivers on today's demanding requirements; the below highlights the versatility of Henkel's latest high-reliability, automotive Grade 0 solutions.

<u>Electrically and Thermally Conductive Paste LOCTITE ABLESTIK QMI529HT-LV</u>

- Built on proprietary bismaleimide (BMI) hybrid resin chemistry platform
- Withstands environmental stress; 1,000 hrs. HTS, 2000 hrs. TCT, passes MSL1
- Wide die size range: medium (2.0 mm x 2.0 mm) to large (up to 8.0 mm x 8.0 mm)
- High thermal conductivity of 8.0 W/m-K and low in-package thermal resistance (0.67 K/W) for outstanding thermal performance
- Good dispensing capability, long open/stage time, low outgassing with minimum resin bleed out
- Well-suited for QFPs, TSSOPs and SOICs

Non-electrically Conductive Paste ABELSTIK ABP 8920TC

- Proprietary bismaleimide (BMI) hybrid resin chemistry platform
- Excellent electrical isolation and low CTE
- Thermal conductivity (3.0 W/m-K) among the highest within non-conductive formulations; low in-package thermal resistance (1.8 K/W)
- Good adhesion on a variety of lead frame finishes including Cu, Ag and PPF
- Ideal for SOICs, SSOPs, BGAs, automotive camera modules, QFPs and QFNs within automotive and industrial apps, modules and sensors and 5G telecom devices

Electrically and Thermally Conductive Film LOCTITE ABLESTIK CDF 500P

- Henkel is the pioneer of conductive die attach film, launching the first such material in 2010
- Inherent film benefits include: elimination of die tilt, controlled bond lines, thin die processing, no resin bleed out, zero or minimal fillet, tight keep out zones and package design scalability
- Film formulation is agnostic to lead frame type and surface (roughened or not), as well as anti-epoxy resin bleed out (EBO) coatings
- Thermal conductivity of 1.8 W/m-K for excellent heat dissipation; low in-package thermal resistance of 1.4 K/W
- Available in 15 µm and 30 µm thicknesses for thin, uniform bond lines
- Robust MSL performance
- AEC Q006 Automotive grade 0

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. Thermal resistance, along with the material's ability to withstand environmental stress as indicated by HTS and TCT analysis, are the most important attributes of high reliability die attach materials.

With excellent thermal, electrical, processing and performance attributes, Henkel's line of automotive Grade 0 die attach solutions are some of the most low-risk materials for high-reliability applications – whether in automotive systems or other demanding environments. To receive additional information, contact the Henkel technical team.

Sources

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