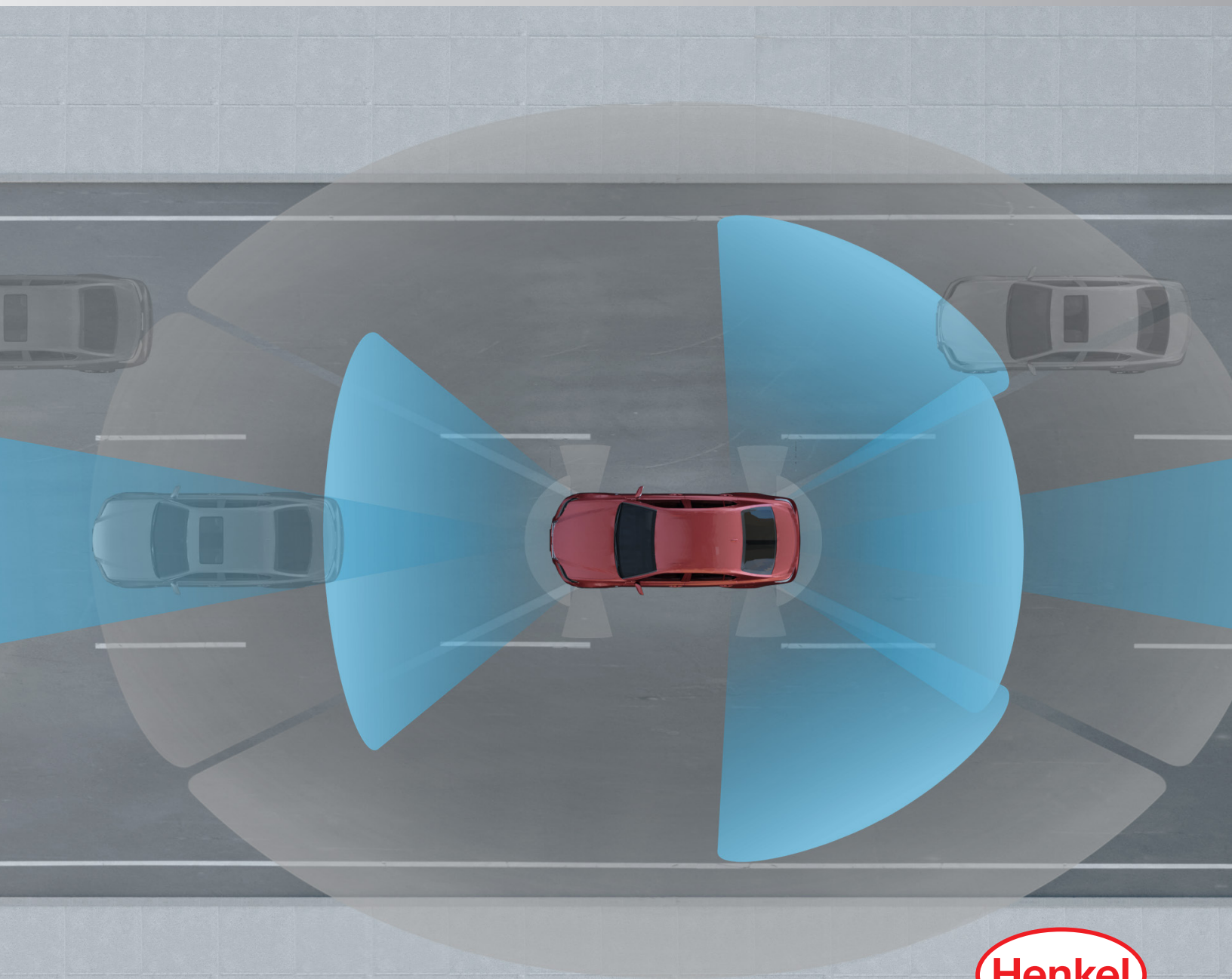
LOCTITE®
TECHNOMELT®

BERGQUIST®

MATERIALS FOR AUTOMOTIVE RADARS

BONDING, CONNECTING, PROTECTING AND THERMAL SOLUTIONS



Henkel

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MATERIALS FOR ADAS RADARS

INTRODUCTION

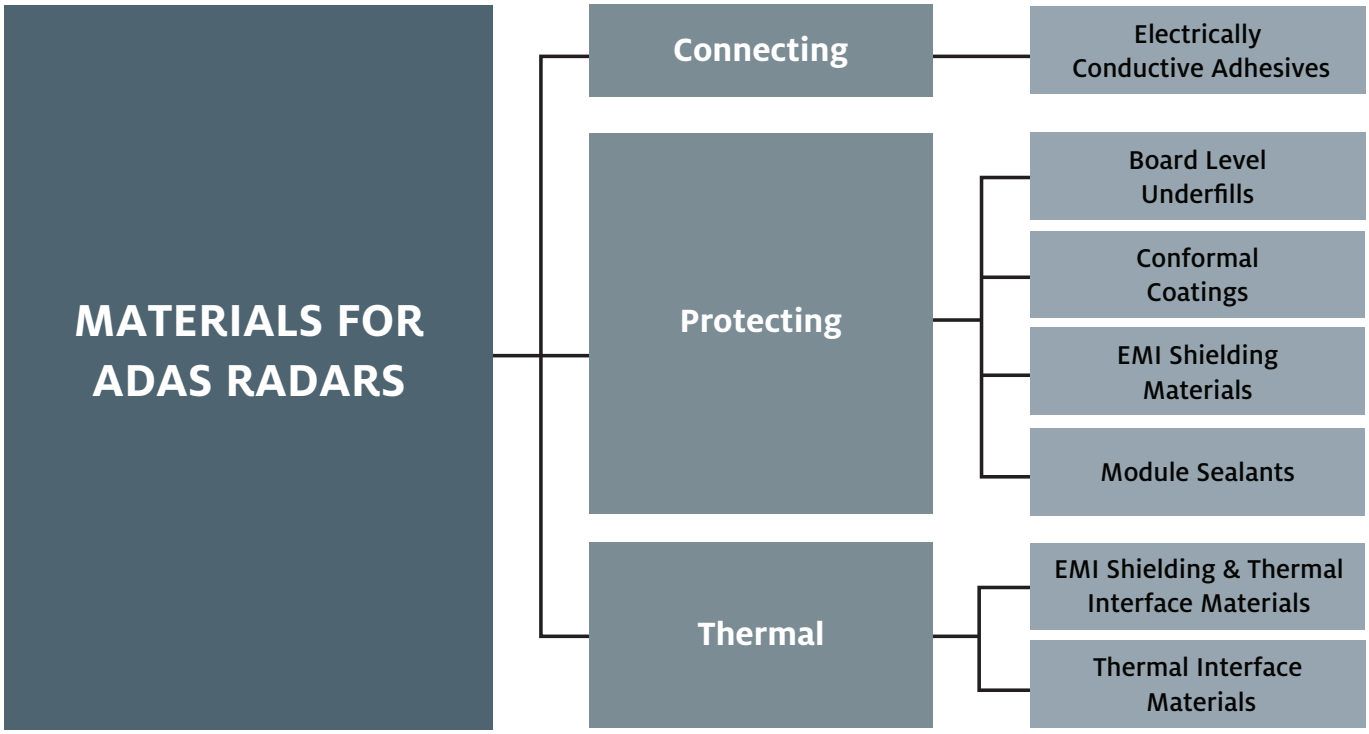
ADAS: DRIVING NEXT-GENERATION AUTOMOTIVE SAFETY

The growth of Advanced Driver Assistance Systems (ADAS) is unprecedented. What were once considered high-end luxuries are now becoming common, optional – sometimes even standard – features on today's mid- and upper-range vehicles. Working in isolation or collaborating to deliver notifications, warnings, and interventional actions to enhance driver safety, camera and radar sensor technologies are critical to ADAS advancement. While camera technology is the go-to sensor for visual object detection, radar offers more complete and exacting information as it measures an object's speed and distance from the vehicle. With this data, features like adaptive cruise control, emergency braking and rear collision warnings offer real-time alerts that greatly improve driver, passenger and pedestrian safety. Ultimately, the radar's functional reliability depends on the integrity of its components and this reality is driving radar designers and manufacturers toward Henkel electronic material solutions.

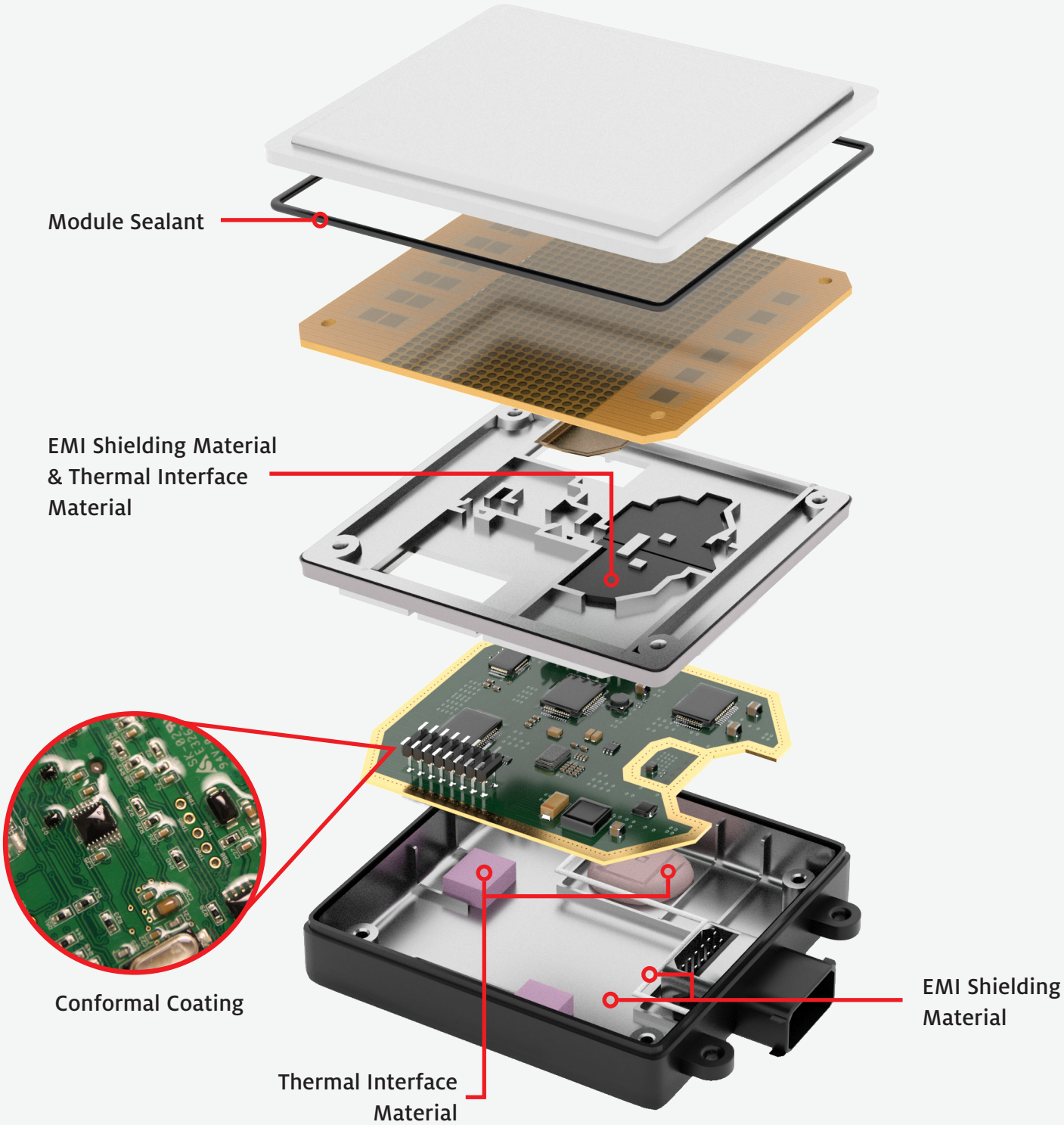
REAL-TIME NOTIFICATION DEMANDS CAPABLE MATERIALS

Today's automotive radar systems provide critical information for accident avoidance. Continuous sensing of a vehicle's distance from an object through measurement of the object's position and velocity, gives drivers a real-time view for informed decision-making and collision prevention. The reliability of the electronics within radars – including chips, components and interconnects – is essential to long-term, dependable functionality, making Henkel's advanced materials fundamental to radar performance. And, as radars become smaller and more compact while packing more powerful function, high performance thermal management solutions, along with PCB and component protection are essential.

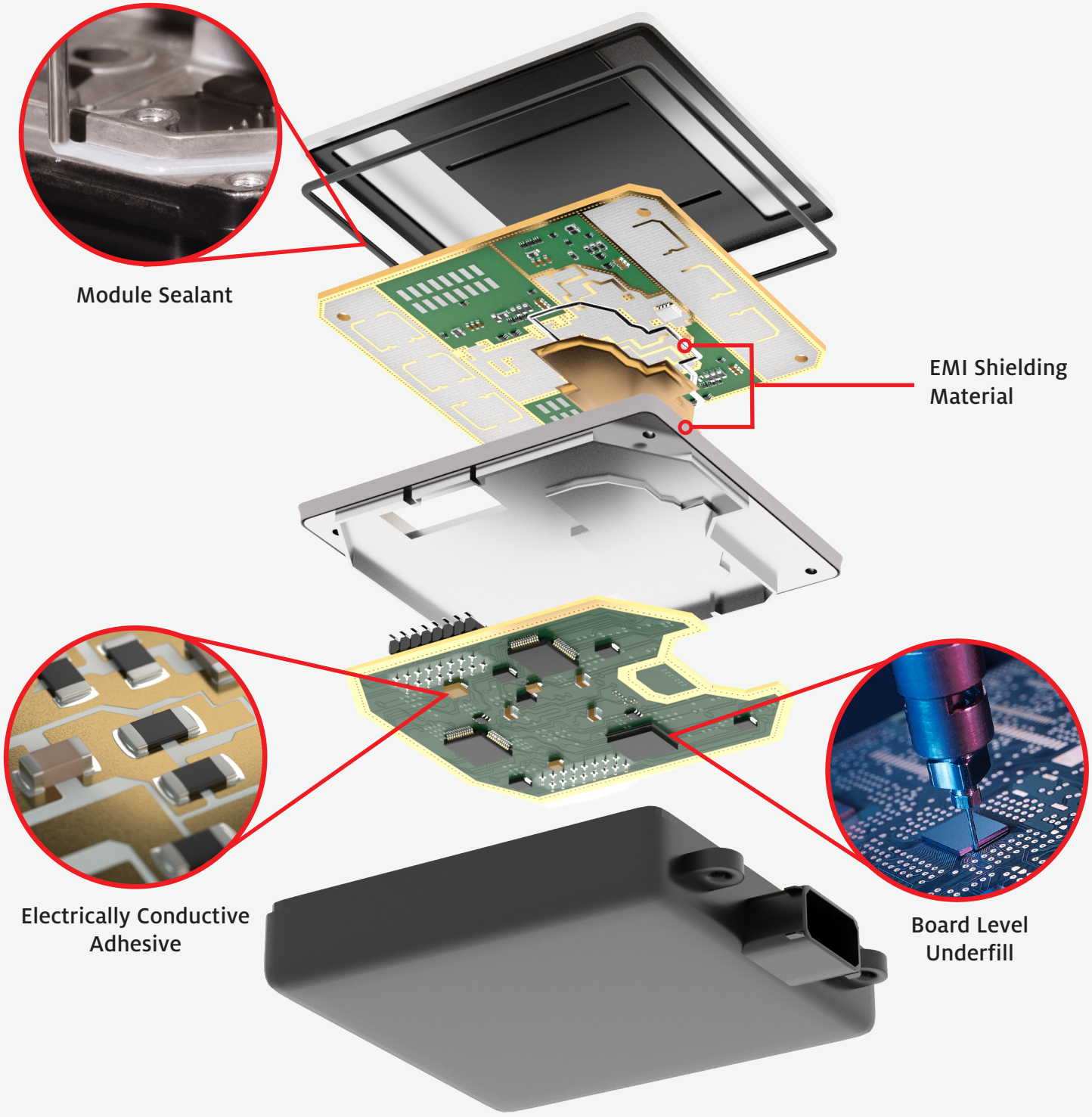
PRODUCT PORTFOLIO



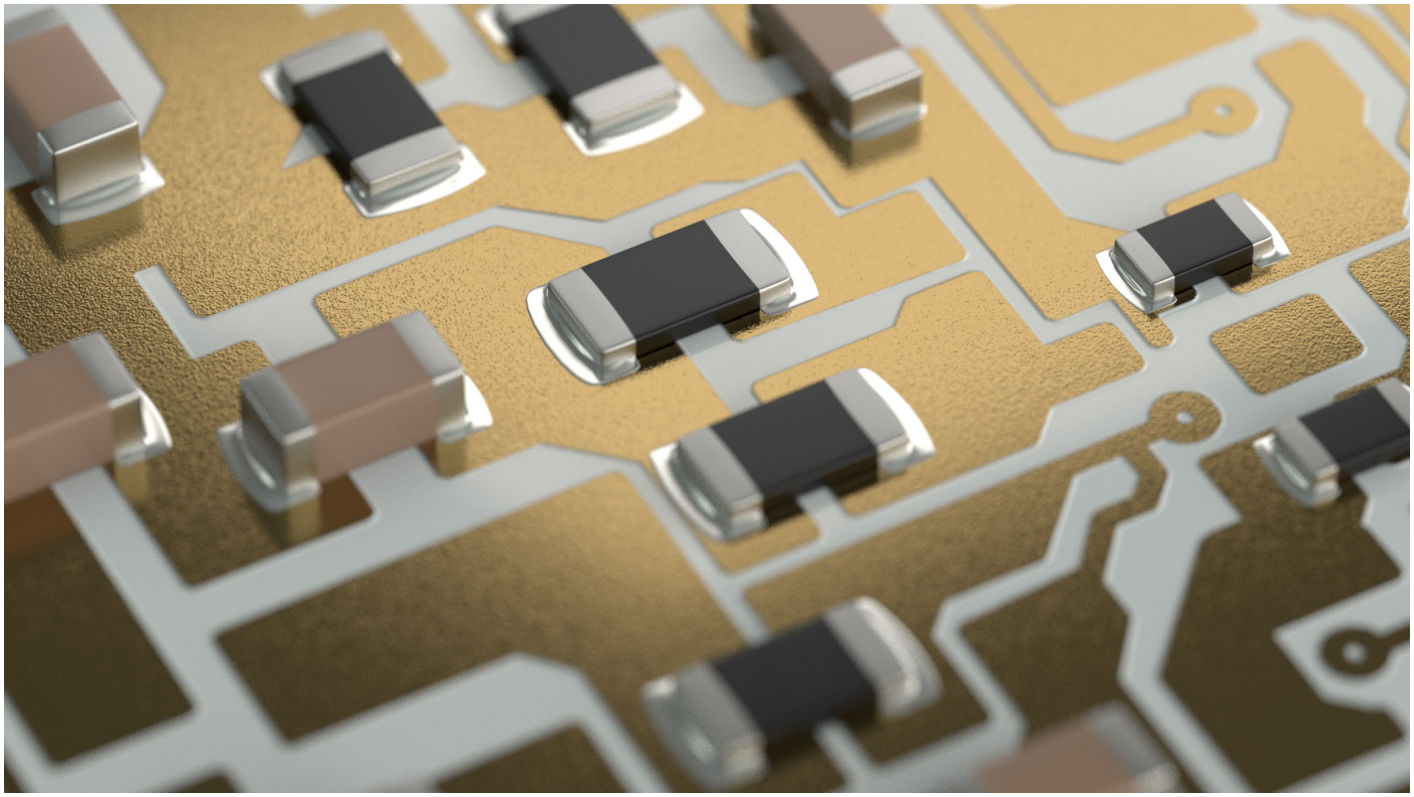
ADAS RADAR SOLUTIONS



ADAS RADAR SOLUTIONS

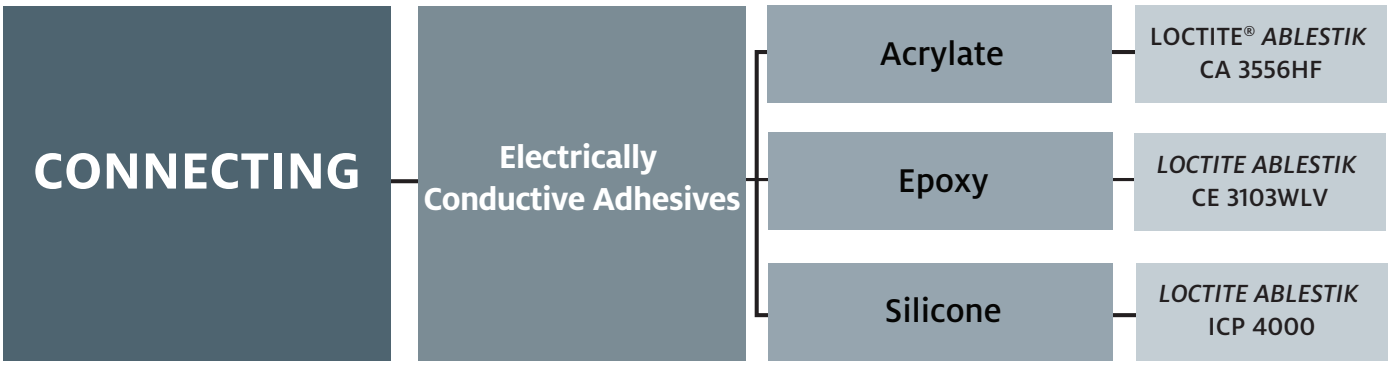


CONNECTING MATERIALS FOR ADAS CAMERAS



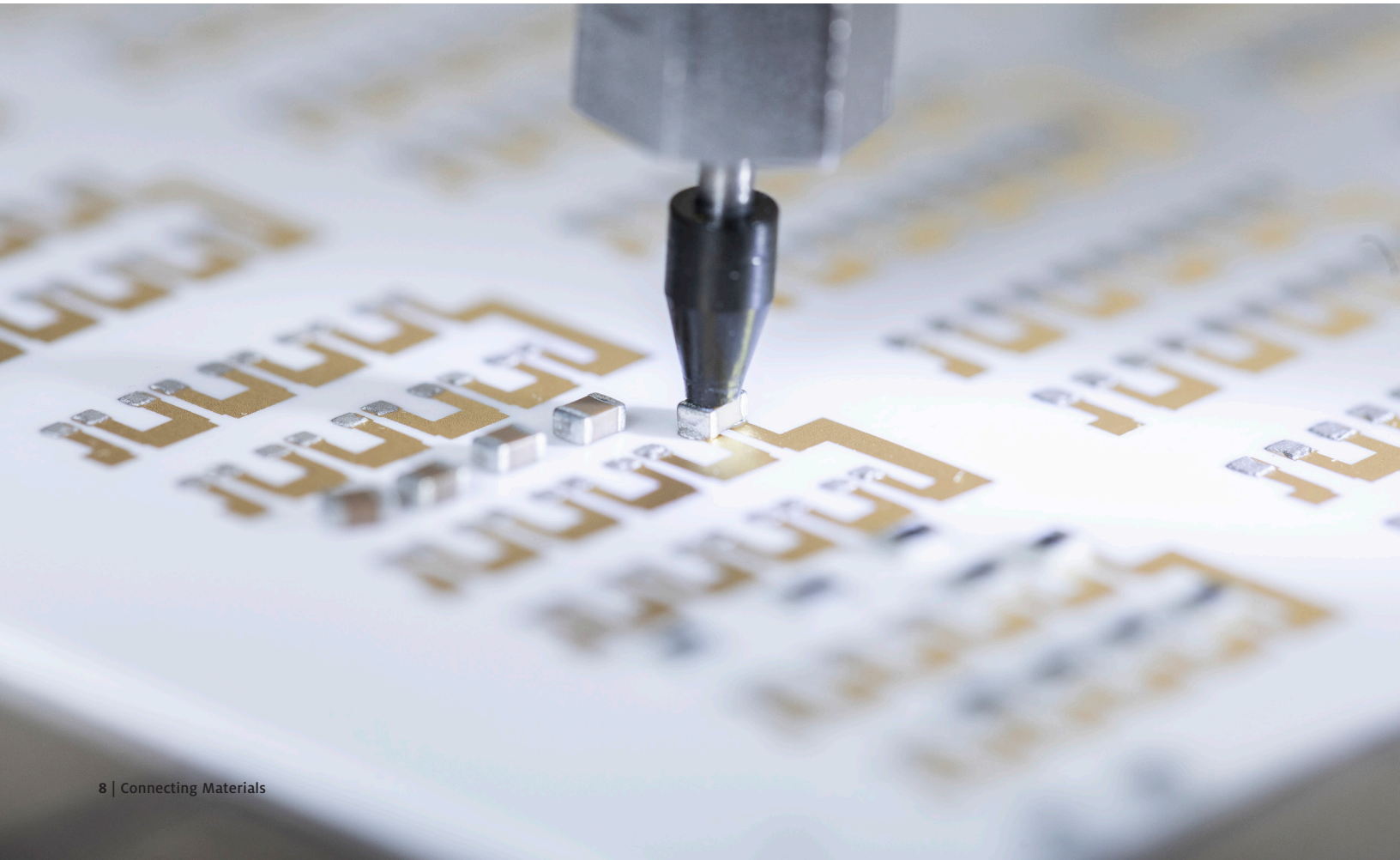
CONNECTING FUNCTIONALITY

Joining all of the components of a radar system for collaborative operation and high reliability is the job of Henkel's portfolio of advanced connecting materials. Electrical interconnection at the board level is facilitated through high-reliability and a wide range of electrically conductive adhesives, an area where Henkel's expertise spans decades. Our scientists and engineering teams developing materials understand the reliability requirements, application-specific considerations, processability objectives and manufacturing demands to advise on the best solutions for optimal results, which is why the world's top automotive electronics manufacturers choose Henkel. When seconds count, reliable connections matter.



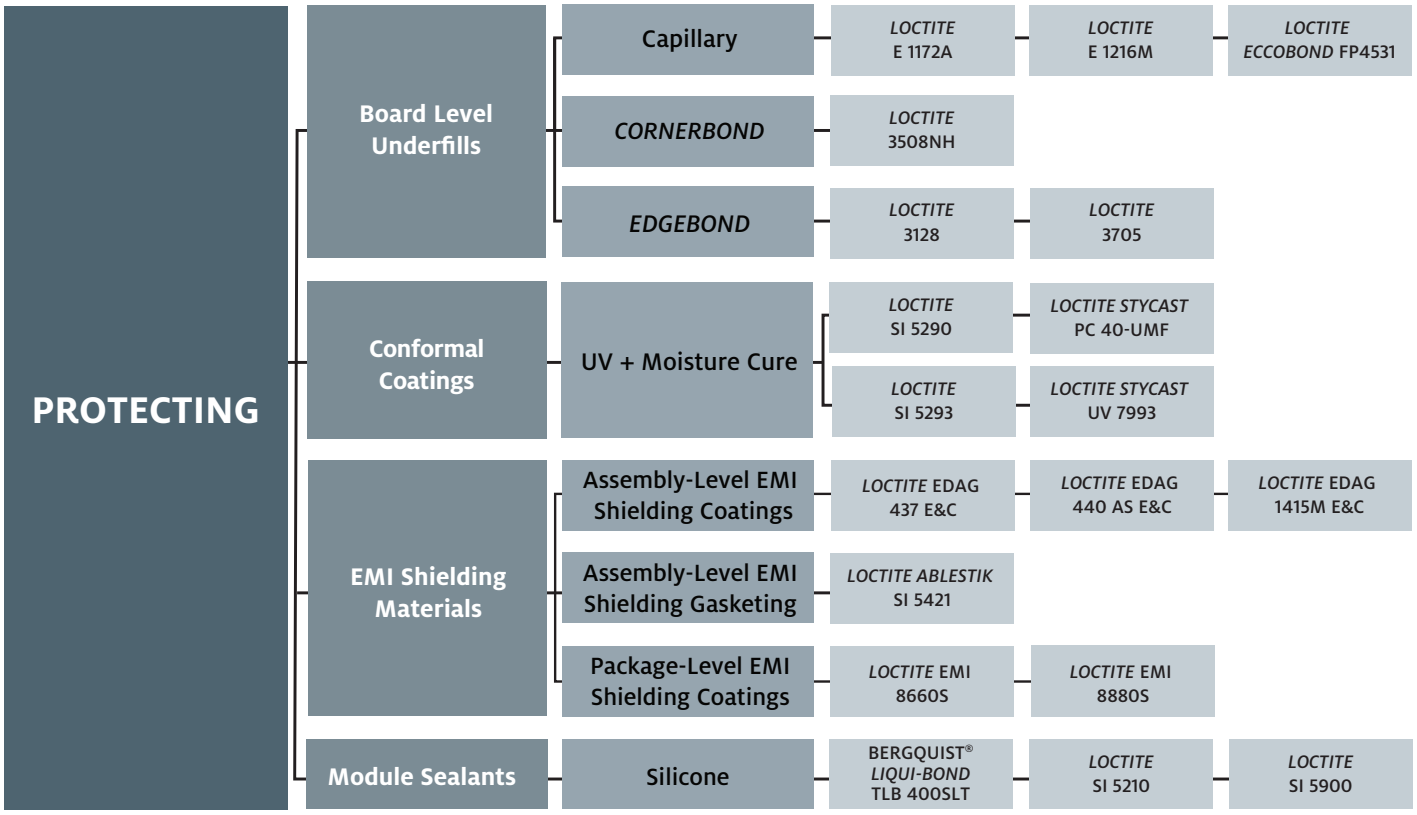
ELECTRICALLY CONDUCTIVE ADHESIVES

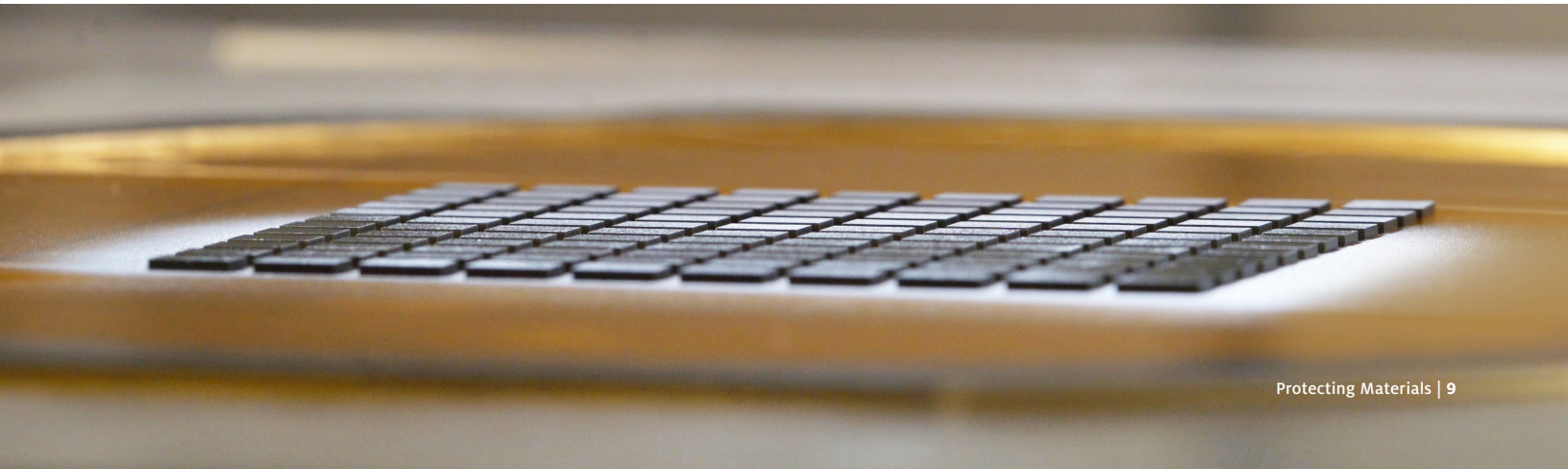
Product Name	Description	Key Attributes	Volume Resistivity (Ω•cm)	Glass Transition Temperature, T_g (°C)	Coefficient of Thermal Expansion, CTE (ppm/°C)		Modulus at 25°C (MPa)	Recommended Cure
					Below T_g	Above T_g		
Acrylate								
LOCTITE® *ABLESTIK* CA 3556HF	Acrylate electrically conductive adhesive	• One component • Fast, low-temperature cure • Excellent flexibility • Good adhesion • Low contact resistance	2.5×10^{-3}	-30	95	278	650	2 min. at 110°C
Epoxy								
LOCTITE ABLESTIK CE 3103WLV	Epoxy electrically conductive adhesive	• Pb-free alternative to solder • Low-temperature cure • Stable contact resistance	8×10^{-4}	114	45	225	4,500	10 min. at 120°C
Silicone								
LOCTITE ABLESTIK ICP 4000	Silicone electrically conductive adhesive	• One component • High flexibility • Excellent electrical conductivity • High-temperature performance • Pb-free alternative to solder • High electrical current carrying capability • Low-temperature cure • Outstanding elongation performance • Low outgassing	6×10^{-5}	-45	N/A	330	101	1 hr. at 130°C



A FULL RANGE OF PROTECTION

Building the radar module with high-performance electronic interconnect materials is just the start. Protecting radar systems from adverse environmental conditions and external interference is equally essential to lasting, dependable performance. Henkel's award-winning protection materials can be found throughout modern-day automotive radar systems, and for good reason. Our conformal coating solutions protect the PCB from moisture and chemical contaminants, which are plentiful in an automotive environment. Once the PCBs are populated with high-value components like micro-BGAs, the fine-pitch solder connections need to be protected from vibration and shock. Market-leading LOCTITE® underfill formulations deliver added solder joint reliability to defend against stress, while Henkel module sealants keep contaminants out of the enclosure. Likewise, innovative Henkel EMI shielding solutions in multiple formats offer vital radio-frequency interference protection at all levels – from the chip to the board to the mid-frame – and effectively isolate the antennae and logic features of the radar system from each other.

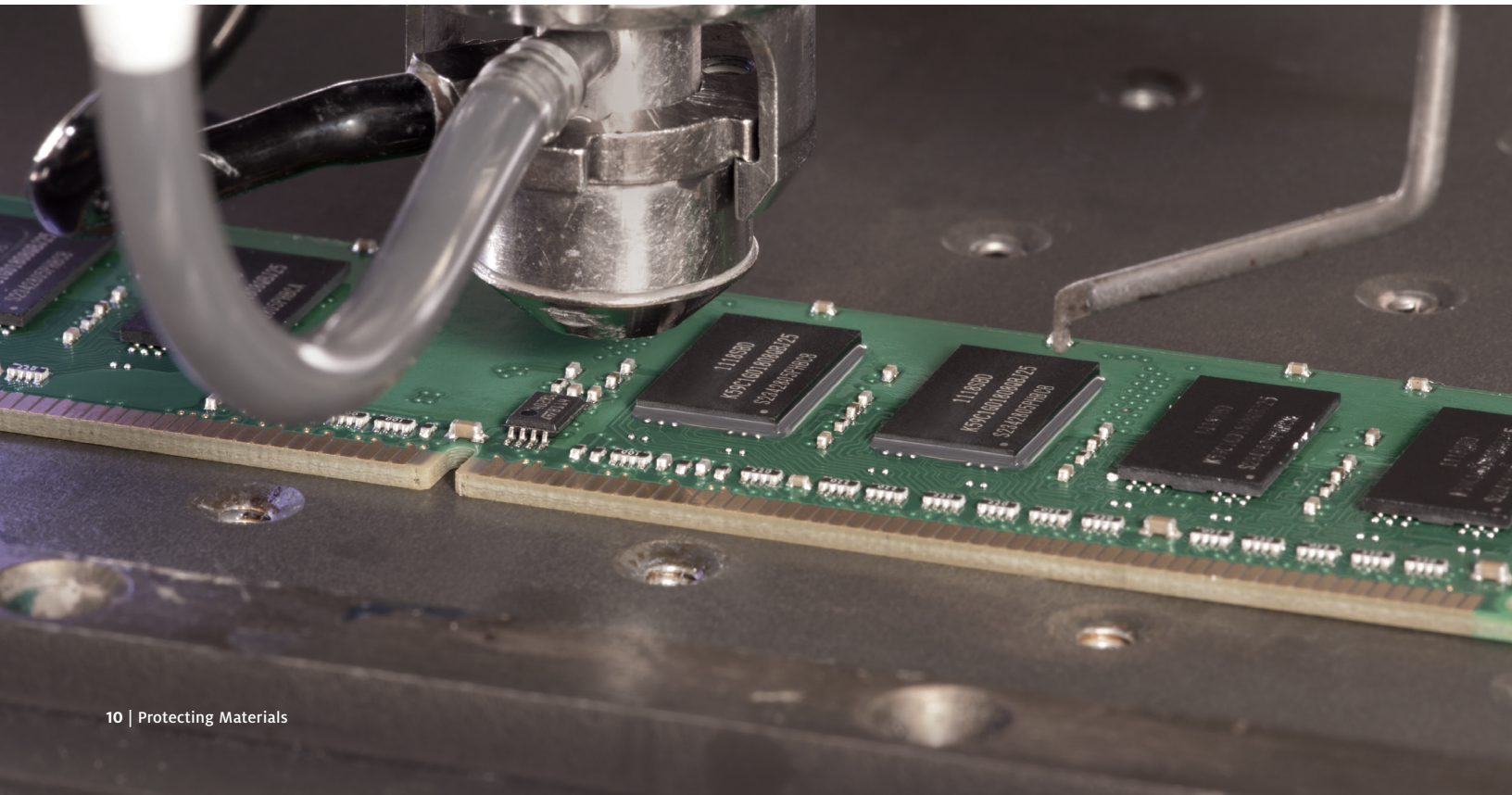




BOARD LEVEL UNDERFILLS

Capillary Underfills

Product Name	Description	Key Attributes	Modulus at 25°C (MPa)	Glass Transition Temperature, T_g (°C)	Coefficient of Thermal Expansion, CTE (ppm/°C)		Pot Life	Recommended Cure
					Below T_g	Above T_g		
LOCTITE ECCOBOND E 1172 A	Non-reworkable, capillary flow, epoxy underfill	• Snap curable • Fast cure at low temperatures • One component • Non-anhydride curing chemistry • Void-free	10,000	135	27	85	48 hr. at 25°C	6 min. at 135°C
LOCTITE E 1216M	Non-reworkable capillary flow underfill	• Snap or inline cure • Fast, void-free underfill of area array devices • Excellent stability during shipping, storage and use • Excellent adhesion and strength • Non-anhydride curing chemistry	2,970	125	35	131	5 days at 25°C	3 min. at 165°C
LOCTITE ECCOBOND FP4531	Capillary flow underfill	• Snap curable • Fast flow • High adhesion strength • Proven workability at high temperatures • Qualified in automotive reliability conditions	7,600	161	28	104	24 hr. at 25°C	7 min. at 160°C



CORNERBOND & *EDGEBOND* Underfills

Product Name	Description	Key Attributes	Viscosity at 25°C (cP)	Glass Transition Temperature, T_g (°C)	Coefficient of Thermal Expansion, CTE (ppm/°C)		Pot Life	Recommended Cure
					Below T_g	Above T_g		
CORNERBOND								
LOCTITE 3508NH	Reworkable epoxy underfill	• One component • Reflow curable • Eliminates post-reflow dispense and cure steps • Reworkable • Halogen-free	70,000	118	65	175	30 days at 25°C	Cure during Pb-free solder reflow profile at 245°C
EDGEBOND								
LOCTITE 3128	Epoxy underfill	• One component • Low temperature cure • Excellent adhesion to a wide range of materials	22,000	45	40	130	3 weeks at 25°C	20 min. at 80°C bondline temperature
LOCTITE 3705	Acrylate underfill	• One component • Thixotropic • Medium viscosity • Fast UV cure • No post cure required • Good adhesion to a variety of substrates	44,000	-39 (T_g 1) 77 (T_g 2)	66	151	30 days at 25°C	80 sec. at 30 mW/cm²

CONFORMAL COATINGS

Product Name	Description	Key Attributes	Viscosity at 25°C (cP)	Operating Temperature (°C)	Volume Resistivity (Ω•cm)	Color	Recommended Cure
UV + Moisture Cure							
LOCTITE SI 5290	Silicone conformal coating	• One component • Designed for severe temperature environments and high-reliability automotive applications • Solvent-free	100 – 350	-53 – 200	2×10^{14}	Transparent amber to yellow	20 – 40 sec. at 70 mW/cm² + 72 hr. at 50% relative humidity
LOCTITE SI 5293	Silicone conformal coating	• One component • Exhibits positive fluorescence under UV light • Repairable • Solvent-free • Designed for severe temperature environments and high-reliability automotive applications	400 – 800	-40 – 200	1×10^{14}	Transparent amber to yellow	20 – 40 sec. per side at 70 mW/cm² + 72 hr. at 50% relative humidity
LOCTITE STYCAST PC 40-UMF	Urethane acrylate conformal coating	• One component • VOC-free • Conforms to IPC-CC-830 requirements	250	-40 – 135	3.5×10^{16}	Clear	10 sec. at 300 – 600 mW/cm² + 2 – 3 days at atmospheric moisture
LOCTITE STYCAST UV 7993	Urethane conformal coating	• One component • Solvent-free • Good moisture resistance • Excellent chemical resistance	120	-40 – 130	2.2×10^{16}	Translucent yellow	5 sec. at 400 – 700 mW/cm² + 100 hr. at 50% relative humidity

EMI SHIELDING MATERIALS

Assembly-Level EMI Shielding Coatings

Product Name	Description	Key Attributes	Attenuation	Sheet Resistance (Ω/sq/25 µm)	Surfaces	Coverage at 10 µm (m²/kg)	Recommended Cure
LOCTITE EDAG 437 E&C	Cu-filled, thermoplastic EMI shielding coating	• Burnish resistant • Excellent environmental resistance • Stable electrical properties after heat cycling • Excellent shielding against radiated electromagnetic interference (EMI) and protection against electrostatic discharge (ESD) • Room temperature cure	50 – 70 dB at 50 µm	< 0.5	Plastic	23	30 min. at 25°C
LOCTITE EDAG 440 AS E&C	Ni-filled, thermoplastic EMI shielding coating	• Excellent shielding against radiated electromagnetic interference (EMI) • Protection against electrostatic discharge (ESD) • Stable in difficult environmental conditions such as high humidity or heat • Room temperature or heat cure	50 – 70 dB at 50 µm	< 0.5	Plastic	17	20 min. at 70°C
LOCTITE EDAG 1415M E&C	Ag-filled, thermoplastic EMI shielding coating	• Excellent shielding against radiated electromagnetic interference (EMI) • Maintains low resistance after exposure to heat, cold, humidity and salt spray • Air drying system that requires no primer or top coat • Room temperature or heat cure	60 dB at 25 µm	< 0.015	Plastic	9	30 min. at 70°C

Assembly-Level EMI Shielding Gasketing

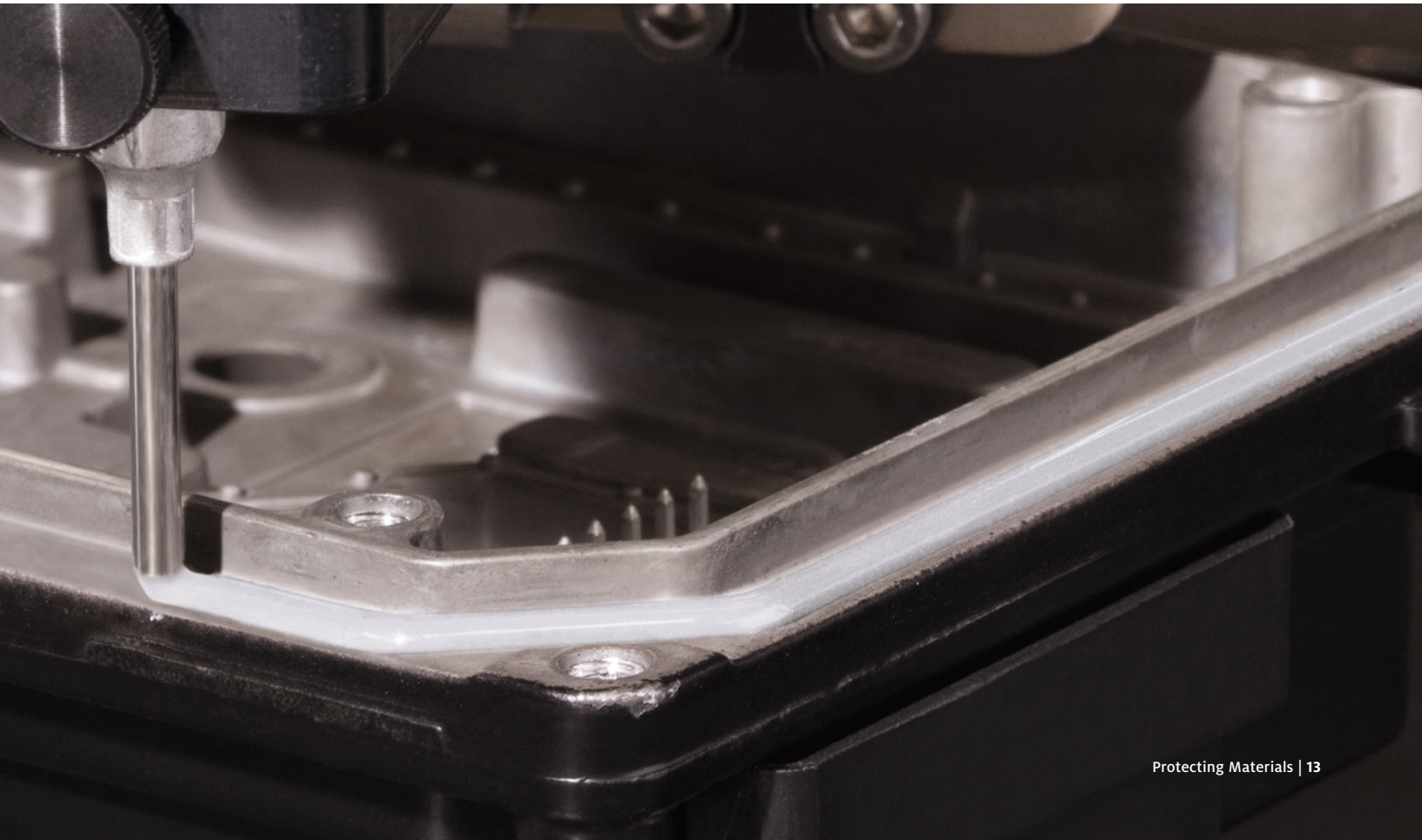
Product Name	Description	Key Attributes	Attenuation	Shore A Hardness	Volume Resistivity (Ω·cm)	Tensile Lap Show Strength, N/m² (TLSS)	Recommended Cure
LOCTITE SI 5421	Ag-filled, silicone gasketing material	• Room temperature cure • Low stress • High flexibility	• 80 dB at 10 MHz • 110 dB at 100 MHz • 100 dB at 10 GHz	50 – 65	$< 1 \times 10^{-2}$	0.7	24 hr. at 25°C

Package-Level EMI Shielding Coatings

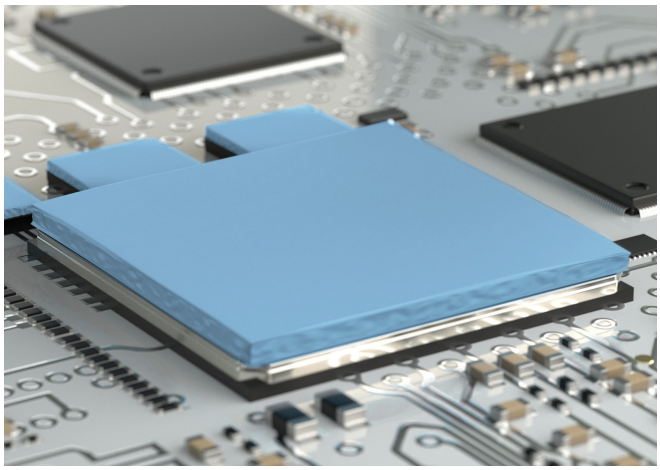
Product Name	Description	Key Attributes	Attenuation	Volume Resistivity (Ω·cm)	Surfaces	Coating Thickness (µm)	Recommended Cure
LOCTITE ABLESTIK EMI 8660S	Package-level, conformal EMI shielding coating	• Thinly spray-coated material provides uniform coverage on top and sidewalls of package • Excellent adhesion to mold compound • Excellent EMI shielding performance at > 100 MHz	90 dB at 3 µm	1.5×10^{-5}	• Epoxy mold compound • Copper	3 – 5	1 hr. at 175°C in air
LOCTITE ABLESTIK EMI 8880S	Package-level, conformal EMI shielding coating	• Thinly spray-coated material provides uniform coverage on top and sidewalls of package • Excellent adhesion to mold compound • Excellent EMI shielding performance at > 10 MHz	90 dB at 3 µm	7.9×10^{-6}	• Epoxy mold compound • Copper	3 – 5	1 hr. at 175°C in air

MODULE SEALANTS

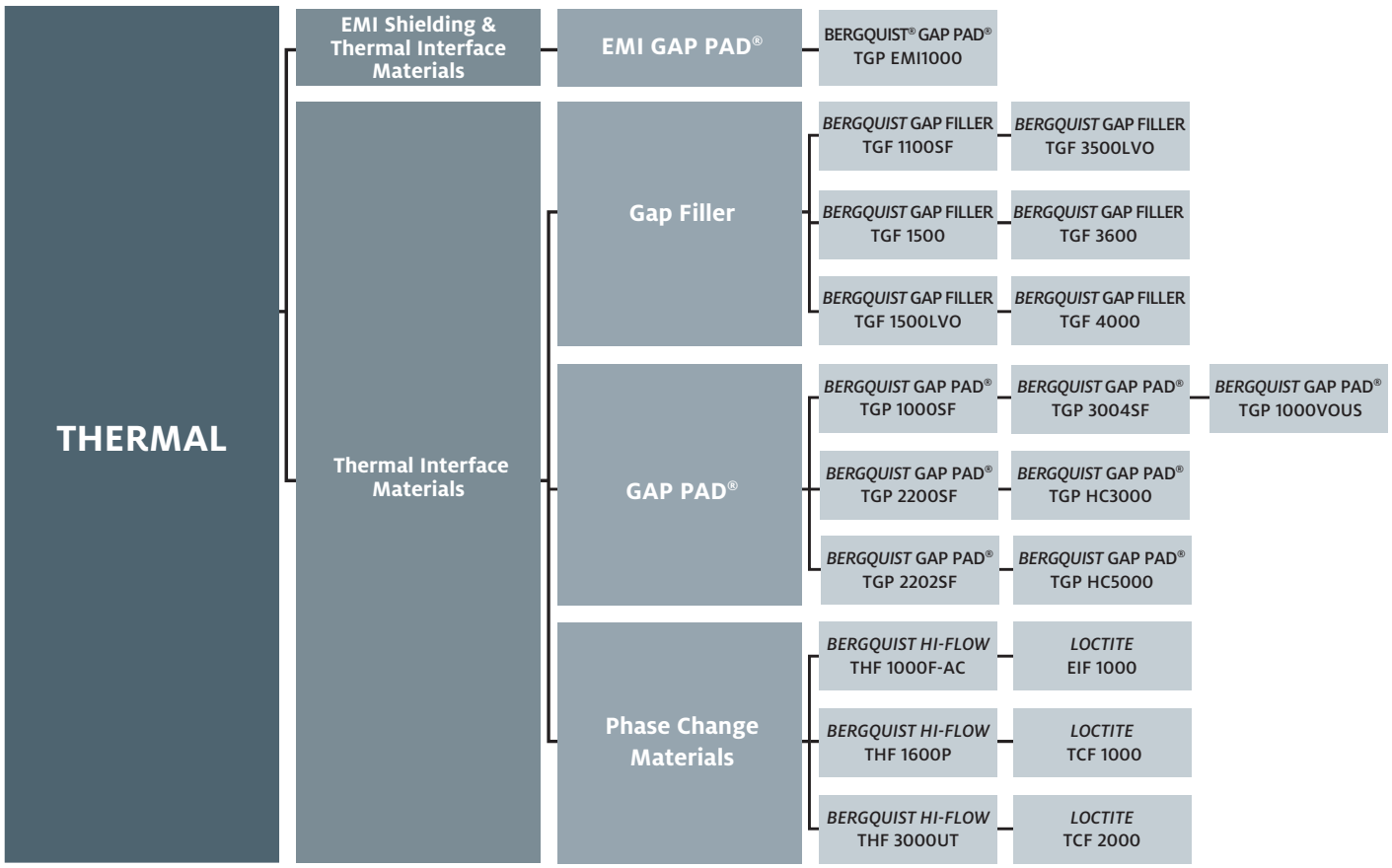
Product Name	Description	Key Attributes	Shore A Hardness	Tensile Strength (MPa)	Recommended Cure
BERGQUIST® *LIQUI-BOND* TLB 400SLT	High performance, two-part, silicone adhesive sealant with an adaptable cure profile	• Fast and adaptable cure (at room or elevated temperatures) • Strong and elastic bond • Thixotropic – designed for automated dispensing as form-in-place gasket (FIPG) • Room temperature storage • Self-fixture time of 12 hr. at 25°C	40	2.1	7 days at 25°C
LOCTITE SI 5210	One component silicone sealant and adhesive paste	• An ultra-fast curing, non-corrosive, thixotropic room temperature vulcanizing (RTV) silicone designed for potting, selective sealing, vibration dampening and repair/rework applications on circuit boards • Effective for automotive electronics applications or other harsh environments • Tack free time of ≤ 5 min. at 22°C and 50% relative humidity	48	2.8	7 days at 22°C and 50% relative humidity
LOCTITE SI 5900	One component silicone sealant and adhesive paste	• Excellent resistance to automotive engine oils • Ability to withstand high joint movement • Excellent adhesion to a wide variety of plastic substrates, as well as glass, ceramics and metals • Thixotropic paste • Tack free time of 7 – 24 min. at 25°C and 50% relative humidity	31 – 46	≥ 1.7	7 days at 25°C and 50% relative humidity



RADARS THAT KEEP THEIR COOL



The ability to offer driver assistance for collision avoidance, pedestrian detection, blind spot notification and, in some cases, even initiate emergency braking make radar systems very cool, safety-enhancing technology. Keeping them cool is imperative. As radar technology has become more compact and powerful, components have diminished in size, yet expanded in function. And, with this dynamic, increased heat generation is the result. In fact, thermal management is one of the most essential pieces of the reliability puzzle. If parts overheat, they don't function. Henkel's BERGQUIST® brand thermal interference materials are the undisputed market leader for effective thermal management solutions. Our award-winning, low-stress gap filling thermal interface materials are enabling high-performance function of digital signal (DSP) and microcontroller (MCU) processors, as well as providing thermal relief from heat generation at the mid-frame. High conformity GAP PAD® materials and automated, throughput-enhancing liquid form-in-place gap fillers effectively absorb and dissipate heat so radars can keep their cool.



EMI SHIELDING AND THERMAL INTERFACE MATERIALS

Product Name	Description	Key Attributes	Thermal Conductivity (W/m•K)	Modulus at 25°C (kPa)	EMI Absorption at 2.4 GHz (dB/cm)	Thickness (mm)	Flammability Rating
BERGQUIST® GAP PAD® TGP EMI1000	Thermally conductive, conformable EMI absorbing material	• Electromagnetic interference (EMI) absorbing • Fiberglass reinforced for puncture, shear and tear resistance • Electrically isolating	1	69	-2.8	0.508 – 3.175	UL 94 V-0

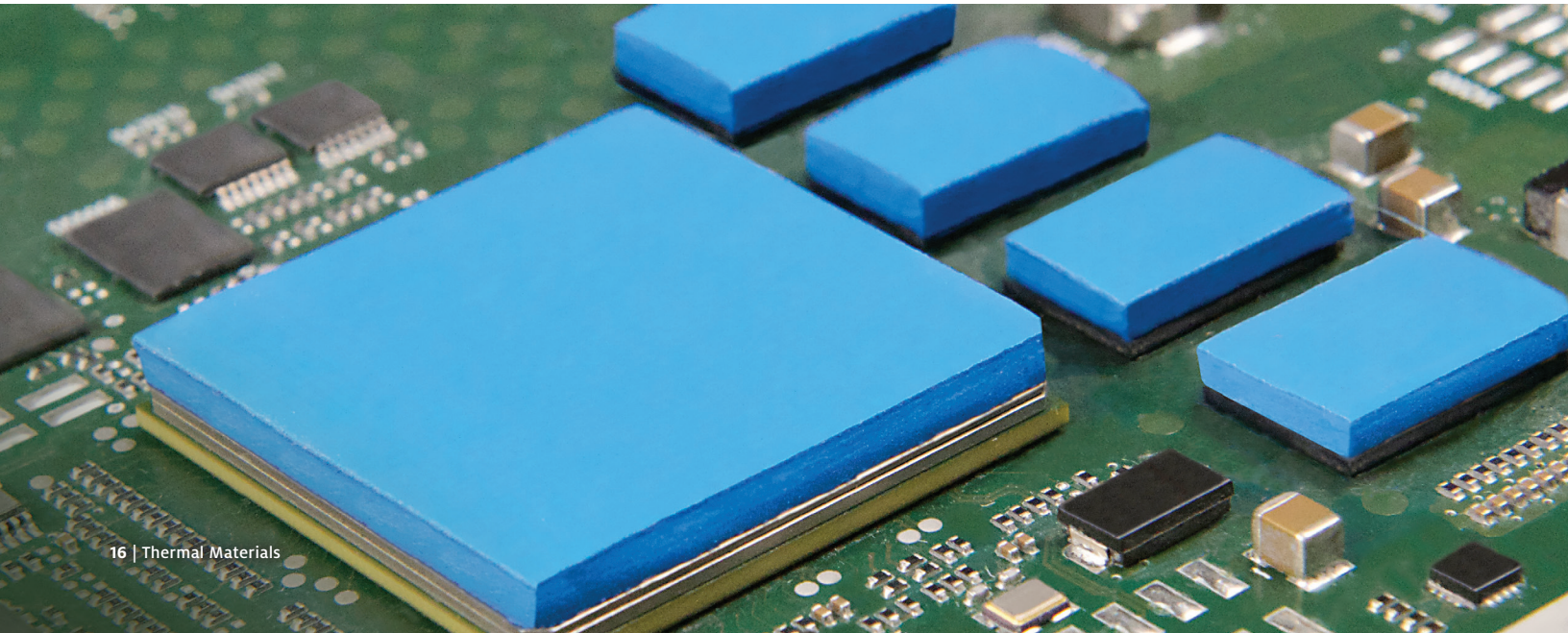
GAP FILLER

Product Name	Description	Key Attributes	Thermal Conductivity (W/m•K)	Viscosity at 25°C (cP)	Dielectric Strength (V/25 µm)	Flammability Rating	Recommended Cure
BERGQUIST GAP FILLER TGF 1100SF	Silicone-free, thermally conductive liquid gap filling material	• No silicone outgassing or extraction • Ultra-conforming material designed for fragile and low-stress applications • Ambient and accelerated cure schedules • 100% solids – no cure by-products	1.1	450,000	400	UL 94 V-0	24 hr. at 25°C
BERGQUIST GAP FILLER TGF 1500	Thermally conductive liquid gap filling material	• Optimized shear thinning characteristics for ease of dispensing • Excellent slump resistance • Ultra-conforming with excellent wet-out for low-stress interface applications • 100% solids – no cure by-products • Excellent low- and high-temperature mechanical and chemical stability • Ambient and accelerated cure schedules	1.8	25,000	400	UL 94 V-0	5 hr. at 25°C
BERGQUIST GAP FILLER 1500LVO	Thermally conductive liquid gap filling material	• Low volatility for silicone sensitive applications • Ultra-conforming with excellent wet-out • 100% solids – no cure by-products • Excellent low- and high-temperature, chemical and mechanical stability • Ambient or accelerated cure schedules	1.8	20,000	400	UL 94 V-0	8 hr. at 25°C
BERGQUIST GAP FILLER TGF 3500LVO	Thermally conductive liquid gap filling material	• Low volatility for outgassing sensitive applications • Ultra-conforming with excellent wet-out for low-stress interfaces on applications • 100% solids – no cure by-products • Ambient or accelerated cure schedules	3.5	45,000	275	UL 94 V-0	24 hr. at 25°C
BERGQUIST GAP FILLER TGF 3600	Thermally conductive liquid gap filling material	• High thermal performance • Thixotropic nature makes it easy to dispense • Ultra-conforming material designed for fragile and low-stress applications • Ambient or accelerated cure schedules	3.6	150,000	275	UL 94 V-0	15 hr. at 25°C
BERGQUIST GAP FILLER TGF 4000	Thermally conductive liquid gap filling material	• High thermal performance • Extended working time for manufacturing flexibility • Ultra-conforming with excellent wet-out • 100% solids – no cure by-products • Excellent low- and high-temperature, chemical and mechanical stability • Ambient or accelerated cure schedules	4.0	50,000	450	UL 94 V-0	24 hr. at 25°C

THERMAL MATERIALS FOR ADAS RADARS

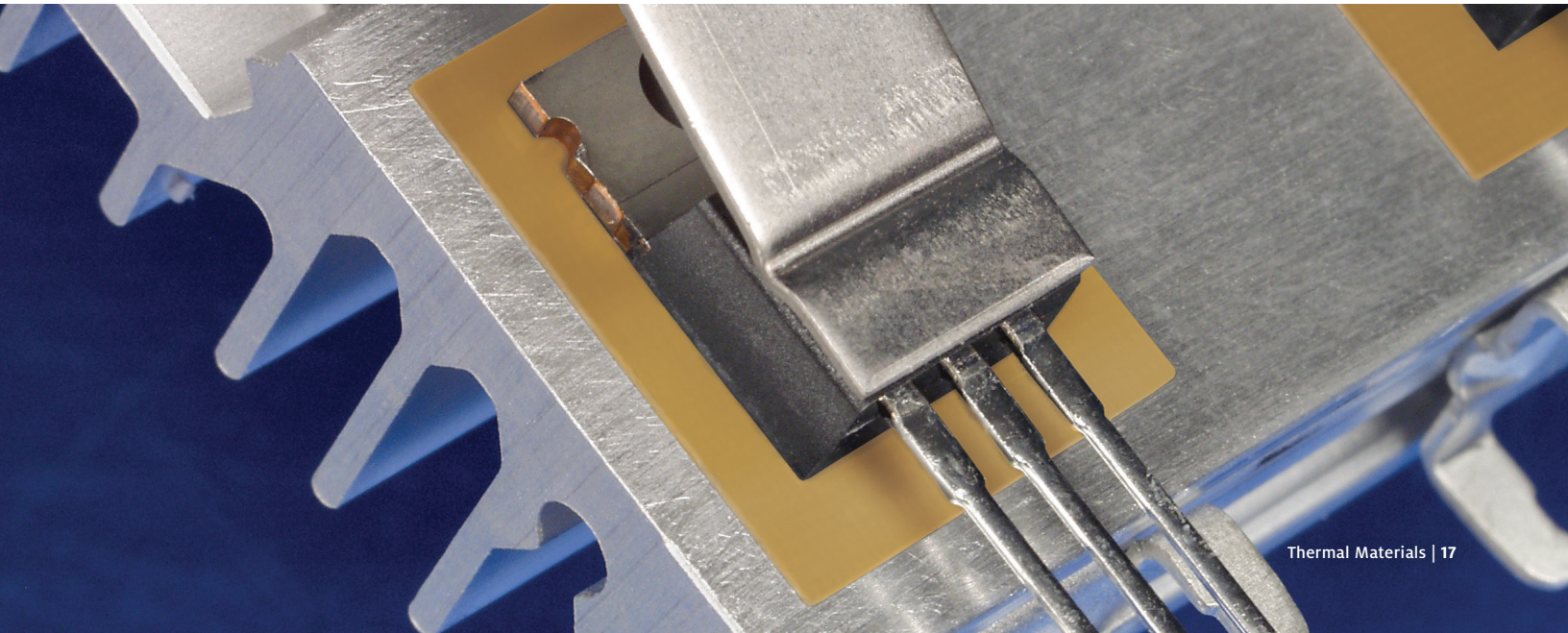
GAP PAD®

Product Name	Description	Key Attributes	Thermal Conductivity (W/m•K)	Modulus at 25°C (kPa)	Dielectric Breakdown Voltage	Thickness (mm)	Flammability Rating
BERGQUIST GAP PAD® TGP 1000SF	Silicone-free, thermally conductive gap filling material	• No silicone outgassing • No silicone extraction • Reduced tack on one side to aid in application assembly • Electrically isolating	0.9	234	6,000 V at 250 µm	• 0.254 – 3.175	UL 94 V-1
BERGQUIST GAP PAD® TGP 2200SF	Silicone-free, thermally conductive gap filling material	• Medium compliance with easy handling • Electrically isolating	2	228	5,000 V at 250 µm	• 0.254 – 3.175	UL 94 V-0
BERGQUIST GAP PAD® TGP 2202SF	Silicone-free, high performance, thermally conductive gap filling material	• Minimal compression set • 12.7 µm film provides tack-free surface • Tacky side allows for ease of handling and placement	2	1,500	5,000 V at 250 µm	• 0.254 – 3.175	UL 94 V-0
BERGQUIST GAP PAD® TGP 3004SF	Silicone-free, high performance, thermally conductive gap filling material	• Excellent thermal performance • 6.4 µm polyethylene terephthalate (PET) provides easy disassembly, leaving no residue • Tacky side allows for ease of handling and placement	3	2,450	6,000 V at 250 µm	• 0.254 – 3.175	UL 94 V-0
BERGQUIST GAP PAD® TGP HC3000	Thermally conductive gap filling material	• High-compliance, low compression stress • Fiberglass reinforced for shear and tear resistance • Low modulus	3	110	5,000 V at 500 µm	• 0.508 – 3.175	UL 94 V-0
BERGQUIST GAP PAD® TGP HC5000	Thermally conductive gap filling material	• Highly conformable • Exceptional thermal performance • High-compliance, low compression stress • Fiberglass reinforced for shear and tear resistance • Low modulus	5	121	5,000 V at 500 µm	• 0.508 – 3.175	UL 94 V-0
BERGQUIST GAP PAD® TGP 1000VOUS	Thermally conductive gap filling material	• Highly conformable, low hardness • “Gel-like” modulus • Decreased strain • Puncture, shear and tear resistant • Electrically isolating	1	55	6,000 V at 500 µm	• 0.508 – 6.350	UL 94 V-0



PHASE CHANGE MATERIALS

Product Name	Description	Key Attributes	Thermal Conductivity (W/m•K)	Phase Change Temperature (°C)	Dielectric Strength (V/25 µm)	Thickness (mm)	Flammability Rating
Aluminum Carrier							
BERGQUIST HI-FLOW THF 1000F-AC	Phase change thermal interface material	• Low thermal impedance • Can be manually or automatically applied to the surfaces of room-temperature heat sinks • Foil reinforced, adhesive coated • Soft phase change compound	1	55	N/A	• 0.102	UL 94 V-0
LOCTITE TCF 1000	Non-insulating, phase change thermal interface material	• Low thermal impedance • Coated on aluminum foil • Used between any non-isolated heat dissipating component and a heat sink or chassis	1	60	N/A	• 0.06 – 0.2	None
LOCTITE TCF 2000	Non-insulating, phase change thermal interface material	• Used between any non-isolated heat dissipating component and a heat sink or chassis • High thermal conductivity	3	51	N/A	• 0.076	UL 94 V-0
Polyimide Carrier							
LOCTITE EIF 1000	High-performance, phase change thermal Interface material	• High dielectric strength • Excellent cut-through resistance	0.45	60	> 5,000	• 0.05 – 0.2	UL 94 V-0
BERGQUIST HI-FLOW THF 1600P	High-performance, phase change thermal interface material	• Field-proven polyimide film • Excellent dielectric performance • Excellent cut-through resistance • Outstanding thermal performance in an insulated pad	1.6	55	5,000	• 0.102 – 0.127	UL 94 V-0
No Carrier							
BERGQUIST HI-FLOW THF 3000UT	High-performance, phase change thermal interface material	• Very low thermal impedance • High thermal conductivity • Naturally tacky • Tabulated for ease of assembly	3	52	N/A	• 0.127 • 0.254	UL 94 V-0



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