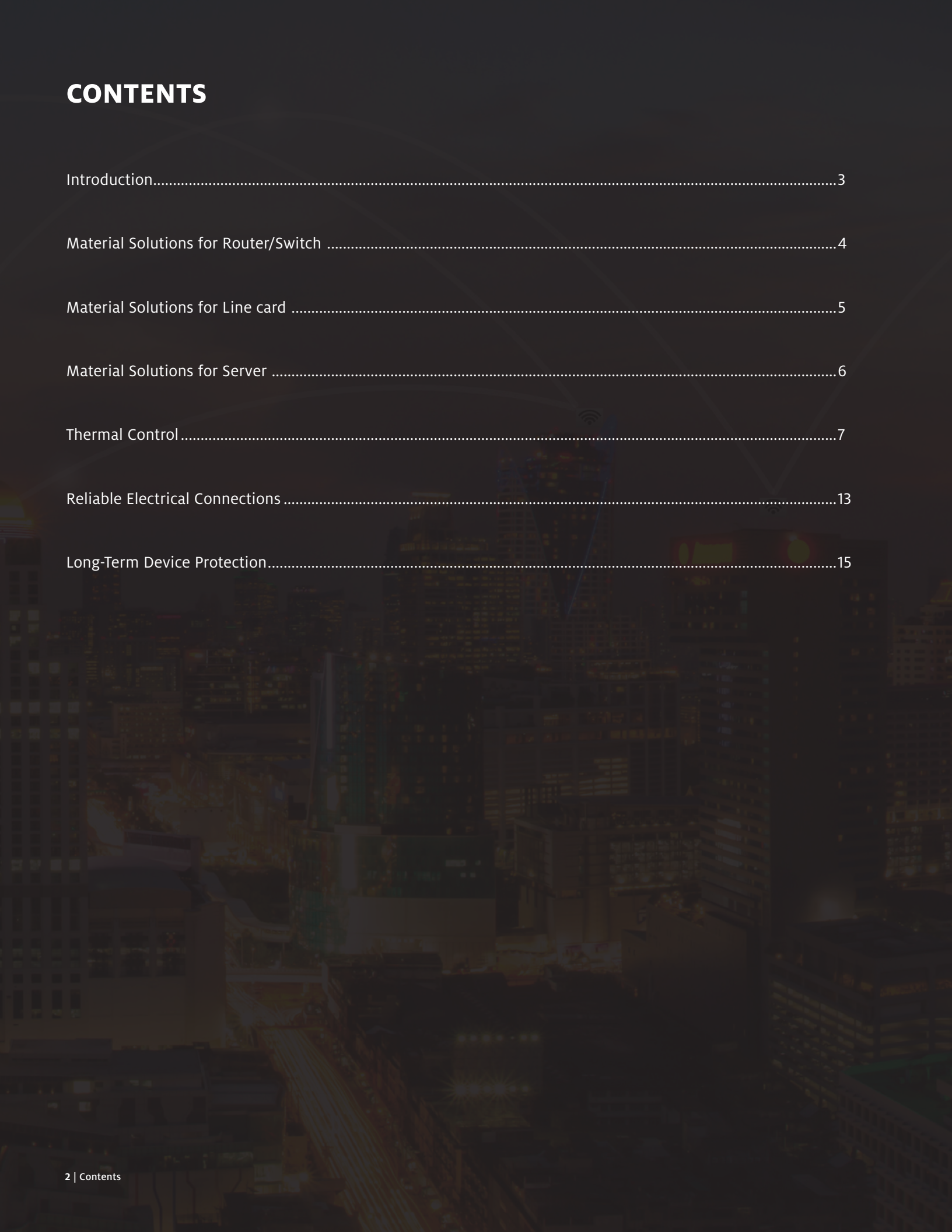


MATERIAL SOLUTIONS FOR
CLOUD/HYPERSCALE DATACENTER SWITCHES, ROUTERS AND SERVERS





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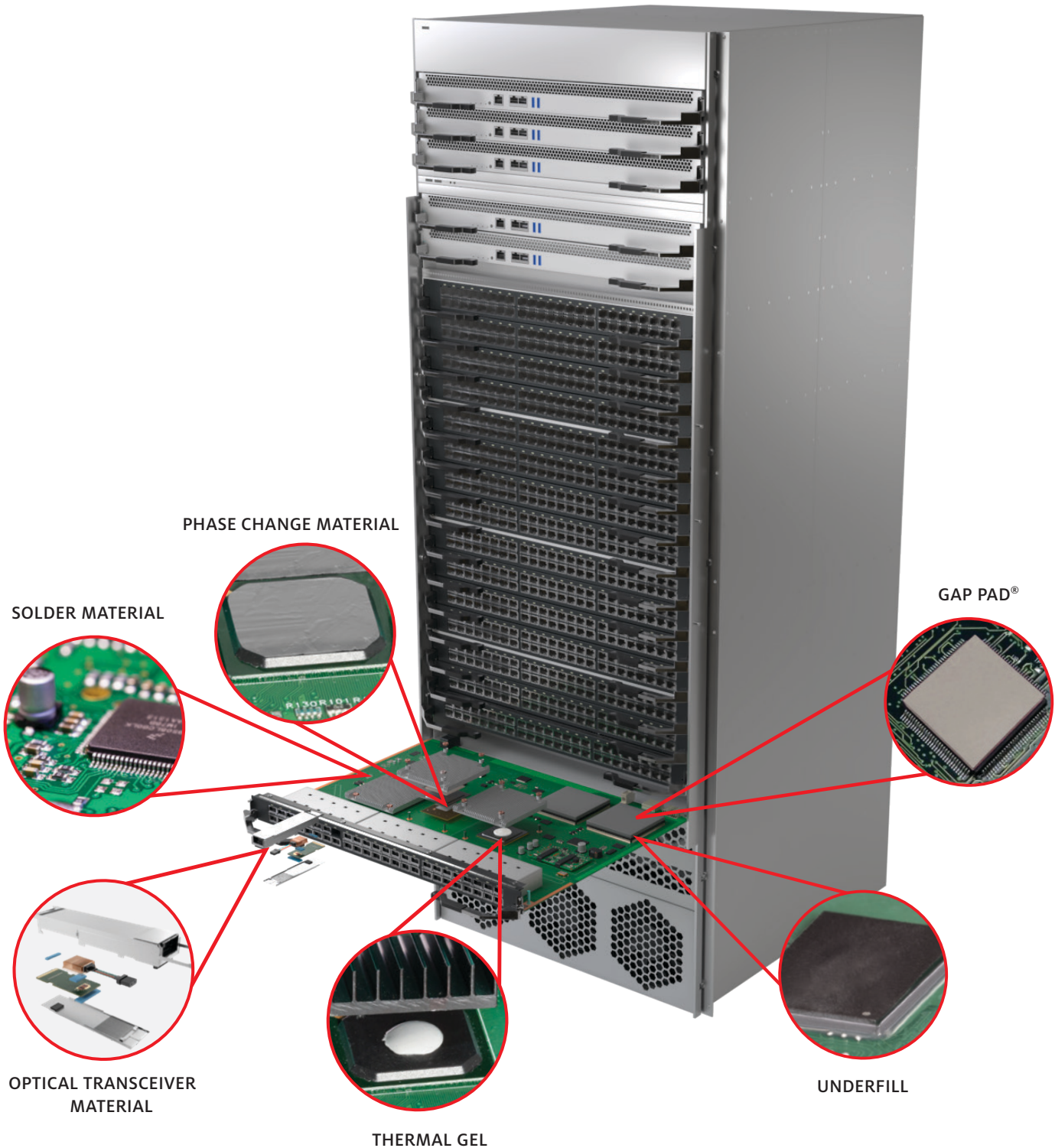


Introduction

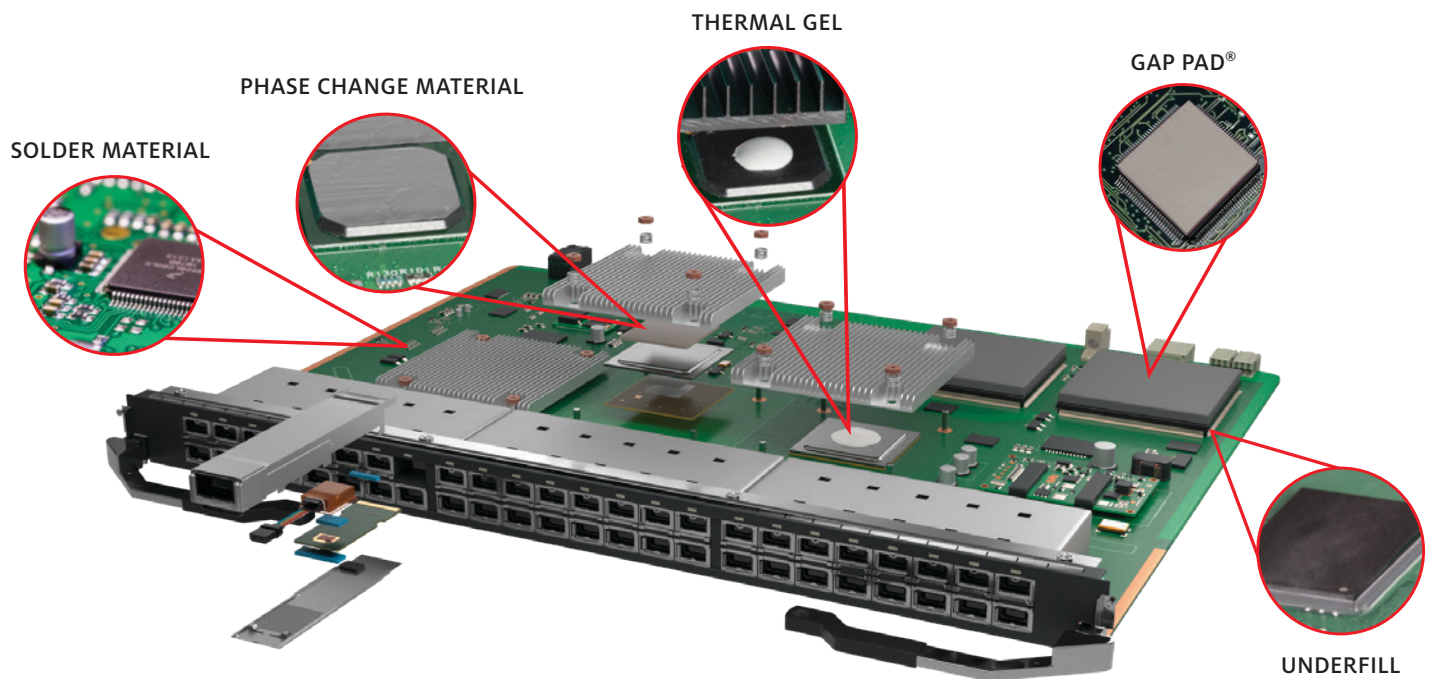
Consumer demand is driving requirements for rich media streaming, cloud-based storage, data mining, analytics and machine learning applications, accelerating the need for next-generation high-speed network access, high performance computing and data processing in Cloud/Hyperscale Datacenter environments. Connectivity between datacenters – known as datacenter interconnect (DCI) – and higher bandwidths are moving the industry towards 400GE solutions for faster data switching and routing performance. Data mining analytics and machine learning applications have spurred the development of technology that allows faster GPU/ASIC processing speeds while increasing the quantities of these devices per line card – all of which results in high component and power densities.

With the convergence of these factors, ensuring the reliability and long-term performance of datacenter electronic components is essential and facilitated by advanced connecting, protecting and thermal management materials. As the largest global innovator and supplier of adhesives, functional coatings and sealants, Henkel is the market leader for advanced material solutions to enable the future of datacom applications.

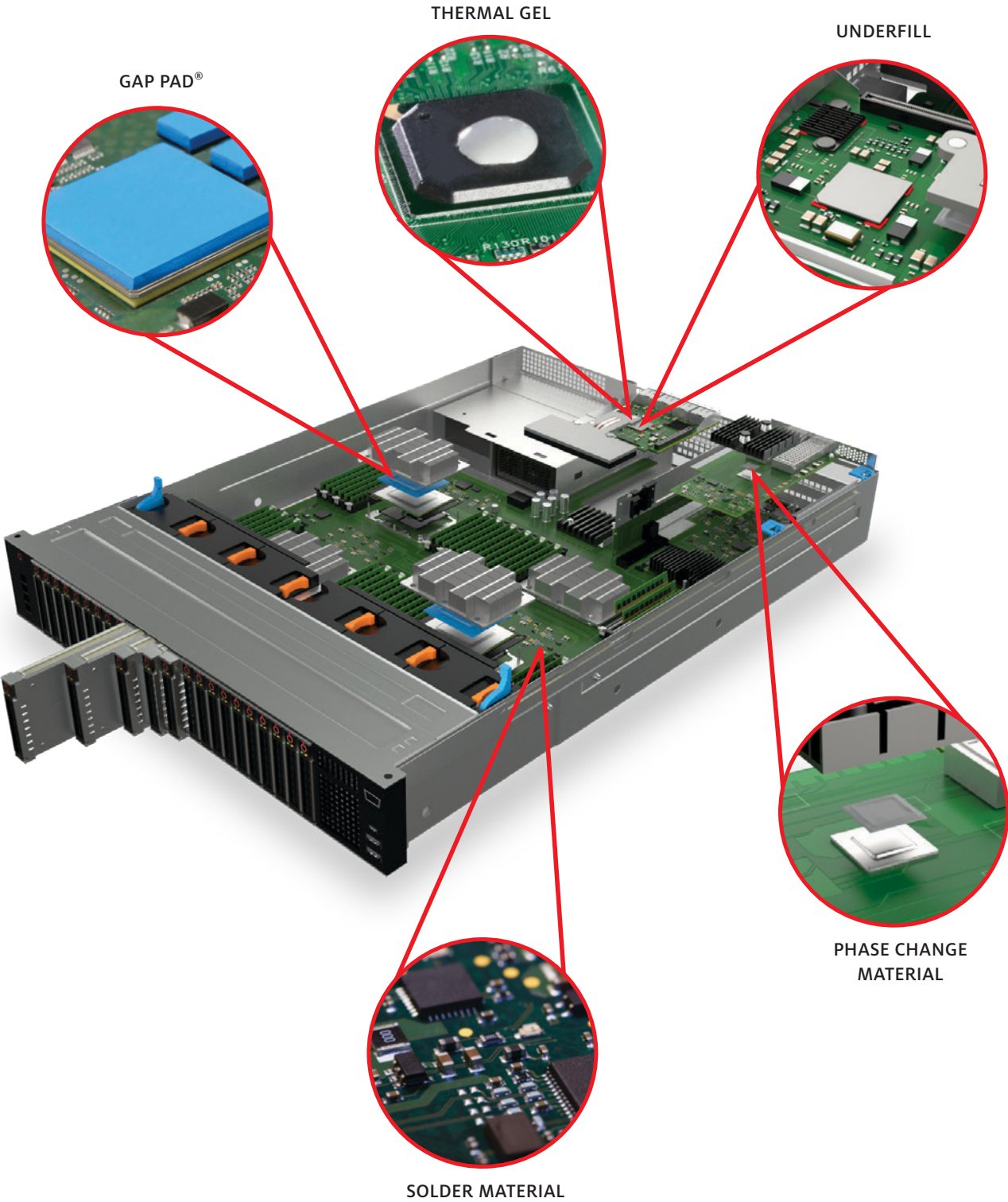
MATERIAL SOLUTIONS FOR ROUTER/SWITCH



MATERIAL SOLUTIONS FOR LINE CARD



MATERIAL SOLUTIONS FOR SERVER

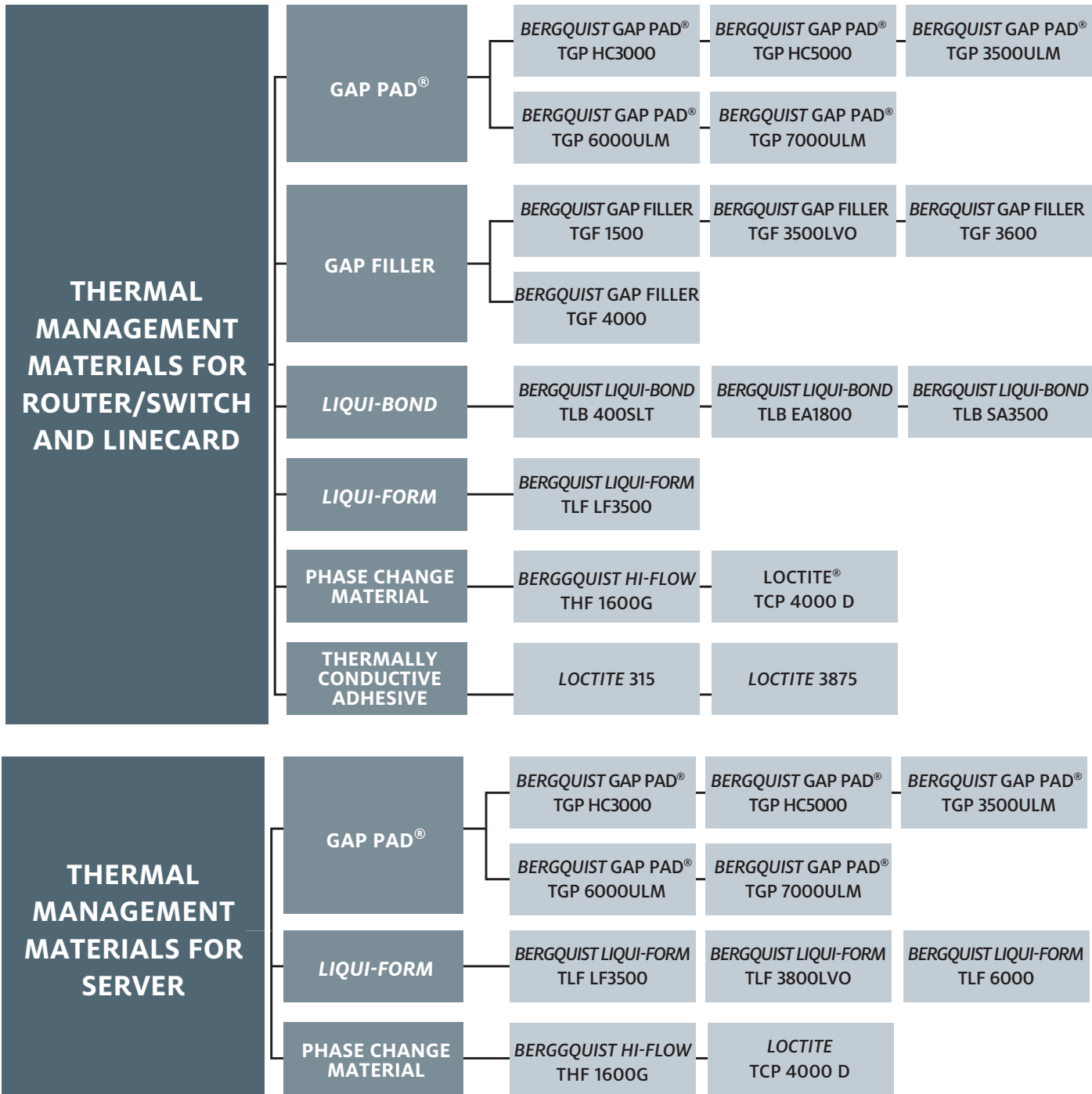




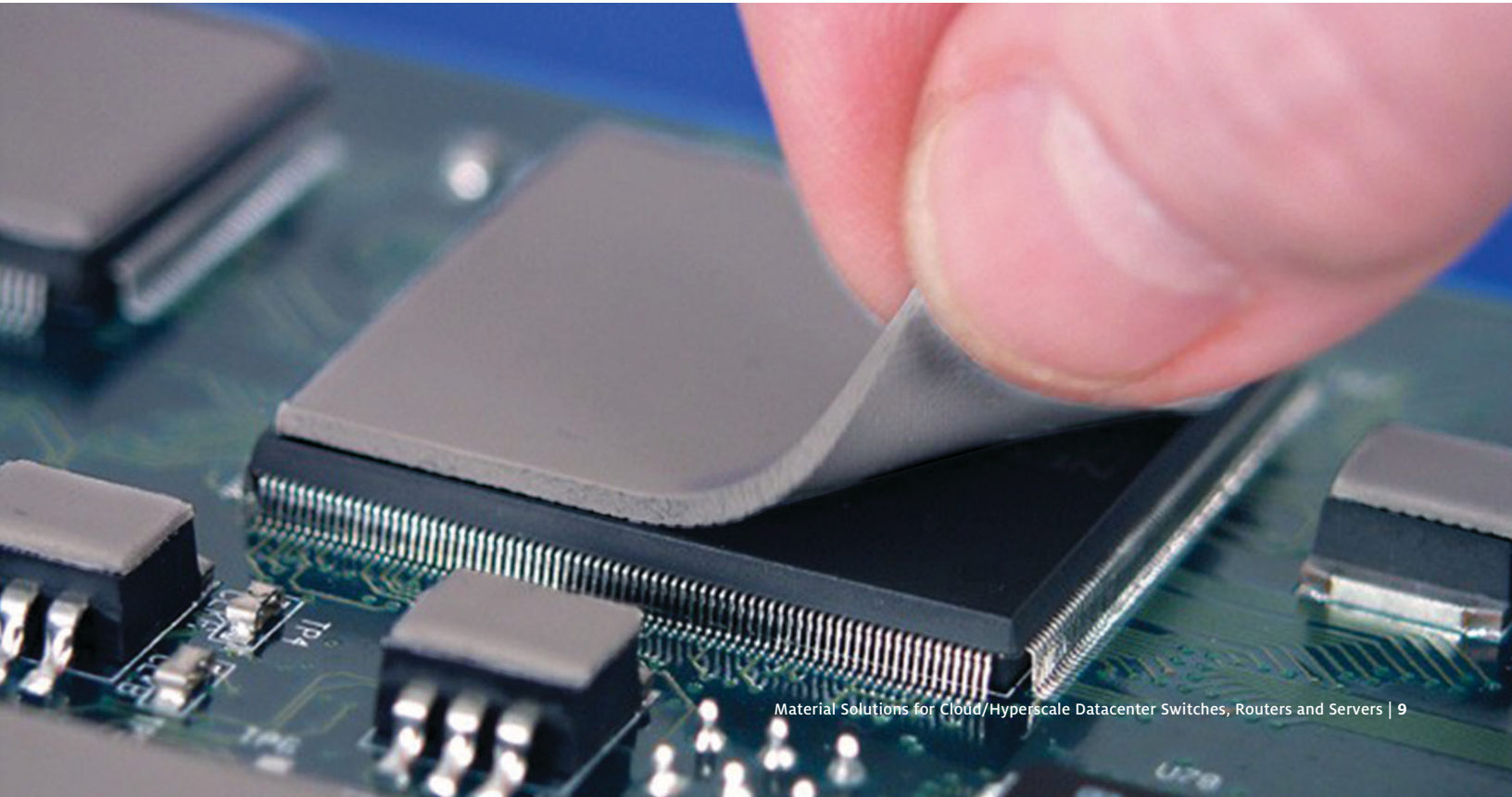
Thermal Control

Depending on the application, Henkel has multiple thermal interface material (TIM) solutions to support improved system-level performance and reliability of high power density line cards through effective thermal management. A range of formulations in pad, film, liquid and gel mediums provide effective and efficient heat dissipation in large, high-performance Layer 1/Layer 2 Switch ASIC, FPGA and GPU devices used in next-generation network equipment and high performance computing servers. For IC devices that do not require a larger heat sink attachment, Henkel's low modulus, high conductivity *BERGQUIST* GAP PAD® deliver excellent conformability and low stress thermal performance. As an alternative to conventional thermal greases, *BERGQUIST* phase change TIMs allow for similar ease-of-application and flexibility in a paste-applied formula that becomes liquidus at specific temperature. However, *BERGQUIST* phase change TIMs do not suffer from the “pump out” and reduced thermal performance over time generally experienced with grease.

Thermal Management Materials

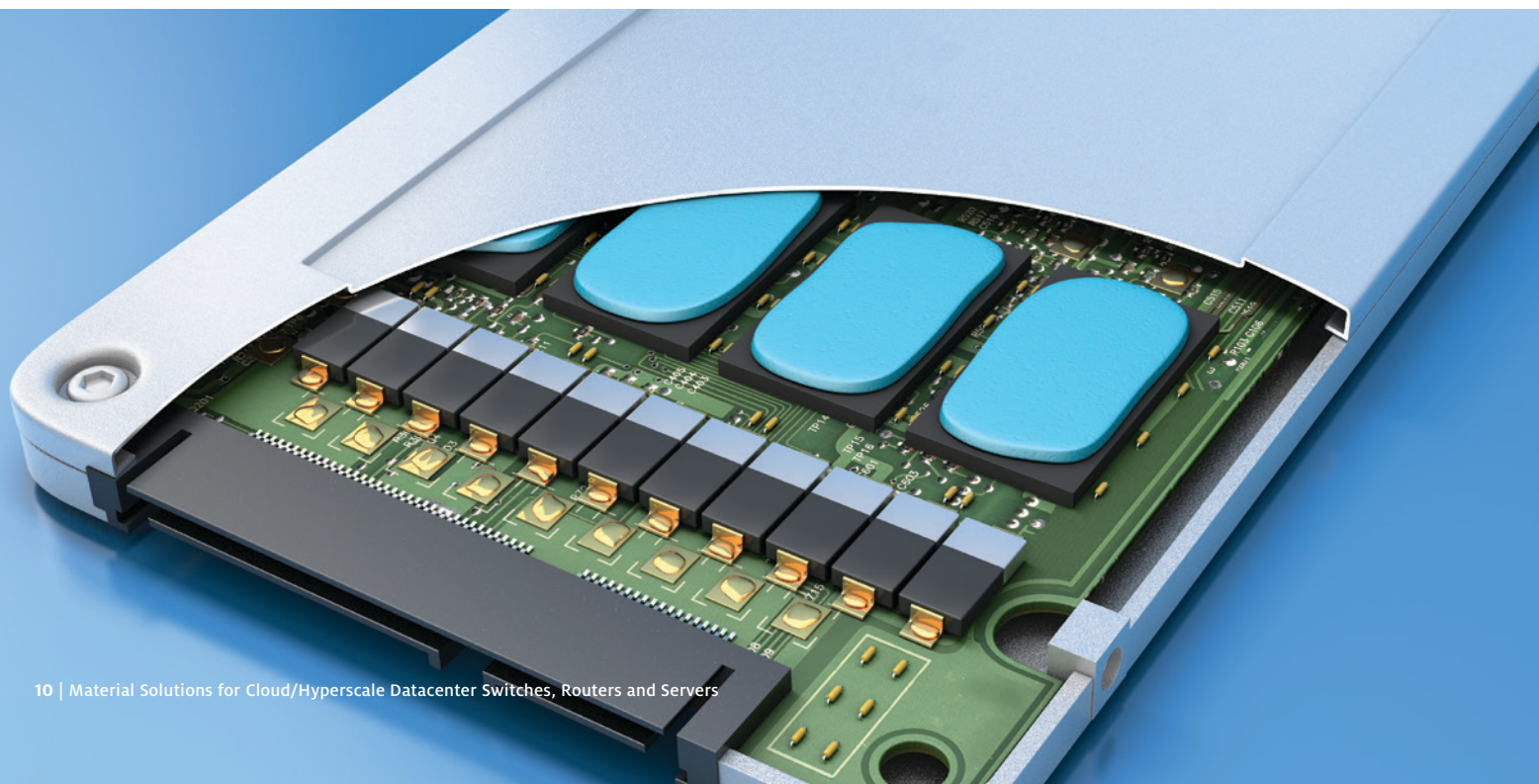


Product	Description	Thermal Conductivity (W/m·K)	Hardness	Dielectric Breakdown Voltage (Vac)	Volume Resistivity (Ω·m)	Reinforcement Carrier	Chemistry
BERGQUIST GAP PAD® TGP HC3000	High-compliance, thermally conductive, low modulus material	3	15 (Shore 00)	> 5000	10 ¹⁰	Fiberglass	Silicone Base
BERGQUIST GAP PAD® TGP HC5000	High-compliance, thermally conductive, low modulus material	5	35 (Shore 00)	> 5000	10 ¹⁰	Fiberglass	Silicone Base
BERGQUIST GAP PAD® TGP 3500ULM	Highly conformable, thermally conductive, ultra-low modulus material	3.5	70 (Shore 000)	> 5000	10 ¹⁰	With or without fiberglass	Silicone Base
BERGQUIST GAP PAD® TGP 6000ULM	A high performance, 6 W/m·K silicone thermal interface material, ultra-low modulus material	6	60 (Shore 000)	> 5000	10 ¹⁰	Fiberglass	Silicone Base
BERGQUIST GAP PAD® TGP 7000ULM	A 7 W/m·K, extremely soft GAP PAD® with exceptional thermal performance at low pressures	7	75 (Shore 000)	> 5000	1.2x10 ¹¹	None	Silicone Base



Gap Filler

Product	Description	Thermal Conductivity (W/m·K)	Hardness (Shore 00)	Dielectric Strength (V/mil)	Volume Resistivity ($\Omega\cdot\text{m}$)	Cure schedule (25°C / 100°C)	Chemistry
<i>BERGQUIST</i> GAP FILLER TGF 1500	Thermally conductive, liquid gap filler material	1.8	50	400	10^{10}	5 hr./10 min.	2K, Silicone Base
<i>BERGQUIST</i> GAP FILLER TGF 3500LVO	Thermally conductive, low outgassing, liquid gap filling material	3.5	40	275	10^{10}	24 hr./30 min.	2K, Silicone Base
<i>BERGQUIST</i> GAP FILLER TGF 3600	Thermally conductive, liquid gap filling material	3.6	35	275	10^{10}	15 hr./30 min.	2K, Silicone Base
<i>BERGQUIST</i> GAP FILLER TGF 4000	Thermally conductive, liquid gap filler material	4	75	450	10^{10}	24 hr./30 min.	2K, Silicone Base



LIQUI-BOND

Product	Description	Tensile Strength (psi)	Shear Strength (psi)	Dielectric Strength (V/mil)	Volume Resistivity ($\Omega \cdot m$)	Breaking Strength (kN/m)
<i>BERGQUIST</i> <i>LIQUI-BOND</i> TLB 400SLT	High performance silicone adhesive sealant with an adaptable cure profile	300	300	250	10^{12}	4.4

Product	Description	Thermal Conductivity (W/m·K)	Hardness	Dielectric Strength (V/mm)	Volume Resistivity ($\Omega \cdot m$)	Shear Strength (psi)
<i>BERGQUIST</i> <i>LIQUI-BOND</i> TLB EA1800	Thermally conductive, two-part, liquid epoxy adhesive	1.8	90 (Shore D)	10,000	10^{14}	450
<i>BERGQUIST</i> <i>LIQUI-BOND</i> TLB SA3500	Thermally conductive, two-part, liquid silicone adhesive	3.5	90 (Shore A)	10,000	10^{10}	450

LIQUI-FORM

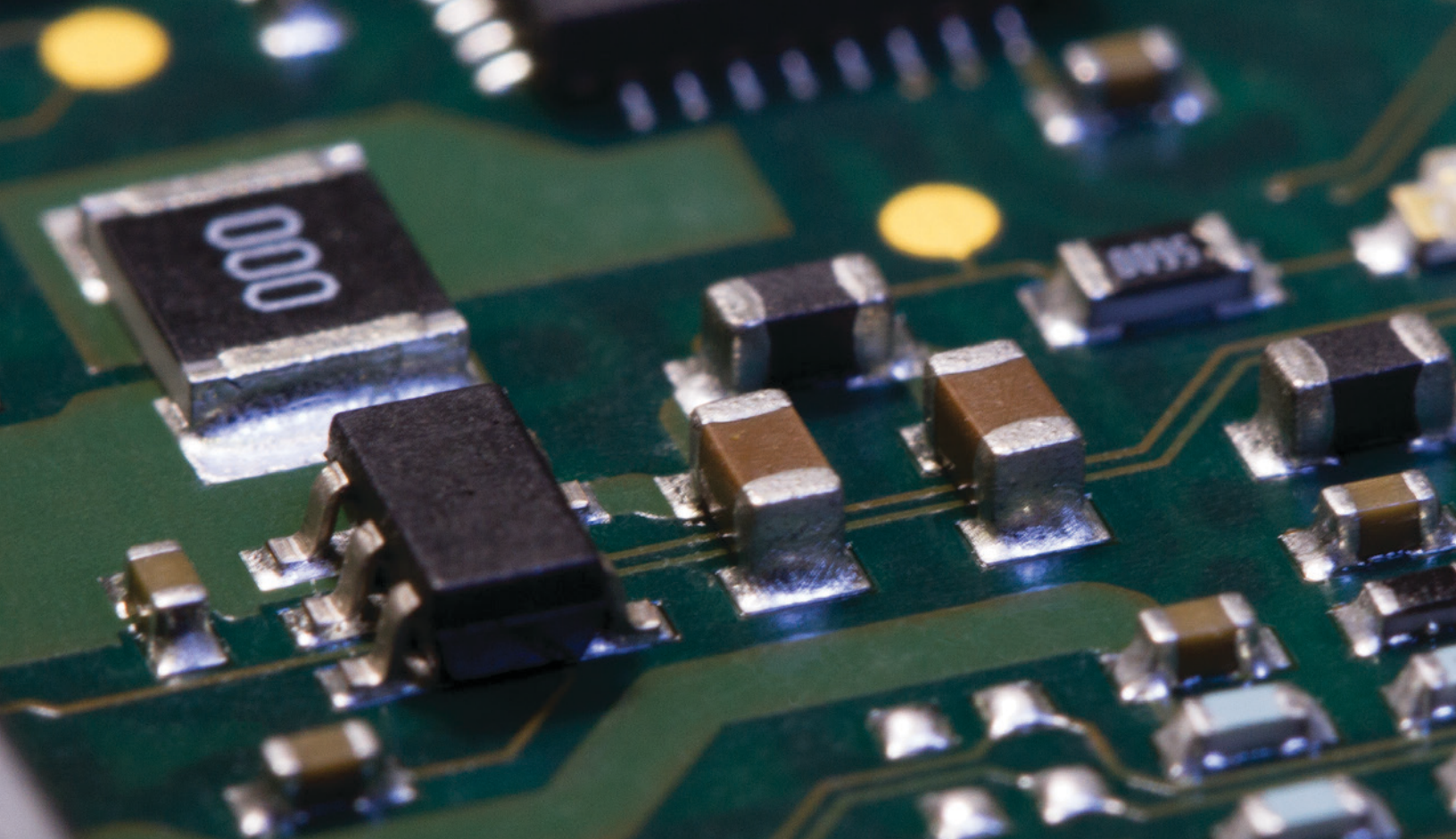
Product	Description	Thermal Conductivity (W/m·K)	Volume Resistivity ($\Omega \cdot m$)	Dielectric Constant at 1,000 Hz	Operating Temperature Range	UL Flammability Rating
<i>BERGQUIST</i> <i>LIQUI-FORM</i> TLF LF3500	Thermally conductive, one-part, liquid formable gel material	3.5	1×10^{11}	8.1	-60 – 200°C	UL 94 V-0
<i>BERGQUIST</i> <i>LIQUI-FORM</i> TLF 3800LVO	Silicone based gel, high conductivity thermal interface material	3.8	1×10^{10}	8	-60 – 200°C	UL 94 V-0
<i>BERGQUIST</i> <i>LIQUI-FORM</i> TLF 6000	Silicone based gel, thermally conductive interface material	6	3.25×10^{10}	5.7	-60 – 200°C	–

Phase Change Materials

Product	Description	Key Attributes	Thermal Conductivity (W/m·K)	Volume Resistivity ($\Omega\cdot\text{m}$)	Dielectric Breakdown Voltage	Thickness (mm)	Flammability Rating
<i>BERGQUIST HI-FLOW THF 1600G</i>	Thermally conductive 55°C phase change compound coated on a fiberglass web. Designed as a thermal interface material between a computer processor and a heat sink	- Thermal impedance: 0.2°C·in²/W at 25 psi - Will not drip or run like grease - Phase change compound coated on a fiberglass carrier	1.6	1x10 ⁸	300	0.127	UL 94 V-0
<i>BERGQUIST HI-FLOW THF 1600P</i>	A thermally conductive 55°C phase change compound coated on a thermally conductive polyimide film	- Thermal impedance: 0.13°C·in²/W at 25 psi - Field-proven polyimide film with excellent dielectric performance and cut-through resistance - Outstanding thermal performance in an insulated pad	1.6	1x10 ¹²	5,000	0.102 – 0.127	UL 94 V-0
<i>LOCTITE® TCP 4000 D</i>	Non-silicone, reworkable phase-change material supplied as a paste that can be stenciled, needle-dispensed or screen-printed onto a heat sink, base plate or other surfaces	- Reworkable - Highly efficient thermal transfer - Thixotropic above phase change temperature	3.4	–	N/A	0.025 – 0.250	–

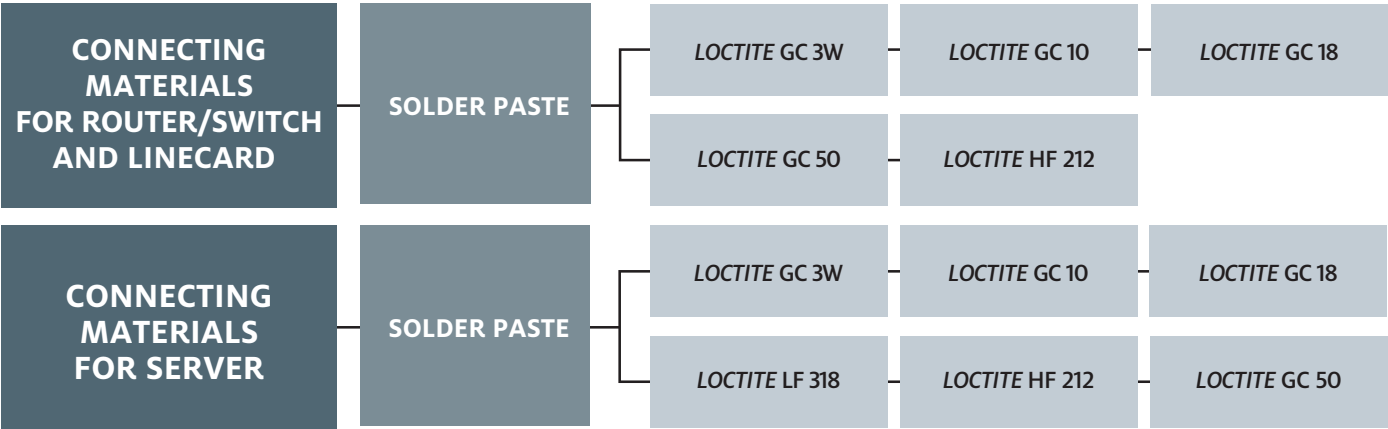
Thermally Conductive Adhesives

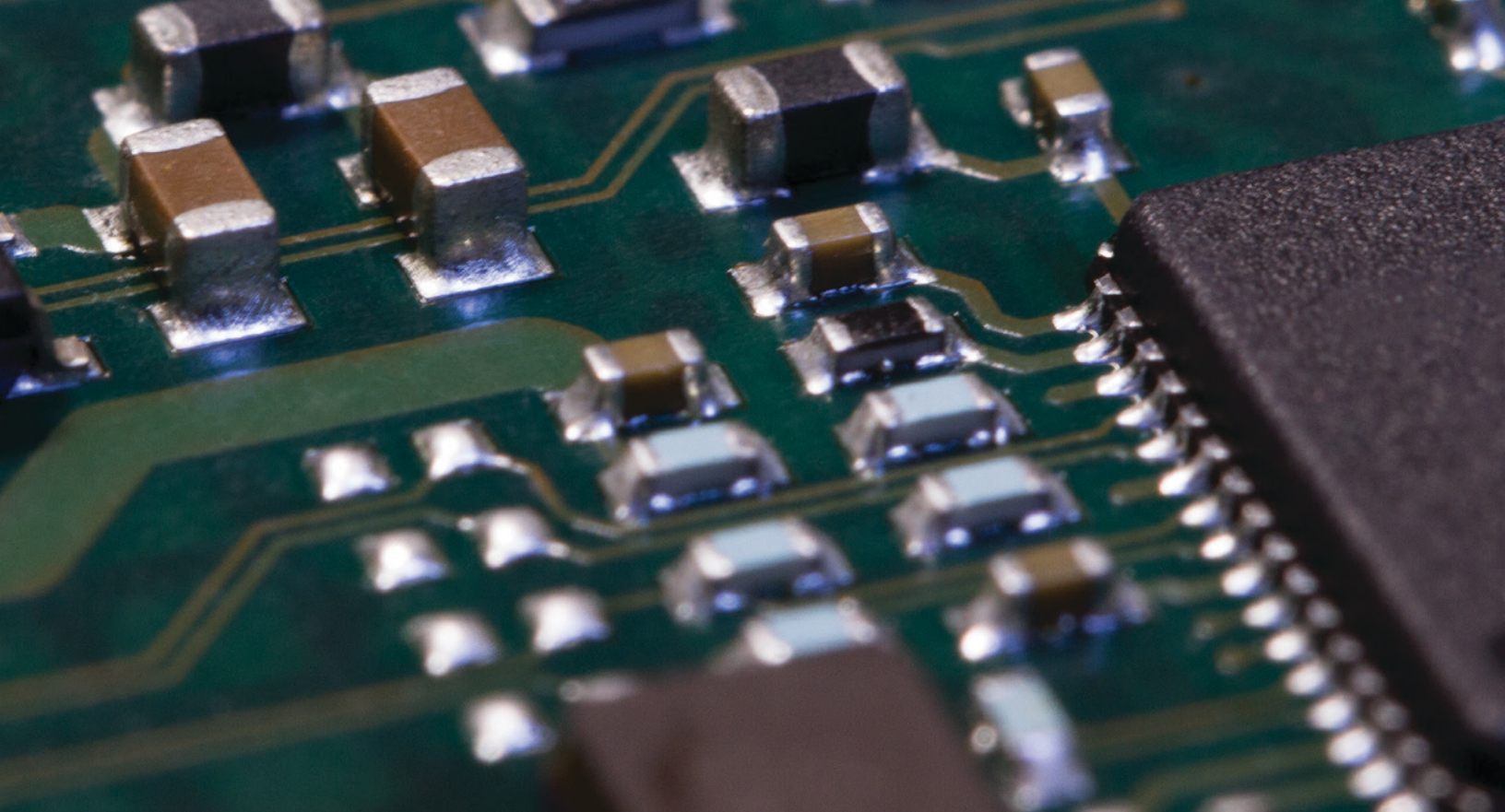
Product	Description	Thermal Conductivity (W/m·K)	Cure Type	Dielectric Strength (kV/mm)	Volume Resistivity ($\Omega\cdot\text{cm}$)	Shear Strength (psi)
<i>LOCTITE 315</i>	Acrylic	0.8	Activator or Heat	26.7	1.3x10 ¹²	1,000
<i>LOCTITE 3875</i>	Bead on Bead – Acrylate	1.75	Activator or Heat	–	–	2,400



Reliable Electrical Connections

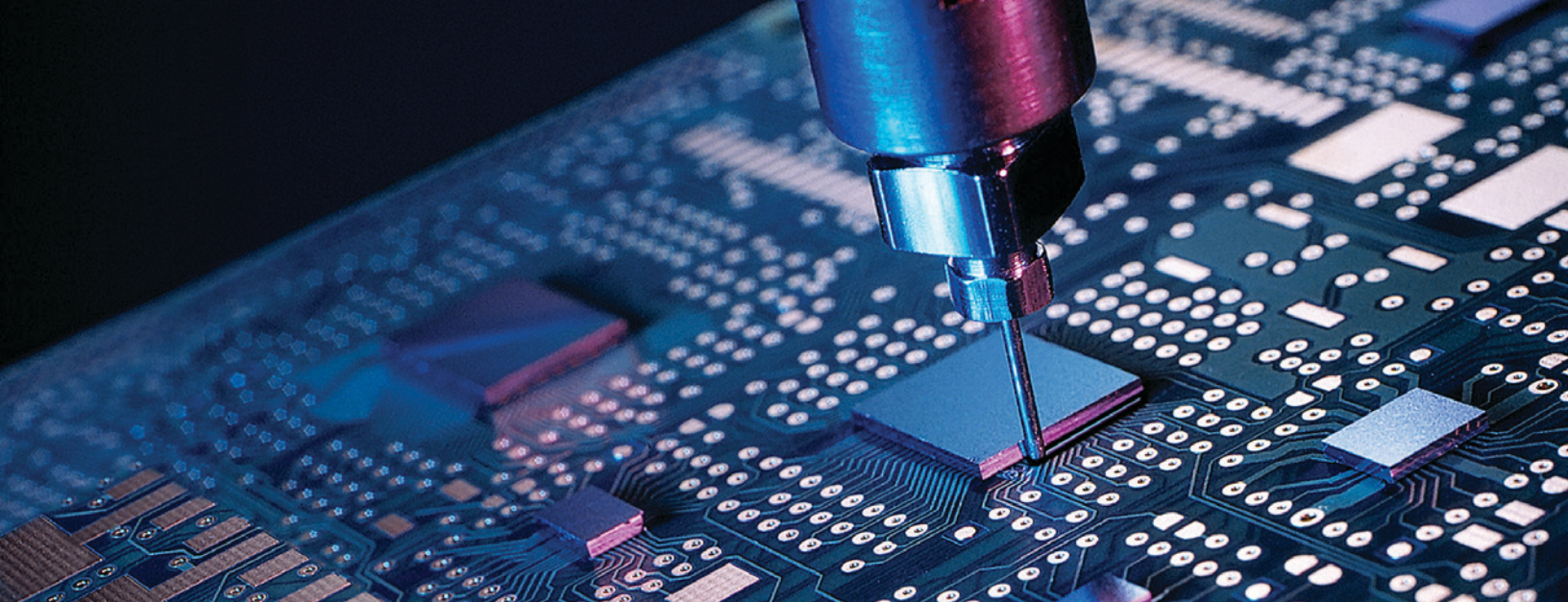
The integrity of electrical connections is vital to optimized line card function. With decades of experience in the development of high-performance, award-winning solder materials, Henkel has formulated a variety of lead-free, halogen-free, temperature stable solder products that provide high reliability and low voiding. These characteristics are especially important for the high pin-count QFN devices often used in 1U/2U networking and high performance computing line cards.





Solder Paste

Product	Description	Alloy	Particle Size Distribution	IPC J-STD-004B Classification	Optimal Shelf-life	Reflow Atmosphere
LOCTITE® GC 3W	Pb-free, water washable, halogen-free, temperature stable solder paste	SAC305	Type 3, 4	ORM0	6 months up to 26.5°C	Air and Nitrogen
LOCTITE GC 10	Pb-free, halogen-free, temperature stable solder paste	SAC305	Type 3, 4, 5	ROLO	12 months up to 26.5°C	Air and Nitrogen
LOCTITE GC 18	2nd generation temperature stable solder paste designed for improved void control especially under QFN's	SAC305	Type 3, 4, 5	ROLO	12 months up to 26.5°C	Air and Nitrogen
LOCTITE LF 318	Halide-free, RoHS-compliant solder paste with pin-testable flux exhibits excellent humidity resistance and ability to resist component movement during high-speed placement	90iSC SAC305 SAC387	Type 3, 4	ROLO	6 months at 0 – 10°C	Air and Nitrogen
LOCTITE HF 212	Pb-free, no clean, halogen-free solder paste	SAC305 SAC0307 SAC387 90ISC	Type 3, 4, 4.5 (4A), 5	ROLO	6 months at 0 – 10°C	Air and Nitrogen
LOCTITE GC 50	Pb-free, no clean, halogen-free solder paste	SAC305	Type 5	ROLO	12 months at 26.5°C	Air and Nitrogen



Long-term Device Protection

As interconnect density on array devices increases and dimensions decrease, protecting components from stress reduces failures and safeguards functionality. Advanced *LOCTITE* brand underfills offer improved mechanical integrity and reliability for fine-pitch array components used in high performance computing and data processing ASICs. Available in reworkable and non-reworkable formulations, *LOCTITE* underfills effectively protect component interconnects with low bump heights.

PROTECTION MATERIALS FOR ROUTER/SWITCH AND LINECARD	UNDERFILL	<i>LOCTITE ECCOBOND</i> UF 1173	<i>LOCTITE ECCOBOND</i> E 1216M	<i>LOCTITE ECCOBOND</i> UF 3812	<i>LOCTITE</i> 3517M
PROTECTION MATERIALS FOR SERVER	UNDERFILL	<i>LOCTITE ECCOBOND</i> UF 1173	<i>LOCTITE ECCOBOND</i> E 1216M	<i>LOCTITE ECCOBOND</i> UF 3812	

Product	Description	Viscosity (Pa·s)	Coefficient of thermal expansion, CTE (alpha 1 - ppm/°C)	Coefficient of thermal expansion, CTE (Alpha 2 - ppm/°C)	Glass Transition Temperature, T _g (°C)	Pot Life (day)
<i>LOCTITE ECCOBOND</i> UF 1173	Low CTE, high T _g underfill for extreme T-Cycle conditions	7.5	26	103	160	2
<i>LOCTITE ECCOBOND</i> E 1216M	Fast flow, non-anhydride underfill	4	35	131	125	–
<i>LOCTITE ECCOBOND</i> UF 3812	Room temperature flow, reworkable underfill	0.35	48	175	131	3
<i>LOCTITE</i> 3517M	Low temperature cure, reworkable underfill	2.6	65	191	78	7

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