LOCTITE®

BERGQUIST®

MATERIAL SOLUTIONS FOR AI DATA CENTER

Henkel

Henkel Adhesive Technologies

CONTENTS

AT A GLANCE

42%	$1.3 Trillion	50kW
YoY Growth in Generative AI*	Generative AI Market by 2032*	Power Demand Expected for Server Racks**

References:
*https://www.networkcomputing.com/data-centers/ai-data-centers-increasing-power-efficiency-gan
**https://www.forbes.com/sites/forbestechcouncil/2023/10/23/how-data-centers-are-evolving-to-meet-ai-demand/?sh=66d5d5fc77ac

OPTIMIZING PERFORMANCE OF ARTIFICIAL INTELLIGENCE ICs IN THE DATA CENTER

Artificial Intelligence (AI) has become ubiquitous across industries wherever exceptionally high computing performance is required. Nowhere is the power of AI and its capacity to manage large, complex workloads in less time with greater efficiency more pronounced than in the data center.

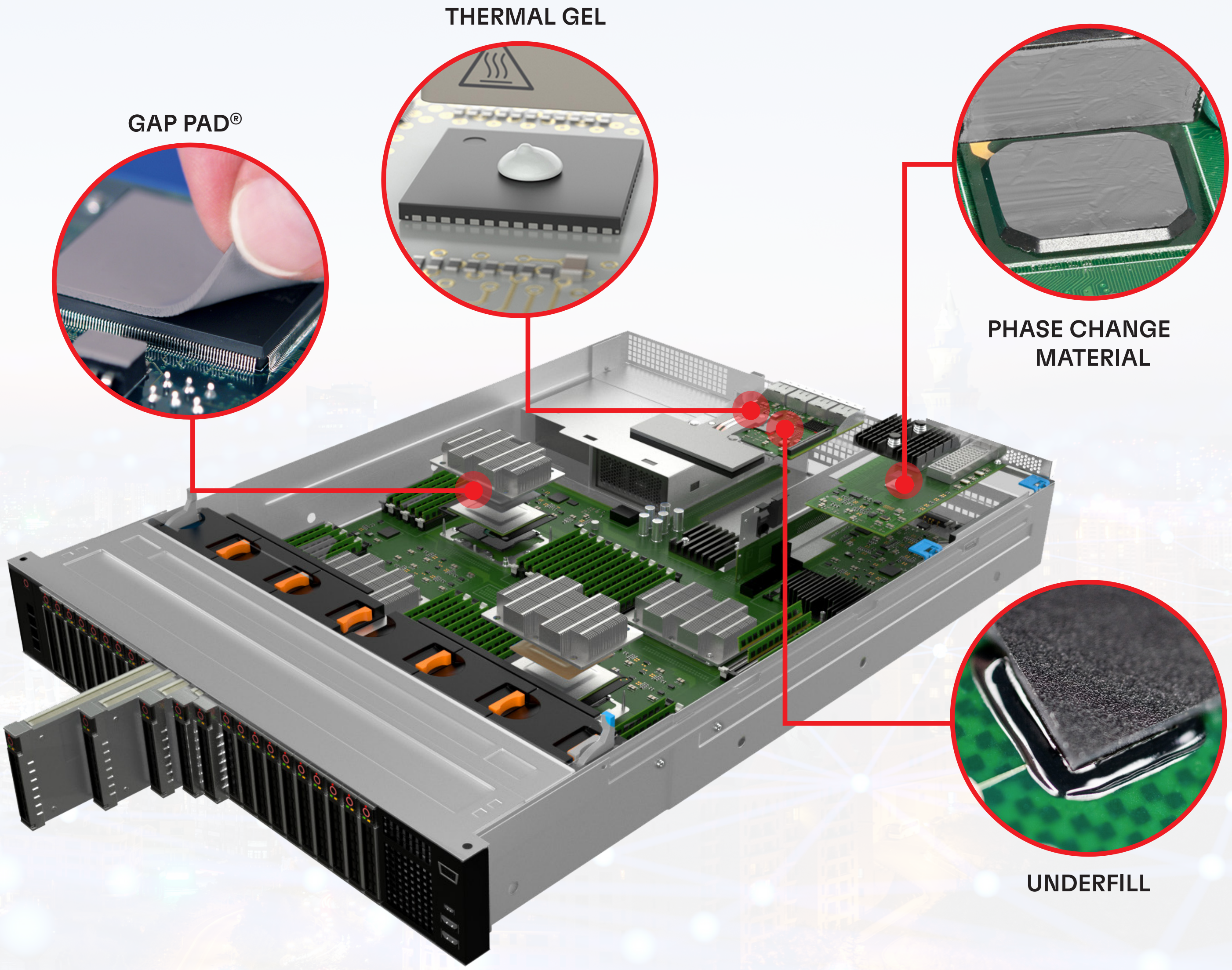
To satisfy the increasing demands for machine learning and generative AI, data center AI chip integration is exploding. By some estimates, AI compute intensity is doubling every six to ten months. And infrastructure capacity is following suit. High-performance computing (HPC) clusters comprising numerous servers are networked together to deliver massive processing capability and faster speeds. High power densities and more significant heat generation are the result.

The racks housing high-performing AI modules made up of GPU/FPGA/ASIC packages are today pushing power levels of 7 kW with the expectation of 50 kW and higher in the not-too-distant future[1]. Speeds are simultaneously accelerating, with optical networks now delivering transmission capability of 1.6 terabits per second. Improving the performance and ensuring the longevity of these high-value systems is imperative. Advanced thermal control and interconnect protection solutions that overcome operational heat and thermo-mechanical stress at their source are essential to maximizing AI workload efficiency.

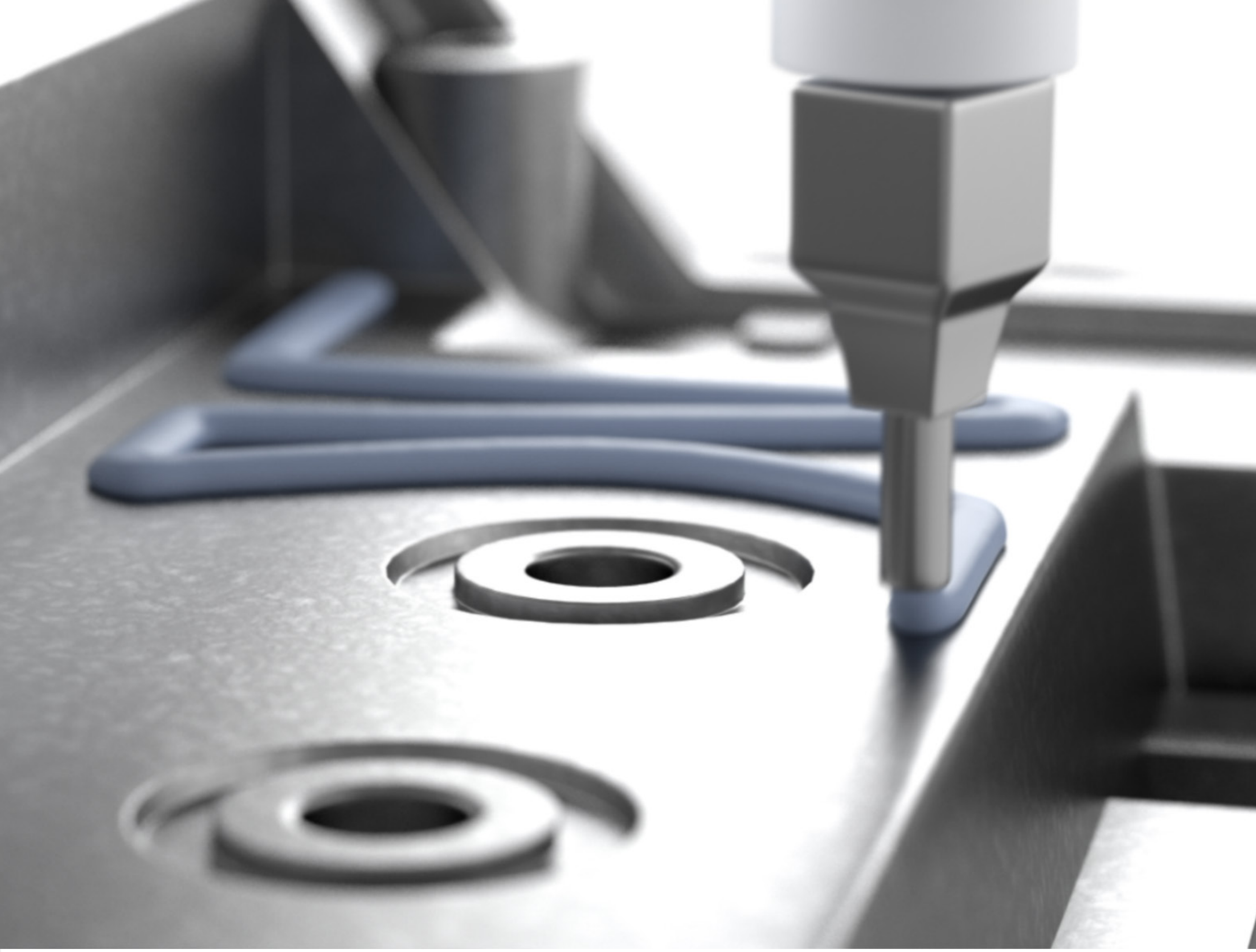
1. Omdia 2022 Data Center Thermal Management Market Analysis report

THERMAL AND PROTECTIVE MATERIALS FOR ADVANCED DATA CENTER SYSTEMS

SERVER


THERMAL GEL
GAP PAD®
PHASE CHANGE MATERIAL
UNDERFILL

ROUTER AND SWITCH

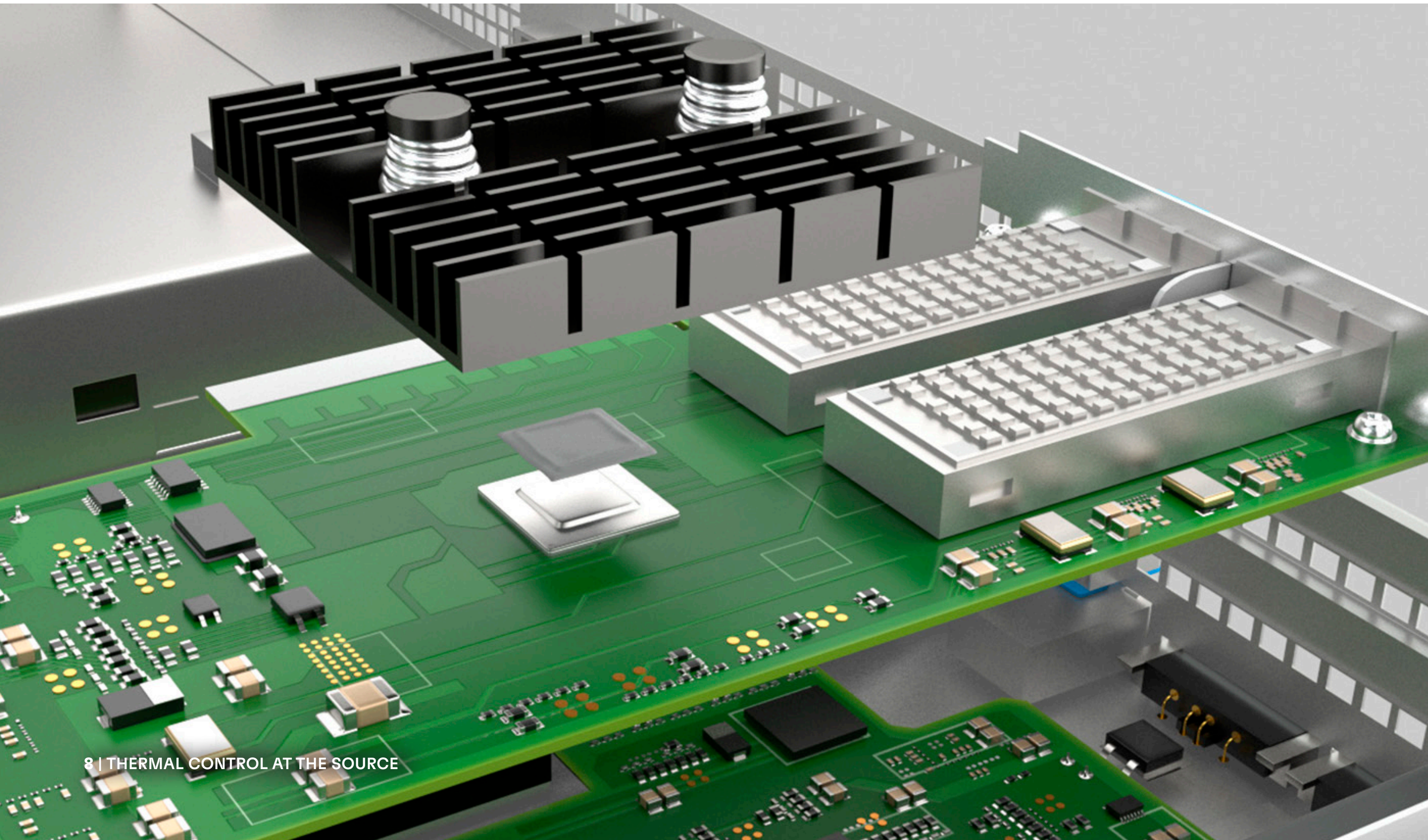


THERMAL CONTROL AT THE SOURCE

Managing data center operating temperatures is one of the biggest challenges facing the HPC sector today. Numerous heat control strategies are employed to enable the most robust function, as unmitigated thermal loads can wreak havoc on performance. Combined with air and liquid cooling, thermal interface materials (TIMs) provide the most effective method to dissipate heat at its source. TIMs offer a more direct path from the heat-generating device to a heat spreader. Pad, liquid, gel, film, and grease TIMs are integrated throughout data center server, router, and switch systems as an essential part of a larger thermal management strategy. Depending on the AI device design, system space constraints, and thermal conductivity/thermal resistance required, various Henkel BERGQUIST® TIM materials may be used.

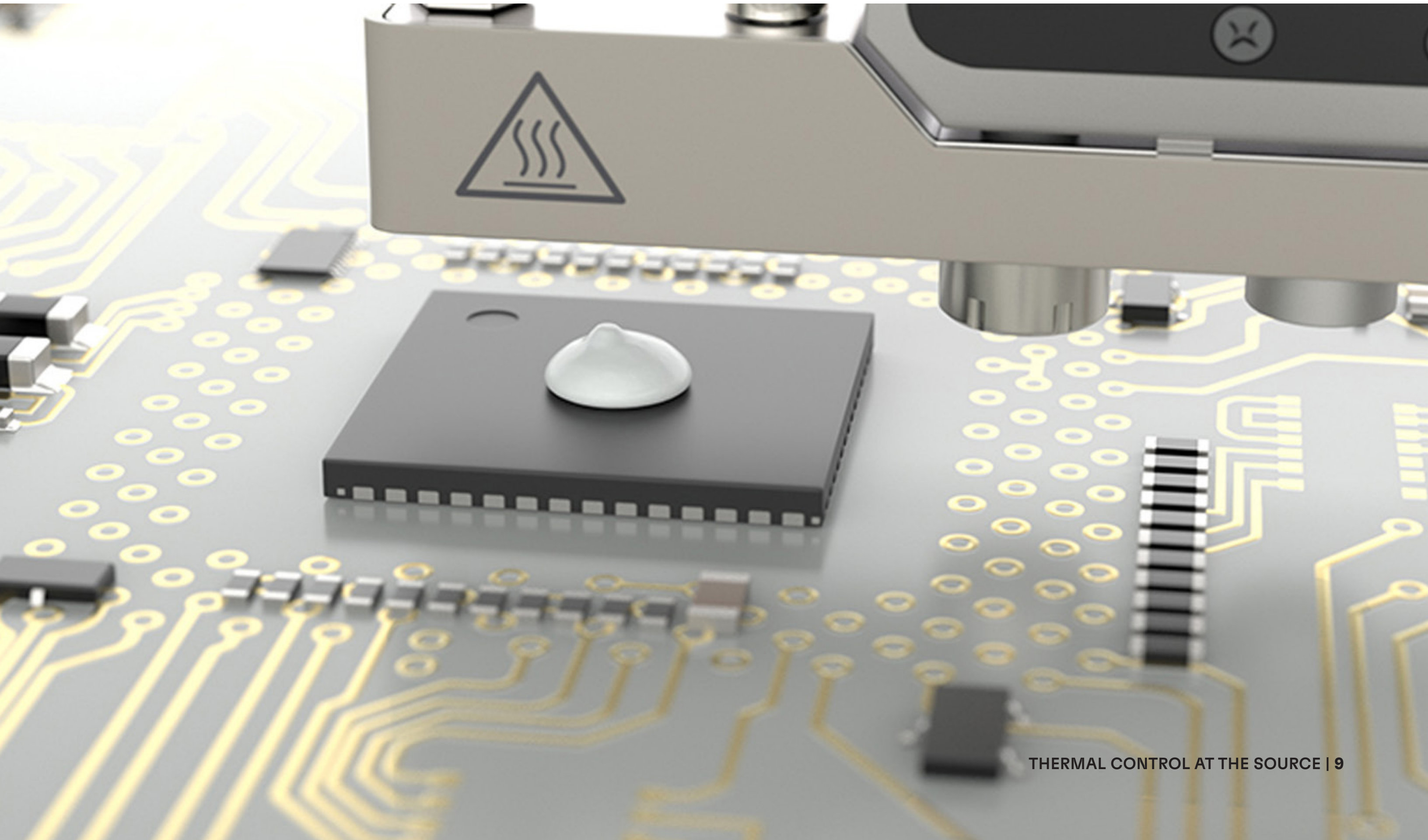
SERVER AND STORAGE - THERMAL INTERFACE MATERIALS

GAP PAD®	LIQUI-FORM	PHASE CHANGE
BERGQUIST® GAP PAD® TGP HC3000	BERGQUIST® LIQUI-FORM TLF LF3500	BERGQUIST® HI-FLOW THF 1600G
BERGQUIST® GAP PAD® TGP HC5000	BERGQUIST® LIQUI-FORM TLF 3800LVO	LOCTITE® TCP 4000 D
BERGQUIST® GAP PAD® TGP 3500ULM	BERGQUIST® LIQUI-FORM TLF 6000HG	BERGQUIST® HI-FLOW THF 1600P
BERGQUIST® GAP PAD® TGP 6000ULM	BERGQUIST® LIQUI-FORM TLF 10000	BERGQUIST® HI-FLOW THF 5000UT
BERGQUIST® GAP PAD® TGP 7000ULM		LOCTITE® TCF 4000 PXF
BERGQUIST® GAP PAD® TGP 10000ULM		
BERGQUIST® GAP PAD® TGP 12000ULM		
BERGQUIST® GAP PAD® TGP 12000		



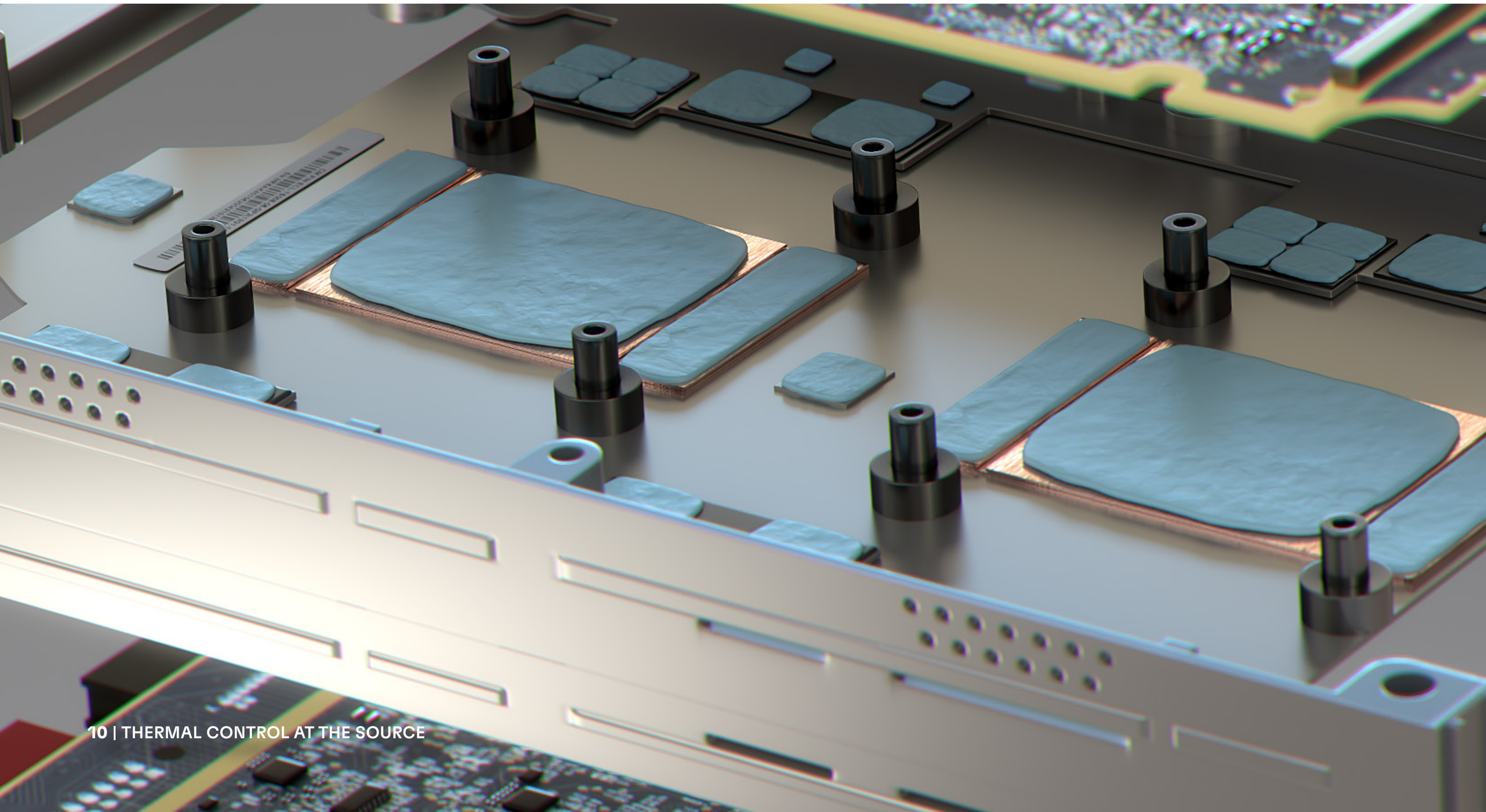
ROUTER AND SWITCH - THERMAL INTERFACE MATERIALS

GAP PAD®	GAP FILLER	LIQUI-BOND	LIQUI-FORM	PHASE CHANGE	THERMALLY CONDUCTIVE ADHESIVE
BERGQUIST® GAP PAD® TGP HC3000	BERGQUIST® GAP FILLER TGF 1500	BERGQUIST® LIQUI-BOND TLB 400SLT	BERGQUIST® LIQUI-FORM TLF LF3500	BERGQUIST® HI-FLOW THF 1600G	LOCTITE® 315
BERGQUIST® GAP PAD® TGP HC5000	BERGQUIST® GAP FILLER TGF 3500LVO	BERGQUIST® LIQUI-BOND TLB EA1800	BERGQUIST® LIQUI-FORM TLF 6000HG	LOCTITE® TCP 4000 D	LOCTITE® 3875
BERGQUIST® GAP PAD® TGP 3500ULM	BERGQUIST® GAP FILLER TGF 3600	BERGQUIST® LIQUI-BOND TLB SA3500	BERGQUIST® LIQUI-FORM TLF 10000	BERGQUIST® HI-FLOW THF 1600P	
BERGQUIST® GAP PAD® TGP 6000ULM	BERGQUIST® GAP FILLER TGF 4000			BERGQUIST® HI-FLOW THF 5000UT	
BERGQUIST® GAP PAD TGP 7000ULM				LOCTITE® TCF 4000 PXF	
BERGQUIST® GAP PAD TGP 10000ULM					
BERGQUIST® GAP PAD® TGP 12000ULM					



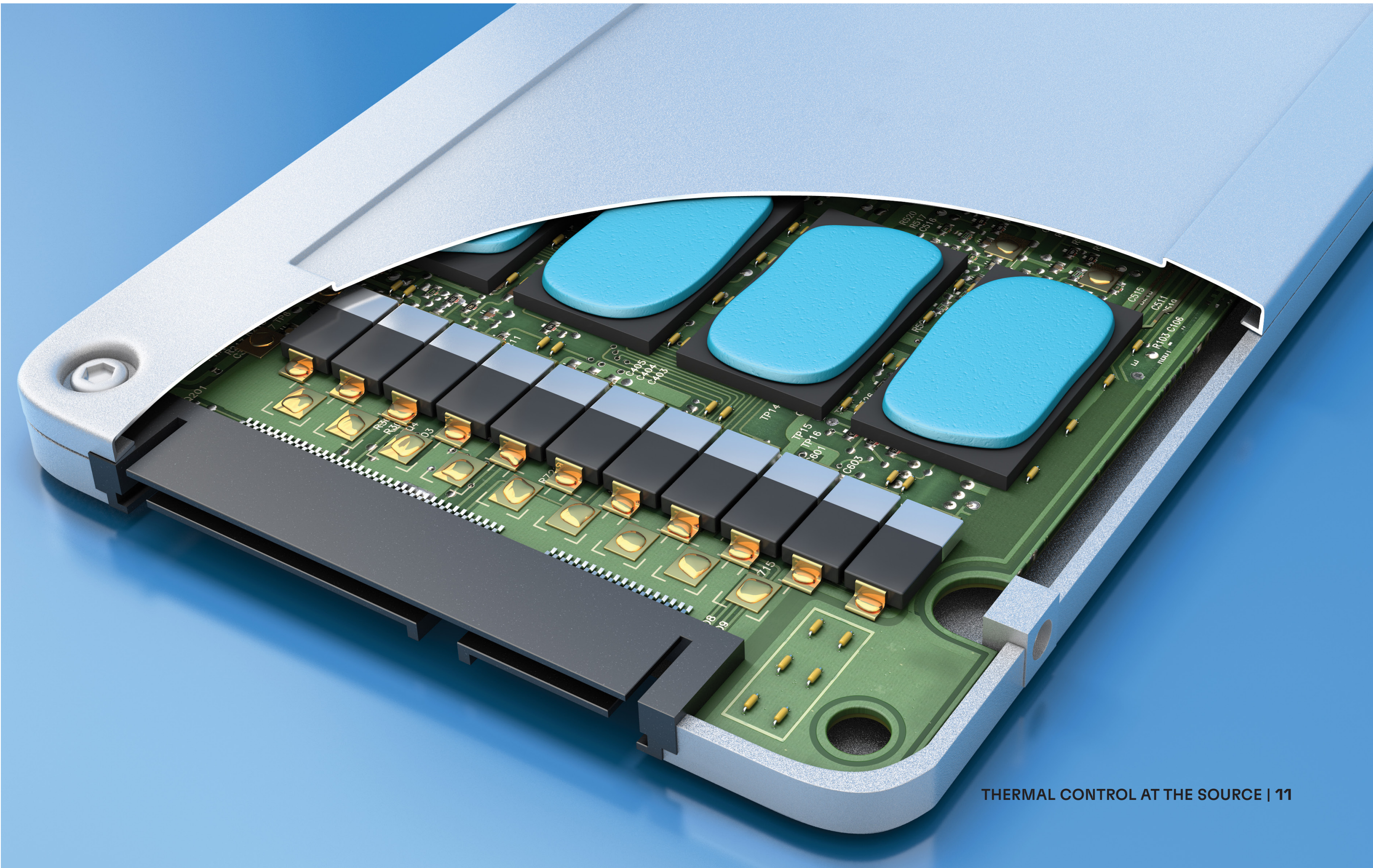
GAP PAD®

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	3.0	15 (Shore 00)	> 5,000	10^{10}	Fiberglass	Silicone Base
BERGQUIST® GAP PAD® TGP HC5000	High-compliance, thermally conductive, low modulus material	5.0	35 (Shore 00)	> 5,000	10^{10}	Fiberglass	Silicone Base
BERGQUIST® GAP PAD® TGP 3500ULM	Highly conformable, thermally conductive, ultra-low modulus material	3.5	70 (Shore 000)	> 5,000	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	6.0	60 (Shore 000)	> 5,000	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	7.0	75 (Shore 000)	> 5,000	$1.2\text{x}10^{11}$	–	Silicone Base
BERGQUIST® GAP PAD® TGP 10000ULM	A 10 W/m·K, extremely soft GAP PAD with exceptional thermal performance at low pressures	10	75 (Shore 000)	3,200	$2.5\text{x}10^{11}$	–	Silicone Base
BERGQUIST® GAP PAD® TGP 12000ULM	A 12 W/m·K, extremely soft GAP PAD with exceptional thermal performance at low pressures	12	68 (Shore 000)	6,200	$1.5 \text{ X } 10^{12}$	–	Silicone Base
BERGQUIST® GAP PAD® TGP 12000	A 12 W/m·K, a soft gap filling material, specially formulated for high performance applications requiring low assembly stress	12	76 (Shore 000)	17,700	$10\text{x}10^{10}$	Reinforcement carrier	Silicone Base



Liquid Gap Filler

Product	Description	Thermal Conductivity (W/m·K)	Hardness (Shore 00)	Dielectric Strength (V/mil)	Volume Resistivity (Ω·m)	Cure schedule (25°C / 100°C)	Chemistry
BERGQUIST® GAP Filler TGF 1500	Thermally conductive, liquid gap filler material	1.8	50	400	10^{10}	5 hr./10 min.	2K, Silicone Base
BERGQUIST® 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
BERGQUIST® GAP Filler TGF 3600	Thermally conductive, liquid gap filling material	3.6	35	275	10^{10}	15 hr./30 min.	2K, Silicone Base
BERGQUIST® GAP filler TGF 4000	Thermally conductive, liquid gap filler material	4	75	450	10^{10}	24 hr./30 min.	2K, Silicone Base



Liqui-Bond Adhesive

Product	Description	Tensile Strength (psi)	Shear Strength (psi)	Dielectric Strength (V/mil)	Volume Resistivity (Ω·m)	Breaking Strength (kN/m)
BERGQUIST® LIQUI-BOND 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 (Ω·m)	Shear Strength (psi)
BERGQUIST® LIQUI-BOND TLB EA1800	Thermally conductive, two-part, liquid epoxy adhesive	1.8	90 (Shore D)	10,000	10^{14}	450
BERGQUIST® LIQUI-BOND TLB SA3500	Thermally conductive, two-part, liquid silicone adhesive	3.5	90 (Shore A)	10,000	10^{10}	450

Liqui-Form Gel

Product	Description	Thermal Conductivity (W/m·K)	Volume Resistivity (Ω·m)	Dielectric Constant at 1,000 Hz	Operating Temperature Range	UL Flammability Rating
BERGQUIST® LIQUI-FORM TLF LF3500	Thermally conductive, one-part, liquid formable gel material	3.5	1×10^{11}	8.10	-60 – 200°C	UL 94 V-0
BERGQUIST® LIQUI-FORM TLF 3800LVO	Silicone based gel, high conductivity thermal interface material	3.8	1×10^{10}	8.00	-60 – 200°C	UL 94 V-0
BERGQUIST® LIQUI-FORM TLF 6000HG	Thermally conductive, one-part, liquid formable gel material	6.0	4.37×10^{11}	7.95	-60 – 200°C	UL 94 V-0
BERGQUIST® LIQUI-FORM TLF 10000	Thermally conductive, pre-cured gel material	10	9.0×10^{13}	–	-60 – 200°C	UL 94 V-0

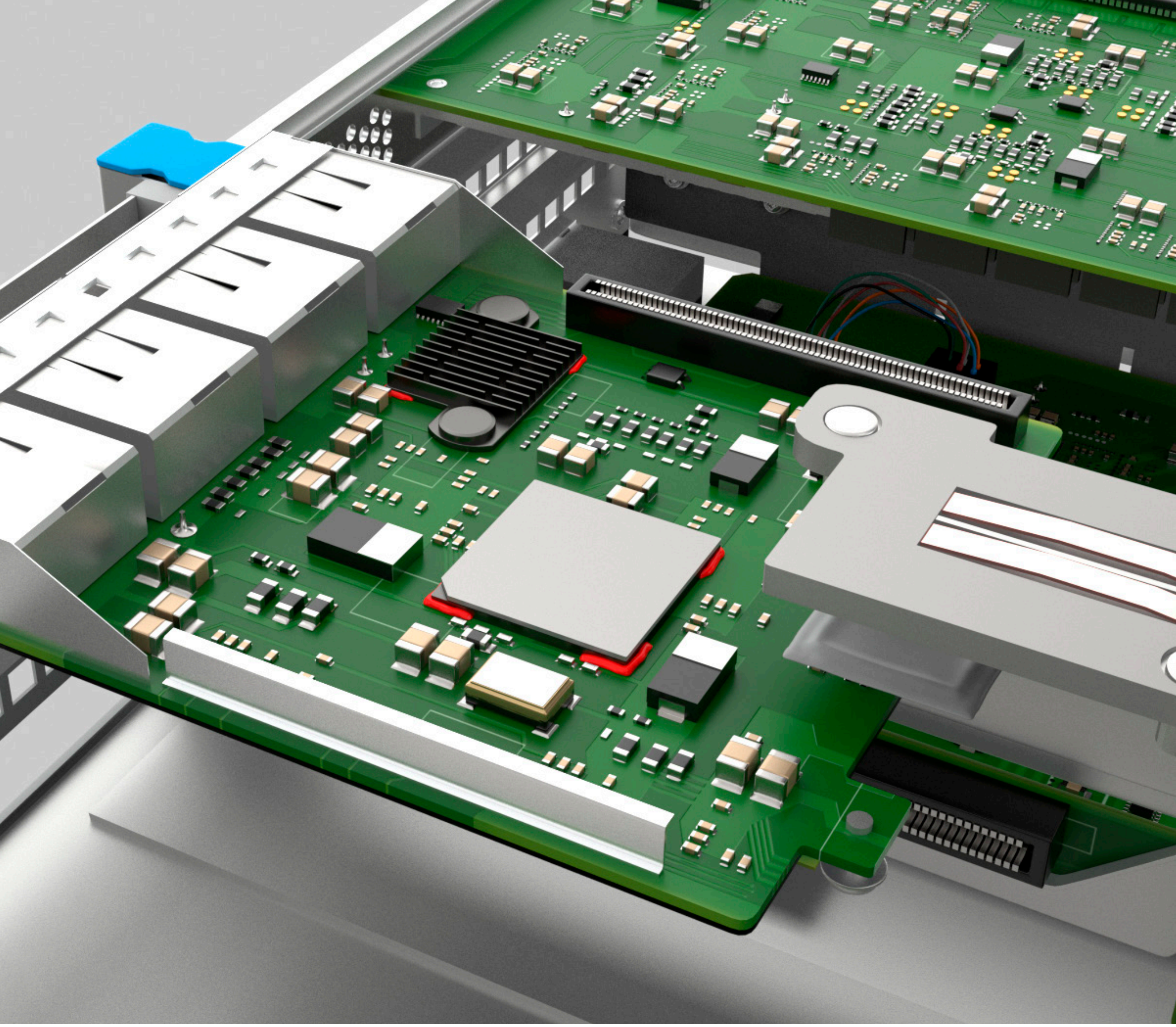
Phase Change Material – Film and Paste

Product	Description	Key Attributes	Thermal Conductivity (W/m-K)	Volume Resistivity (Ω·m)	Dielectric Breakdown Voltage	Thickness (mm)	Flammability Rating
BERGQUIST® HI-FLOW THF 1600G	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·in^2/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
BERGQUIST® HI-FLOW THF 1600P	A thermally conductive 55°C phase change compound coated on a thermally conductive polyimide film	• Thermal impedance: 0.13°C·in^2/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
LOCTITE® TCP 4000 D	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	–
LOCTITE® TCF 4000 PXF	A grey, non-silicone reworkable phase change thermal interface material designed	• Low thermal resistance • Nonsilicone • No pump-out, dry-out or pull-out	3.4	–	–	0.2	–

Product	Description	Material Thicknesses (Mil)	Phase Change Temperature	Operating Temperature	Thermal Conductivity (W/M-k)	Ul Flammability Rating
BERGQUIST® HI-FLOW THF 5000UT	Reworkable phase change thermal interface material suitable for use between a heat sink and variety heat generating components	8, 10, 12, 16	45°C	-40 to 150°C	Multiple Thickness, ASTM D5470 5.3 Thin Bondline Materials, modified ASTM D5470 8.5	UL 94 V-0

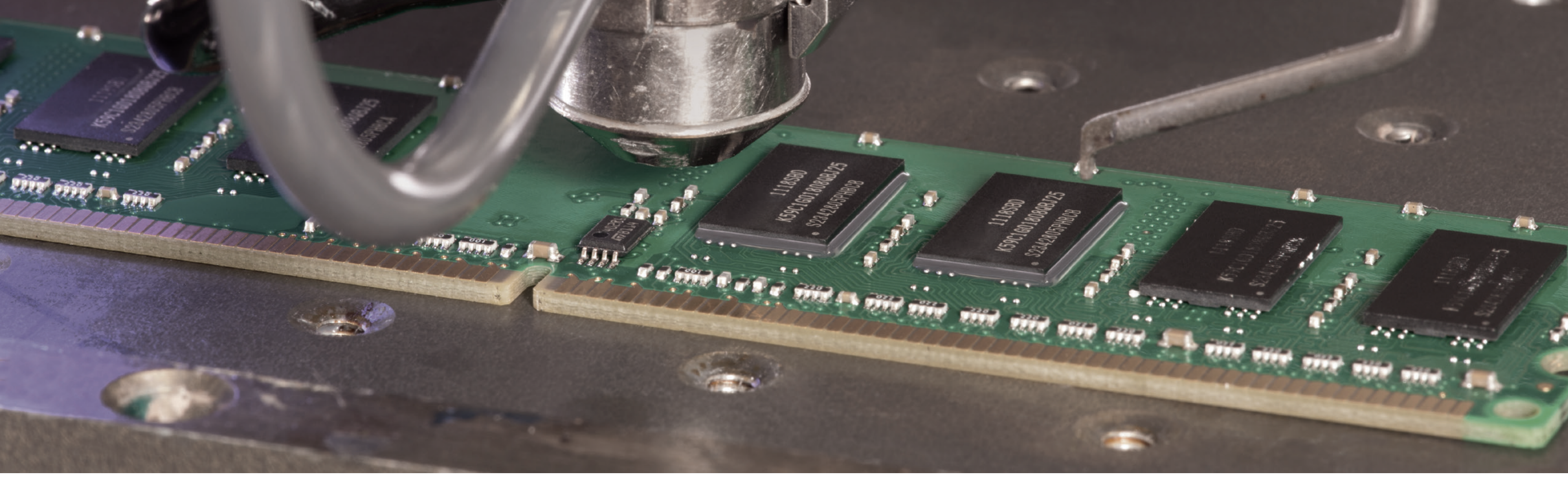
Thermally Conductive Adhesives

Product	Description	Thermal Conductivity (W/m-K)	Cure Type	Dielectric Strength (kV/mm)	Volume Resistivity (Ω·cm)	Shear Strength (psi)
LOCTITE® 315	Acrylic	0.8	Activator or Heat	26.7	1.3×10^{12}	1,000
LOCTITE® 3875	Bead on Bead – Acrylate	1.75	Activator or Heat	–	–	2,400



HIGH-VALUE IC PROTECTION

The complex architectures of AI packages with high-density interconnects require thorough protection from thermo-mechanical stress. Underfills and encapsulants deliver the mechanical integrity necessary to help prevent stress-induced failures of next-generation high performing computing GPU, FPGA, and ASIC AI devices. Henkel's formulations have excellent flow characteristics for complete encapsulation of interconnects with micron-level interspaces and low bump heights, offering exceptional protection against the strain from demanding temperature cycling and operational extremes.



ROUTER AND SWITCH, SERVER AND STORAGE PROTECTION MATERIALS

Edgebond	Underfill
LOCTITE® ECCOBOND UF 3711	LOCTITE® ECCOBOND UF 1173
	LOCTITE® ECCOBOND E 1216M
	LOCTITE® ECCOBOND UF 3812
	LOCTITE® 3517M

Product	Description	Viscosity	Coefficient of thermal expansion, CTE (alpha 1)	Coefficient of thermal expansion, CTE (alpha 2)	Glass Transition Temperature, T_g (°C)	Pot Life (day)
LOCTITE® ECCOBOND UF 1173	Low CTE, high T_g underfill for extreme T-Cycle conditions	7.5 Pa·s	26 ppm/°C	103 ppm/°C	160	2
LOCTITE® ECCOBOND E 1216M	Fast flow, non-anhydride underfill	4 Pa·s	35 ppm/°C	131 ppm/°C	125	–
LOCTITE® ECCOBOND UF 3812	Room temperature flow, reworkable underfill	0.35 Pa·s	48 ppm/°C	175 ppm/°C	131	3
LOCTITE® ECCOBOND UF 3711	Curable adhesive for chipts to enhance the reliability performance	35,000 MPa·s	20 µm/m/K	62 µm/m/K	13.6 at 25°C by DMa, GPa	-
LOCTITE® 3517M	Low temperature cure, reworkable underfill	2.6 Pa·s	65 ppm/°C	191 ppm/°C	78	7

LOCTITE® BERGQUIST®

AMERICAS

UNITED STATES
Henkel Corporation
14000 Jamboree Road
Irvine, CA 92606
United States
Tel: +1.888.943.6535
Fax: +1.714.368.2265

Henkel Corporation
20021 Susana Road
Rancho Dominguez, CA 90221
United States
Tel: +1.310.764.4600
Fax: +1.310.605.2274

Henkel Corporation
18930 W. 78th Street
Chanhassen, MN 55317
United States
Tel: +1.952.835.2322
Tel: +1.800.347.4572
Fax: +1.952.835.0430

BRAZIL
Henkel Brazil
Av. Prof. Vernon Krieble, 91
06690-070 Itapevi, Sao Paulo
Brazil
Tel: +55.11.3205.7001
Fax: +55.11.3205.7100

ASIA-PACIFIC

CHINA
Henkel Management Center

Building 7, No. 99 Jiang Wan Cheng Road
Shanghai 200438,
China
Tel: +86.21.2891.8000
Fax: +86.21.2891.8952

ABLESTIK (Shanghai) LIMITED
No. 332 Meigui South Road
WaiGaoQiao Free Trade Zone, Pu Dong
Shanghai 200131,
China
Tel: +86.21.2702.5888
Fax: +86.21.5048.4169

JAPAN
Henkel Japan Ltd.
27-7, Shin Isogo-cho
Isogo-ku Yokohama, 235-0017
Japan
Tel: +81.45.286.0161
Email: jp.ae-csdesk@henkel.com

KOREA
Henkel Korea Co. Ltd.
18th Floor of tower B, BYC High City Bldg
Gasan Digital 1-ro, Geumcheon-gu,
Seoul, 08506
South Korea
Tel: +82.2.6150.3000
Fax: +82.2.6947.5203

SINGAPORE
Henkel Singapore Pte Ltd.
401, Commonwealth Drive
#03-01/02 Haw Par Technocentre,
Singapore 149598
Tel: +65.6266.0100
Fax: +65.6472.8738 / +65.6266.1161

TAIWAN
Henkel Taiwan Ltd.
10F, No. 866, Zhongzheng Road,
Zhonghe District, New Taipei City, 23586
Taiwan
Tel: +866.2.2227.1988
Fax: +866.2.2226.8699

EUROPE

DÜSSELDORF
Henkelstraße 67
40589 Düsseldorf
Germany
Tel: +49.211.797.0
Fax: ++49.211.798.4008

BELGIUM
Henkel Belgium N.V.
Nijverheidsstraat 7
B-2260 Westerlo
Belgium
Tel: +32.1457.5611
Fax: +32.1458.5530

UNITED KINGDOM
Henkel Ltd.
Adhesives Limited Technologies House
Wood Lane End
Hemel Hempstead
Hertfordshire HP2 4RQ
United Kingdom
Tel: +44.1442.278000
Fax: +44.1442.278071

Across the Board,
Around the Globe.

next.henkel-adhesives.com