

**LOCTITE®**

**BERGQUIST®**

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



**Henkel**

Henkel Adhesive Technologies

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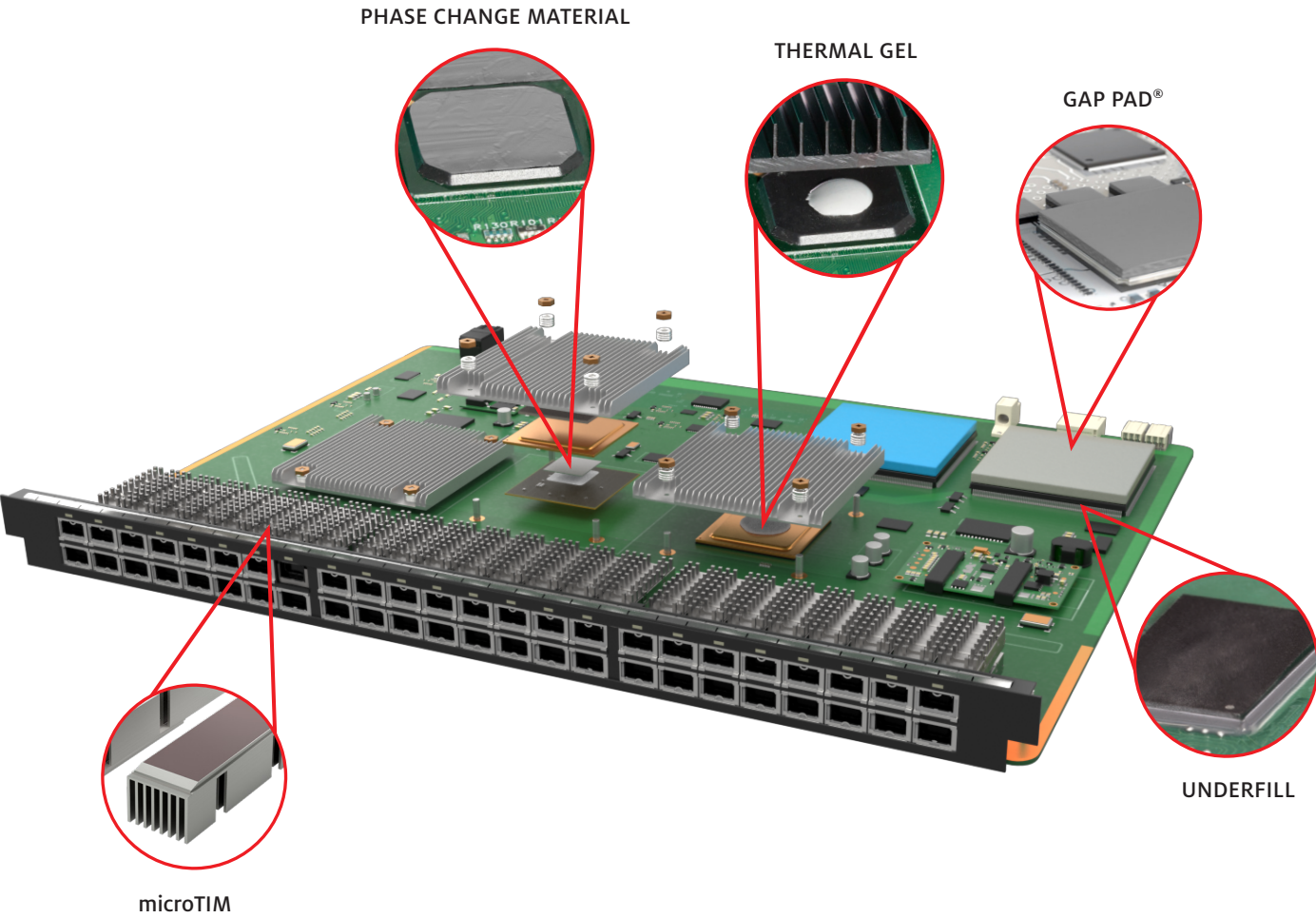
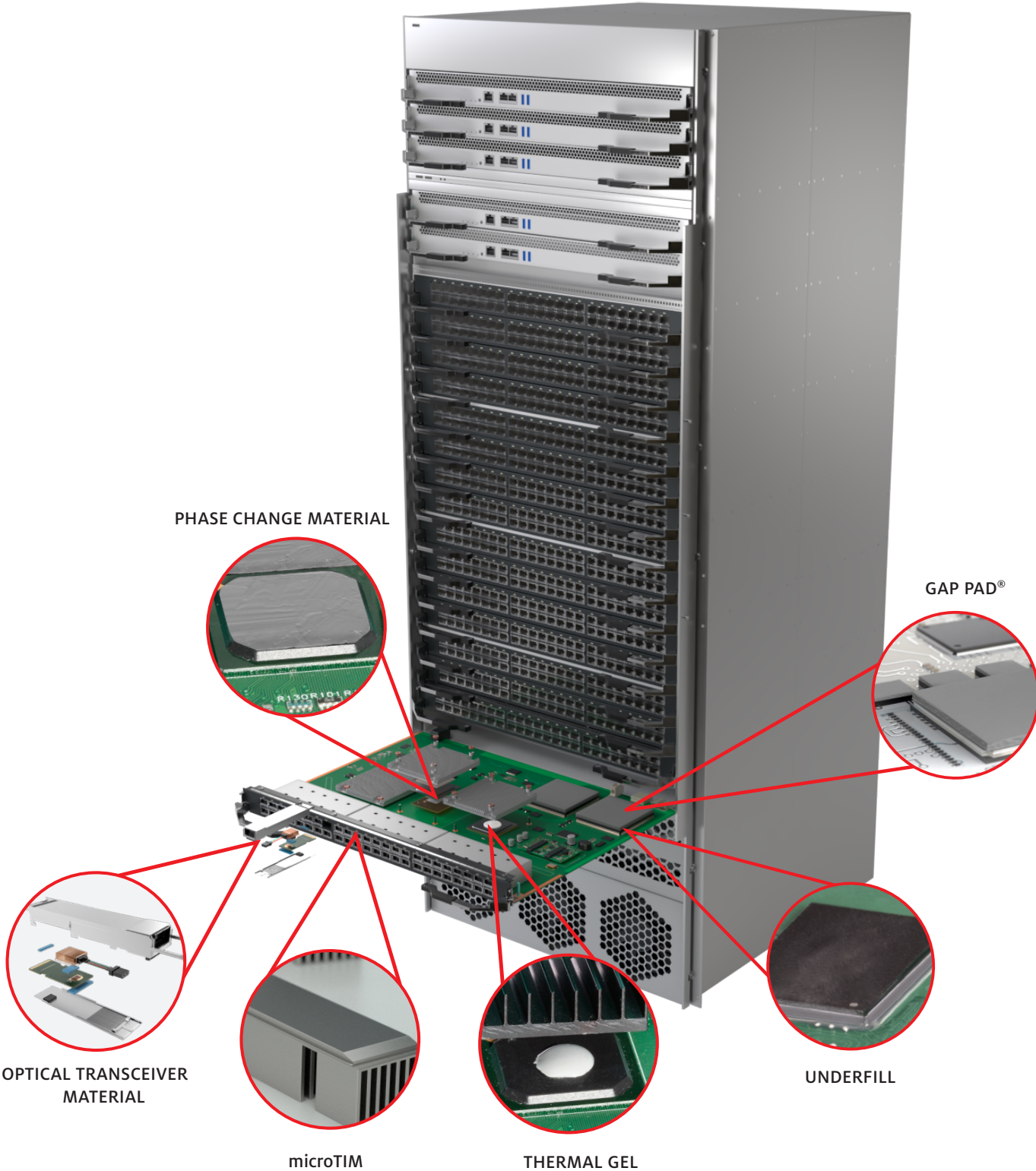
## Introduction

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.

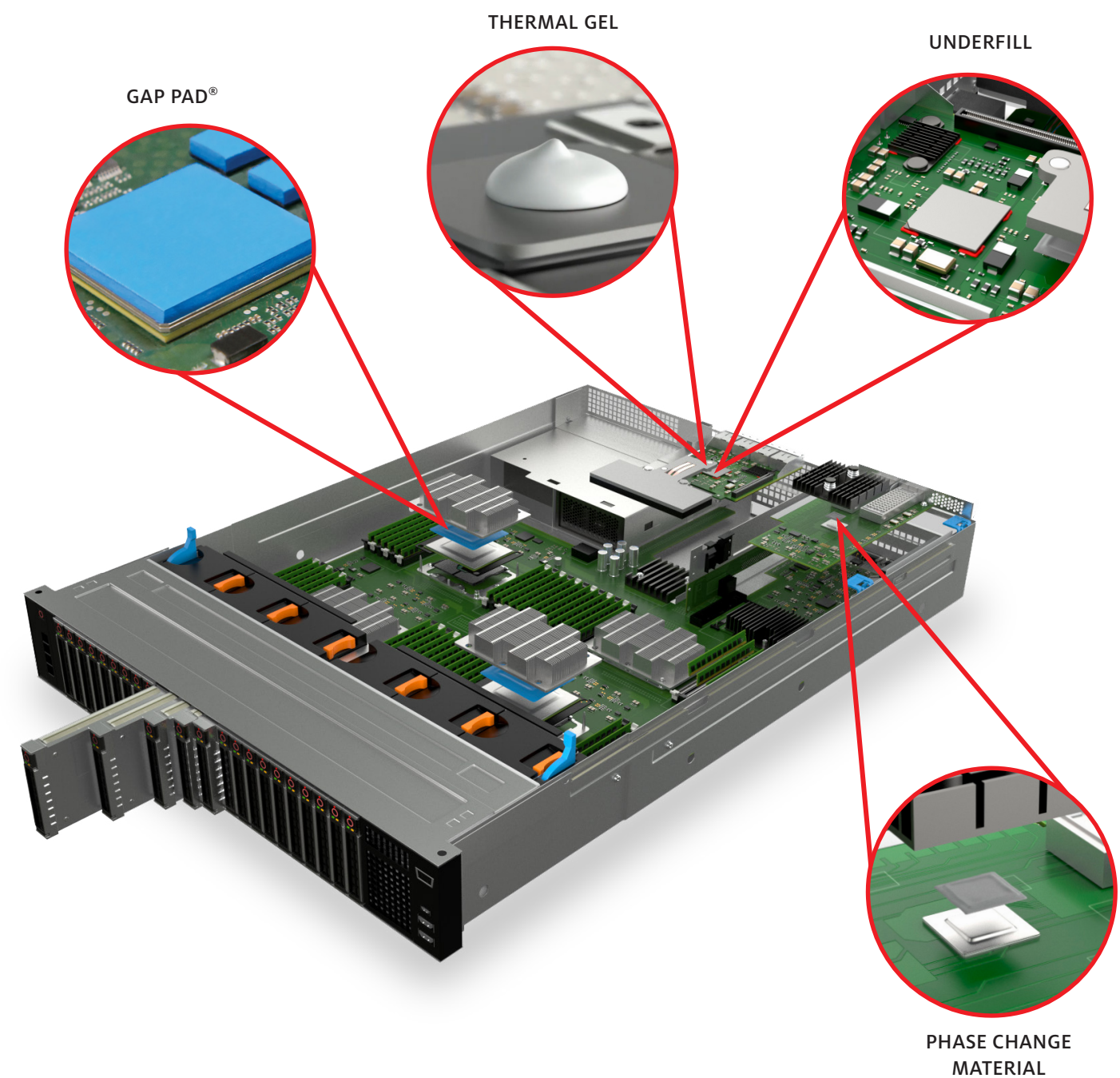
With the convergence of these factors, ensuring the reliability and long-term performance of datacenter electronic components is essential and facilitated by advanced connecting, protecting and thermal management materials. As the largest global innovator and supplier of adhesives, functional coatings 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



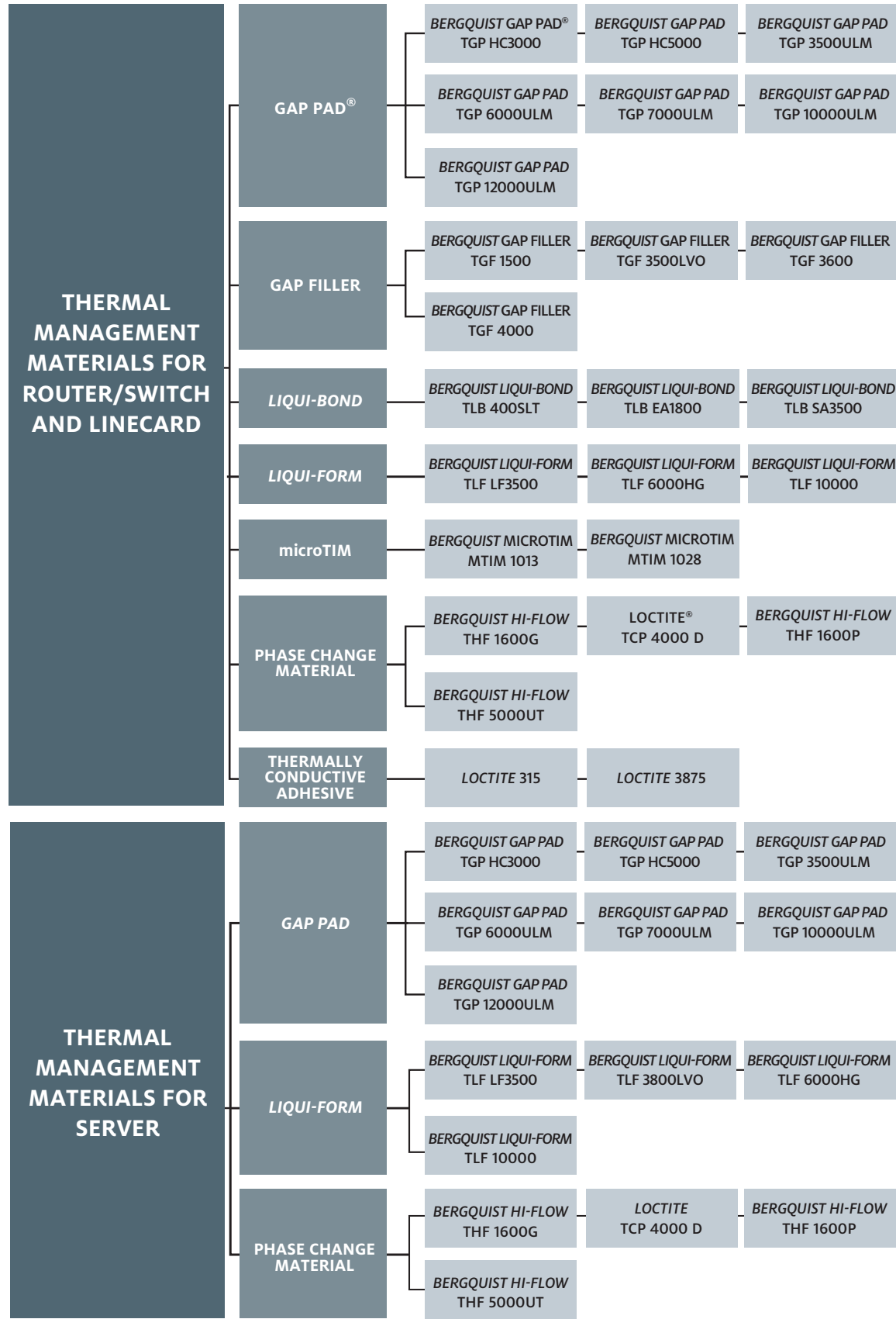
# MATERIAL SOLUTIONS FOR SERVER



## Thermal Control

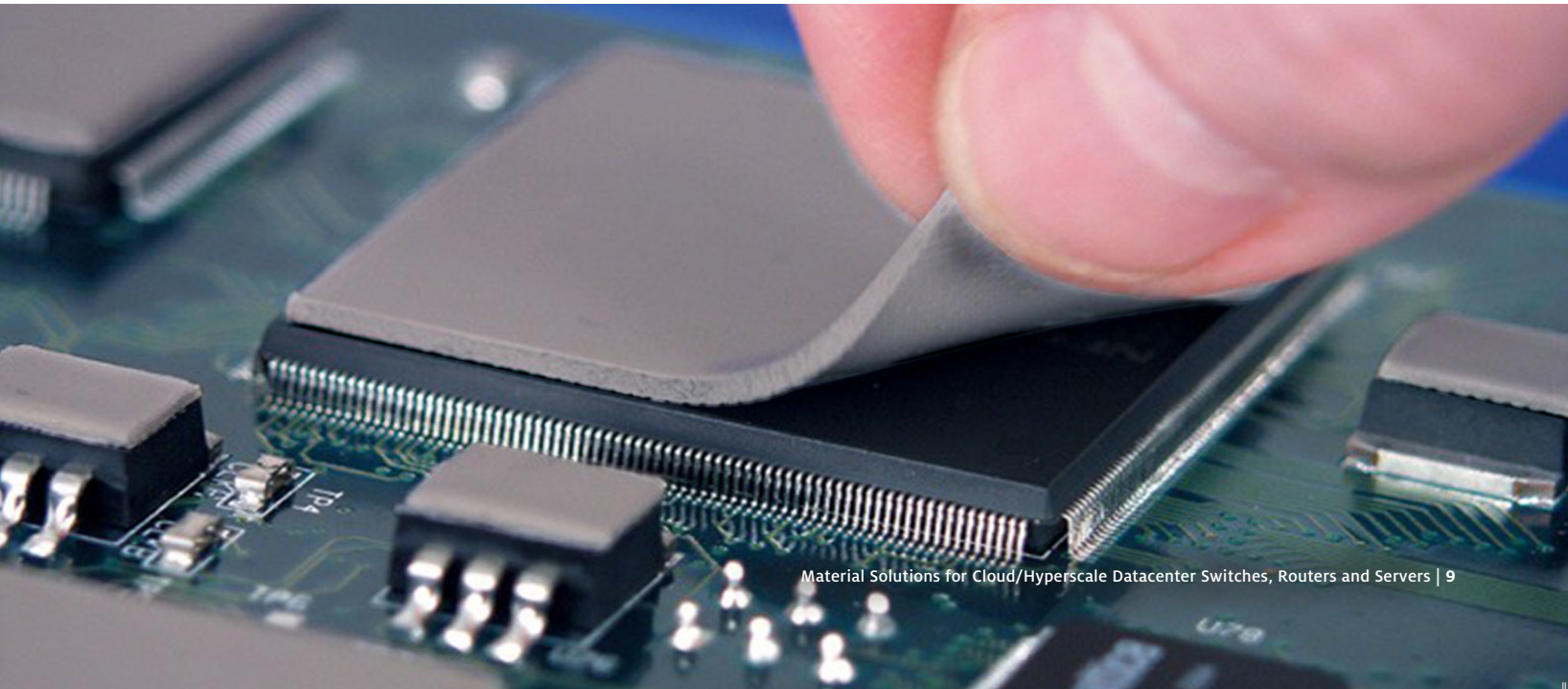
Depending on the application, Henkel has multiple thermal interface material (TIM) solutions to support improved system-level performance and reliability of high-power density line cards through effective thermal management. A range of formulations in pad, film, liquid and gel mediums provide effective 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



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 <sup>10</sup>         | Fiberglass                 | Silicone Base |
| BERGQUIST GAP PAD TGP HC5000   | High-compliance, thermally conductive, low modulus material                                 | 5.0                          | 35 (Shore 00)  | > 5,000                            | 10 <sup>10</sup>         | Fiberglass                 | Silicone Base |
| BERGQUIST GAP PAD TGP 3500ULM  | Highly conformable, thermally conductive, ultra-low modulus material                        | 3.5                          | 70 (Shore 000) | > 5,000                            | 10 <sup>10</sup>         | 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 <sup>10</sup>         | 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                            | 1.2x10 <sup>11</sup>     | –                          | 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                              | 2.5x10 <sup>11</sup>     | –                          | 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 X 10 <sup>12</sup>   | –                          | Silicone Base |



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 <sup>10</sup>         | 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 <sup>10</sup>         | 24 hr./30 min.               | 2K, Silicone Base |
| BERGQUIST GAP FILLER TGF 3600    | Thermally conductive, liquid gap filling material                 | 3.6                          | 35                  | 275                         | 10 <sup>10</sup>         | 15 hr./30 min.               | 2K, Silicone Base |
| BERGQUIST GAP FILLER TGF 4000    | Thermally conductive, liquid gap filler material                  | 4                            | 75                  | 450                         | 10 <sup>10</sup>         | 24 hr./30 min.               | 2K, Silicone Base |

LIQUI-BOND

| 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 <sup>12</sup>         | 4.4                      |

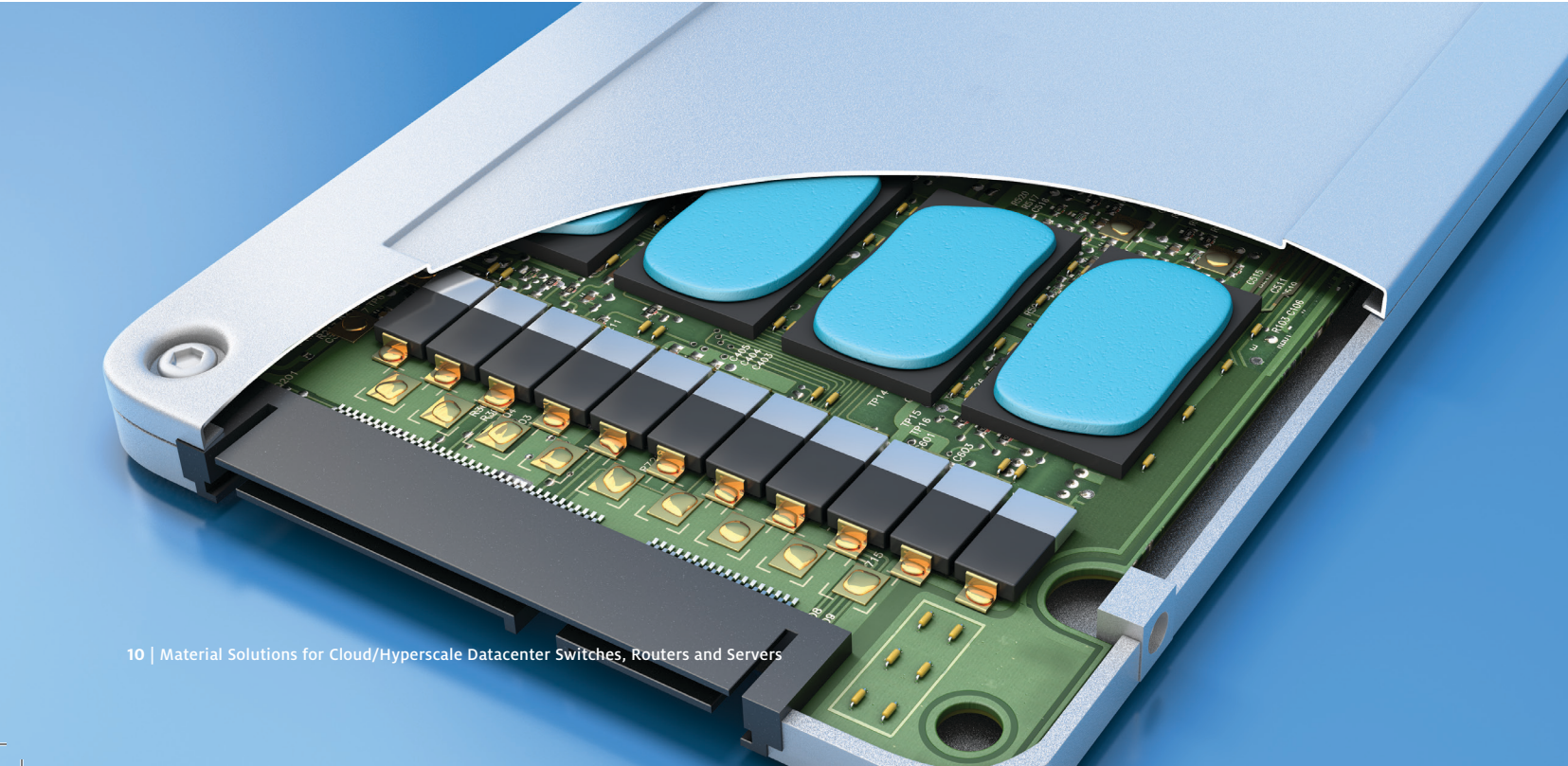
| Product                         | Description                                              | Thermal Conductivity (W/m·K) | Hardness     | Dielectric Strength (V/mm) | Volume Resistivity (Ω·m) | Shear Strength (psi) |
|---------------------------------|----------------------------------------------------------|------------------------------|--------------|----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

LIQUI-FORM

| 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                          | 1x10 <sup>11</sup>       | 8.10                            | -60 – 200°C                 | UL 94 V-0              |
| BERGQUIST LIQUI-FORM TLF 3800LVO | Silicone based gel, high conductivity thermal interface material | 3.8                          | 1x10 <sup>10</sup>       | 8.00                            | -60 – 200°C                 | UL 94 V-0              |
| BERGQUIST LIQUI-FORM TLF 6000HG  | Thermally conductive, one-part, liquid formable gel material     | 6.0                          | 4.37x10 <sup>11</sup>    | 7.95                            | -60 – 200°C                 | UL 94 V-0              |
| BERGQUIST LIQUI-FORM TLF 10000   | Thermally conductive, pre-cured gel material                     | 10                           | 9.0 × 10 <sup>13</sup>   | –                               | -60 – 200°C                 | UL 94 V-0              |

microTIM

| Product                      | Description                                             | Appearance | Film Thickness, Optical Profilometer (µm) | Durability Performance, mass loss ( % ) | Volume Resistivity (GΩ·m) | Operating Temperature Range |
|------------------------------|---------------------------------------------------------|------------|-------------------------------------------|-----------------------------------------|---------------------------|-----------------------------|
| BERGQUIST microTIM MTIM 1013 | Dielectric coated metal substrate optimizes performance | Tan        | 24±3                                      | <15                                     | >1                        | Up to 175°C                 |
| BERGQUIST microTIM MTIM 1028 | Dielectric coated metal substrate optimizes performance | Tan        | 25±5                                      | <15                                     | >1                        | -40 – 125°C                 |



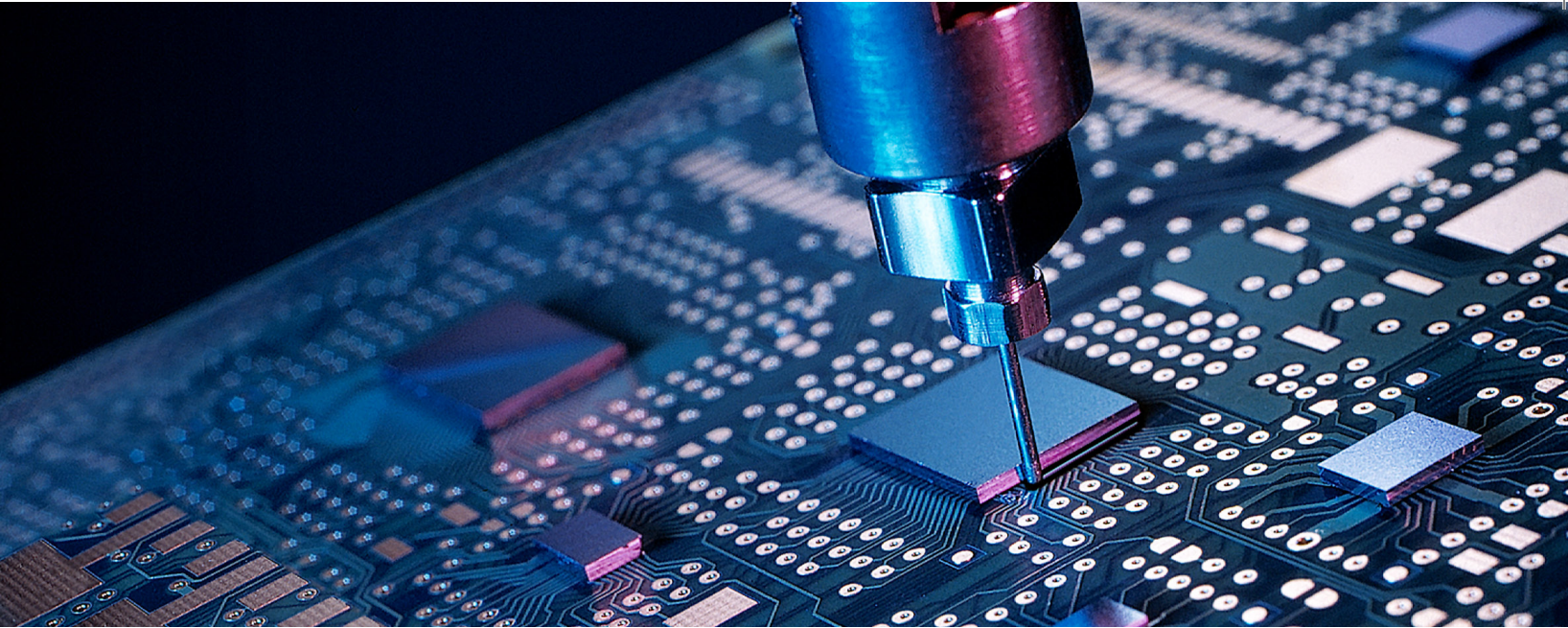
Phase Change Materials

| 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           | <ul style="list-style-type: none"><li>Thermal impedance: 0.2°C-in²/W at 25 psi</li><li>Will not drip or run like grease</li><li>Phase change compound coated on a fiberglass carrier</li></ul>                                                             | 1.6                          | 1x10 <sup>8</sup>        | 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                                                                           | <ul style="list-style-type: none"><li>Thermal impedance: 0.13°C-in²/W at 25 psi</li><li>Field-proven polyimide film with excellent dielectric performance and cut-through resistance</li><li>Outstanding thermal performance in an insulated pad</li></ul> | 1.6                          | 1x10 <sup>12</sup>       | 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 | <ul style="list-style-type: none"><li>Reworkable</li><li>Highly efficient thermal transfer</li><li>Thixotropic above phase change temperature</li></ul>                                                                                                    | 3.4                          | –                        | N/A                          | 0.025 – 0.250  | –                   |

| Product                      | Description                                                                                                                    | Material Thicknesses (Mil) | Phase Change Temperature | Operating Temperature | Thermal Conductivity (W/M·k)                                                        | UI 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              |

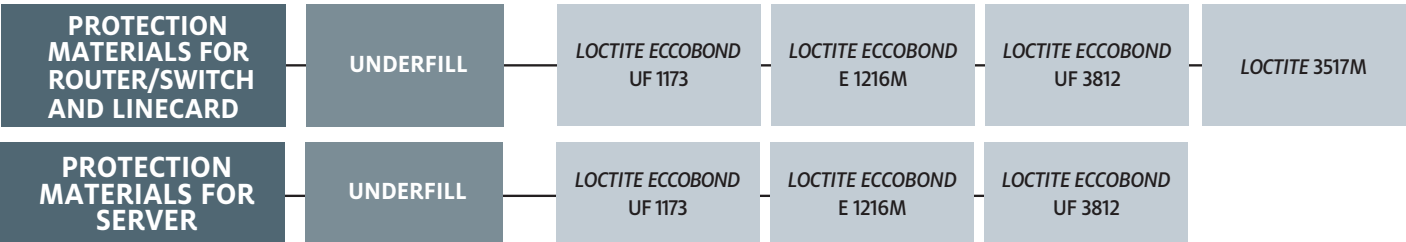
Thermally Conductive Adhesives

| 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                        | 1.3x10 <sup>12</sup>      | 1,000                |
| LOCTITE 3875 | Bead on Bead – Acrylate | 1.75                         | Activator or Heat | –                           | –                         | 2,400                |



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.



| 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 <sub>g</sub> (°C) | Pot Life (day) |
|--------------------------|-----------------------------------------------------------------------|------------------|----------------------------------------------------------|----------------------------------------------------------|---------------------------------------------------|----------------|
| LOCTITE ECCOBOND UF 1173 | Low CTE, high T <sub>g</sub> underfill for extreme T-Cycle conditions | 7.5              | 26                                                       | 103                                                      | 160                                               | 2              |
| LOCTITE ECCOBOND E 1216M | Fast flow, non-anhydride underfill                                    | 4                | 35                                                       | 131                                                      | 125                                               | –              |
| LOCTITE ECCOBOND UF 3812 | Room temperature flow, reworkable underfill                           | 0.35             | 48                                                       | 175                                                      | 131                                               | 3              |
| LOCTITE 3517M            | Low temperature cure, reworkable underfill                            | 2.6              | 65                                                       | 191                                                      | 78                                                | 7              |



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[henkel-adhesives.com/electronics](http://henkel-adhesives.com/electronics)