

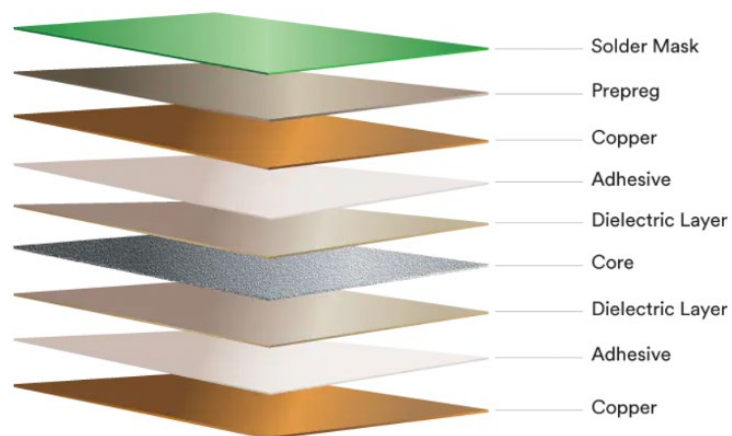


Science.
Applied to Life.™

Exploring 3M™ Boron Nitride Cooling Fillers for TIM and CCL Applications

What are Copper Clad Laminates (CCLs)

Copper clad laminates (CCLs) are the foundation to the printed circuit boards (PCBs) used in a wide range of electronic applications across market segments. In some layers of the copper clad laminate, there is an opportunity to improve signal transmission and manage heat with 3M™ Boron Nitride Cooling Filler solutions.



Picture 1: Shows the layers related to CCLs

Where to Find CCLs

Copper clad laminates (CCLs) are crucial in applications where heat management and signal integrity are important. Some specific applications include:

Heat Management Applications:

- Power Electronics: power supply units, inverters and converters, motor drives, medical devices
- Automotive Electronics: engine control units (ECUs), battery management systems (BMS)
- Telecommunications: base stations and antennas

Signal Loss Applications:

- High-Speed Digital Circuits: data centers, computing devices
- High-Frequency RF and Microwave Circuits: communication devices, radar systems
- Telecommunications: networking equipment, 5G infrastructure
- Aerospace and Defense: avionics, electronic warfare systems

Key Properties for Heat Management and Signal Loss:

- Thermal Conductivity: High thermal conductivity materials help in efficient heat dissipation.
- Low Dielectric Loss: Materials with low dielectric loss ensure minimal signal attenuation and distortion.
- Low Coefficient of Thermal Expansion (CTE): Reduces the risk of mechanical stress and failure due to temperature changes.

Copper clad laminates designed for these applications often incorporate specialized materials and constructions to meet the demanding requirements of heat management and signal integrity.

3M™ Boron Nitride Cooling Fillers are an Excellent Solution for CCLs

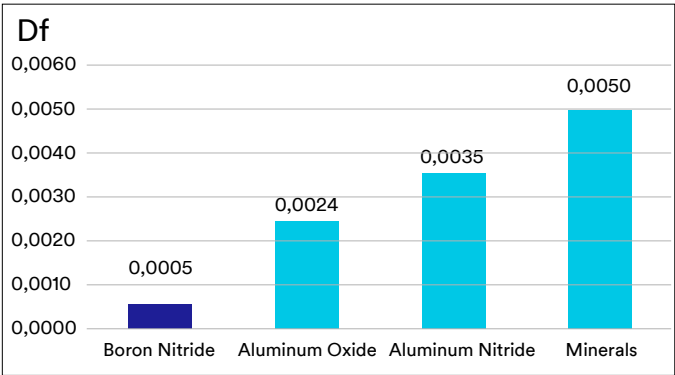
3M™ Boron Nitride Cooling Fillers are low dielectric fillers used in polymer materials to help engineers tailor to a target Dk & Df value while also optimizing thermal properties both in-plane and through-plane for heat dissipation.

Incorporating 3M™ Boron Nitride Cooling Fillers help improve the data transfer velocity and reduce the signal transmission power loss as required in many applications. 3M™ Boron Nitride Cooling Fillers can support the miniaturization of electronics design by enabling production of thinner designs.

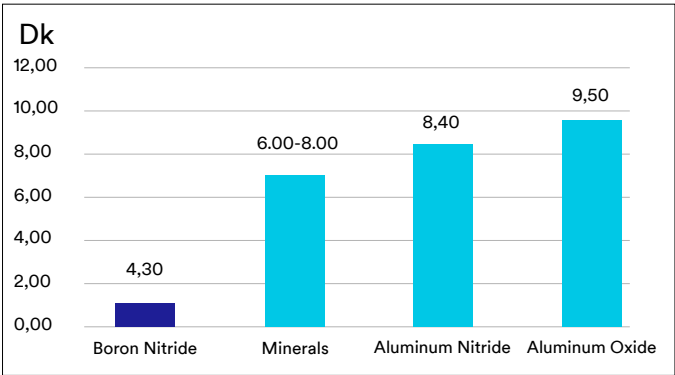
In terms of Dk & Df, 3M™ Boron Nitride Cooling Fillers can offer:

- 1. Lowest known loss factor (Df) compared to all ceramic fillers with Df of 0.00051
- 2. Lower known Dk than all other electrically insulating thermal fillers with a Dk of 4
- 3. When temperature/frequency increases, the Df and Dk of boron nitride stays constant

Loss factor (Df)



Dielectric constant (Dk)

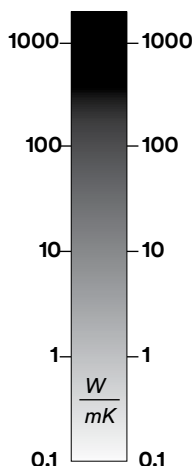


Picture 2: Shows the Df and Dk data of 3M™ Boron Nitride Cooling Fillers

3M™ Boron Nitride Cooling Fillers are 8-20x more thermally conductive than alumina fillers (intrinsic) and 2-8x more thermally conductive when mixed in polymers.

Graphene up to 6,000
Diamond up to 2,300

Copper up to 300
Aluminum up to 230
Graphite up to 165



Boron Nitride up to 400

Aluminum Nitride 100

Alumina 20-50
Mineral Fillers - 15

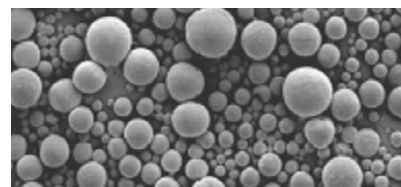
Silica 1 to 10

Glass 0.05 to 1.1

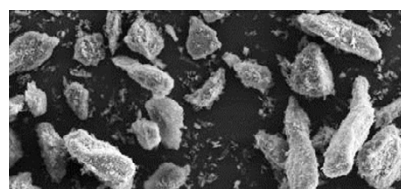
Polymer 0.1 to 0.45
Air 0.024 to 0.026



Boron Nitride



Spherical Alumina



Alumina Silicate

Picture 3: Shows 3M™ Boron Nitride Cooling Filler thermal conductivity

Optimal 3M™ Boron Nitride Cooling Filler Solutions for CCLs

The following 3M™ Boron Nitride Cooling Filler solutions are recommended as standard options for initial testing in CCL applications. The particle size distribution of the CFP listed fits well with common CCL solutions across the markets while 3M CFA 50M and 3M CFA 75 are very suitable for applications where through-plane thermal conductivities are the key focus.

| 3M™ Boron Nitride Cooling Filler Grade | Particle Size Distribution | | | | Bulk Density, Scott (g/cm³) | Bulk Density, DIN (g/cm³) | Surface Area (m²/g) |
|--|----------------------------|----------------------|----------------------|----------------------|-----------------------------|---------------------------|---------------------|
| | D ₁₀ (µm) | D ₅₀ (µm) | D ₉₀ (µm) | D ₉₇ (µm) | | | |
| Platelets CFP 001 | n.a. | 0.5 ** | 0.5 ** | – | < 0.14 | – | < 30 |
| Platelets CFP 0075 | 2 – 3.5 | 6 – 8.5 | 6 – 8.5 | – | < 0.22 | – | < 5.5 |
| Platelets CFP 012 | 2 – 4.5 | 8 – 14 | 8 – 14 | – | < 0.25 | – | < 4.5 |
| Agglomerates CFA 50M * | 5 – 10 | 15 – 30 | 15 – 30 | – | – | 0.1 – 0.4 | < 3.5 |
| Agglomerates CFA 75 * | 5 – 16 | 25 – 55 | 25 – 55 | – | – | 0.25 – 0.4 | < 3.5 |

Table 1: Shows specifications of 3M™ Boron Nitride Cooling Fillers

Bulk density determined according to ASTM B329/ISO 3923-2 (Scott density) and according to ISO 23145-2 (DIN density).

Particle size distribution measured by laser light scattering (Mastersizer 2000, dispersion in ethanol).

* Particle size distribution measured by laser light scattering (Mastersizer 2000, dry, 0.1 bar)

** Data determined by means of SEM pictures

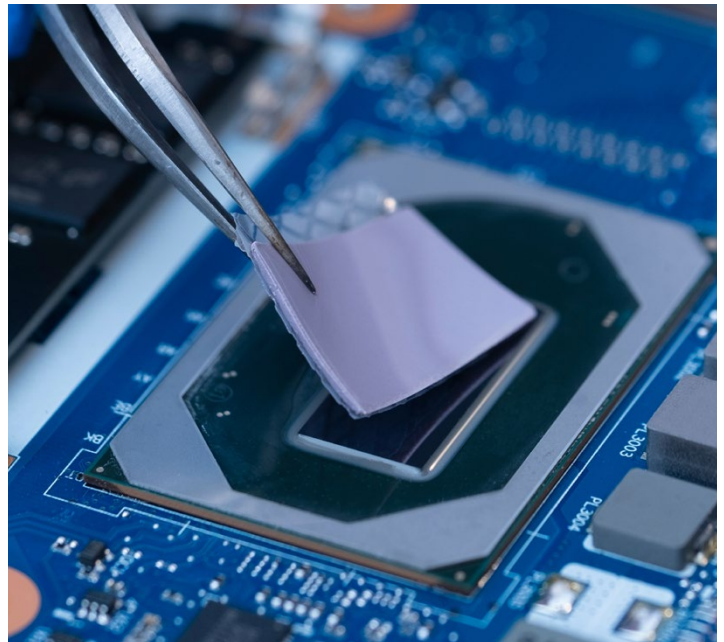
Understanding Thermal Interface Materials (TIMs)

Thermal interface materials (TIMs) are substances inserted between two surfaces to improve the thermal coupling between them. They are used to enhance the heat transfer from one surface to another, which is crucial in various electronic and mechanical systems. TIMs are crucial in electronics, automotive, and other industries where efficient heat management is essential for performance and reliability.

TIM Applications

Thermal interface materials (TIMs) are used in various applications to enhance thermal conductivity between components. Some common applications include:

1. **Consumer Electronics:** Enhancing heat dissipation in smartphones, tablets, and laptops.
2. **Automotive Electronics:** Managing thermal performance in engine control units and battery management systems.
3. **LED Lighting:** Improving thermal management in LED bulbs and display backlighting.
4. **Telecommunications:** Ensuring efficient heat transfer in routers, switches, and base stations.
5. **Medical Devices:** Providing thermal management in imaging equipment and diagnostic devices.
6. **Power Electronics:** Enhancing cooling in inverters, converters, and power supplies.
7. **Industrial Equipment:** Managing heat in motor drives, robotics, and automation systems.



Advantages of 3M™ Boron Nitride Cooling Fillers in TIM Applications

3M offers a full portfolio offering of boron nitride cooling filler additives for your application needs and come in several different form factors including soft agglomerates. In TIM foils and pads, due to their soft structure and purity, 3M™ Boron Nitride Cooling Filler Agglomerates give some of the highest known through-plane conductivity and flexibility in the polymer matrix – enabling TIM designs with the following features:

- High electrical insulation
- Low shore hardness
- High breakdown voltage
- Good peel strength
- High through-plane thermal conductivity from 5W/mK
- Convenient processability

Recommended 3M™ Boron Nitride Cooling Filler Solutions for TIMs

The following 3M™ Boron Nitride Cooling Filler solutions are recommended as standard options for initial testing in TIM applications. Thanks to their controlled particle size distribution, excellent isotropic heat transfer capabilities and excellent adaption to flexible matrix materials, 3M™ Boron Nitride Cooling Filler Agglomerates are optimal solutions for TIM applications.

| 3M™ Boron Nitride Cooling Filler Grade | Particle Size Distribution | | | | Bulk Density, Scott (g/cm³) | Bulk Density, DIN (g/cm³) | Surface Area (m²/g) |
|--|----------------------------|----------------------|----------------------|----------------------|-----------------------------|---------------------------|---------------------|
| | D ₁₀ (µm) | D ₅₀ (µm) | D ₉₀ (µm) | D ₉₇ (µm) | | | |
| Agglomerates CFA 50M | 5 – 10 | 15 – 30 | 35 – 70 | – | – | 0.1 – 0.4 | < 3.5 |
| Agglomerates CFA 75 | 5 – 16 | 25 – 55 | 75 – 115 | – | – | 0.25 – 0.4 | < 3.5 |
| Agglomerates CFA 100 | 10-35 | 50-80 | 95-145 | – | – | 0.25-0.4 | < 3.0 |
| Agglomerates CFA 125 | 15-40 | 75-120 | 170-220 | – | – | 0.25-0.5 | < 3.0 |
| Agglomerates CFA 150 | 20-80 | 120-200 | 240-360 | – | – | 0.3-0.55 | < 3.0 |

Table 2: Shows specifications of 3M™ Boron Nitride Cooling Fillers

Bulk density determined according to ASTM B329/ISO 3923-2 (Scott density) and according to ISO 23145-2 (DIN density). Particle size distribution measured by laser light scattering (Mastersizer 2000, dry, 0.1 bar)

[3M.com/thermalmanagement](https://www.3M.com/thermalmanagement)



Warranty, Limited Remedy, and Disclaimer: Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. User is solely responsible for evaluating the 3M product and determining whether it is fit for a particular purpose and suitable for user's method of application. User is solely responsible for evaluating third party intellectual property rights and for ensuring that user's use of 3M product does not violate any third party intellectual property rights. Unless a different warranty is specifically stated in the applicable product literature or packaging insert, 3M warrants that each 3M product meets the applicable 3M product specification at the time 3M ships the product. 3M MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY IMPLIED WARRANTY OF NON-INFRINGEMENT OR ANY IMPLIED WARRANTY OR CONDITION ARISING OUT OF A COURSE OF DEALING, CUSTOM OR USAGE OF TRADE. If the 3M product does not conform to this warranty, then the sole and exclusive remedy is, at 3M's option, replacement of the 3M product or refund of the purchase price. For industrial use only. Not intended, labeled or packaged for consumer sale or use.

Limitation of Liability: Except where prohibited by law, 3M will not be liable for any loss or damages arising from the 3M product, whether direct, indirect, special, incidental or consequential, regardless of the legal theory asserted, including warranty, contract, negligence or strict liability.

Technical Information: Technical information, recommendations, and other statements contained in this document or provided by 3M personnel are based on tests or experience that 3M believes are reliable, but the accuracy or completeness of such information is not guaranteed. Such information is intended for persons with knowledge and technical skills sufficient to assess and apply their own informed judgment to the information. No license under any 3M or third party intellectual property rights is granted or implied with this information.



3M Advanced Materials Division

3M Center
St. Paul, MN 55144 USA

Phone 1-800-367-8905

Web www.3M.com/thermalmanagement

3M Technical Ceramics

Zweigniederlassung der 3M Deutschland GmbH
Max-Schaidhauf-Str. 25, 87437 Kempten, Germany

Phone +49 (0)831 5618-0

Web www.3M.de/bncf

3M is a trademark of 3M Company.
Used under license by 3M subsidiaries
and affiliates.

Please recycle. Printed in USA © 3M 2025.
All rights reserved. Issued: 08/2025