

ENGINEERING CONSIDERATIONS FOR NEXT-GENERATION PUTTY PAD THERMAL INTERFACE MATERIALS

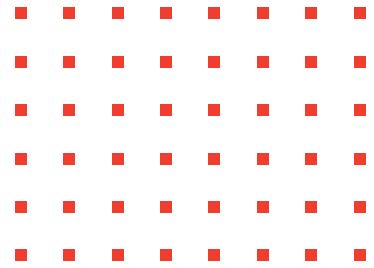
A Practical Guide to Selecting High-Performance Materials for Challenging Gap Applications

As electronic systems become smaller and more powerful, thermal interface materials must accommodate increasingly complex mechanical and thermal conditions.

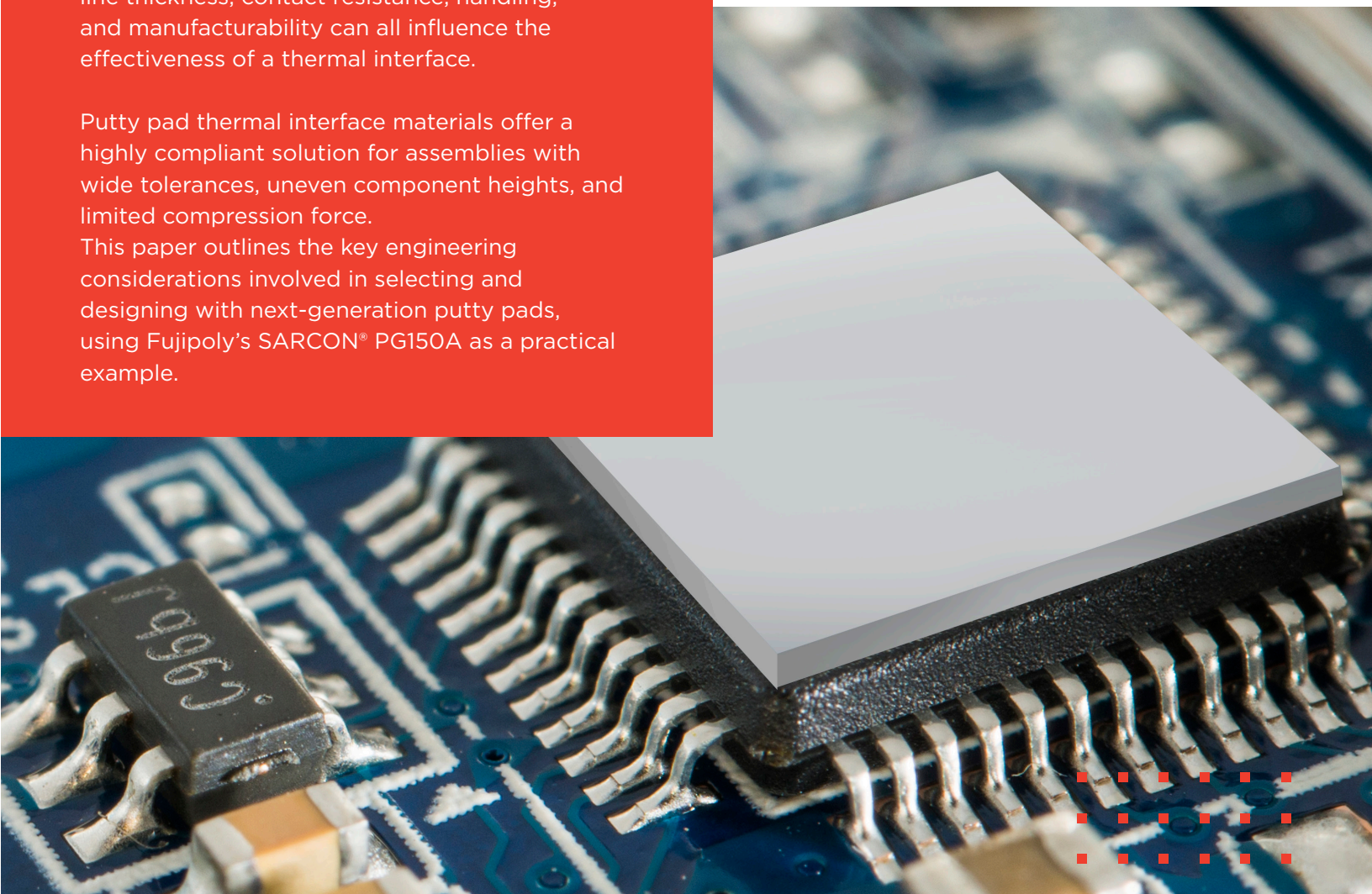
Published thermal conductivity remains important, but it does not tell the complete performance story. Material softness, compression force, gap tolerance, bond-line thickness, contact resistance, handling, and manufacturability can all influence the effectiveness of a thermal interface.

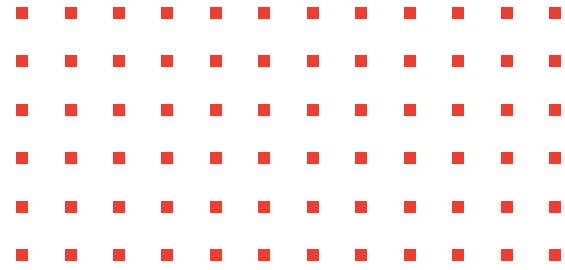
Putty pad thermal interface materials offer a highly compliant solution for assemblies with wide tolerances, uneven component heights, and limited compression force.

This paper outlines the key engineering considerations involved in selecting and designing with next-generation putty pads, using Fujipoly's SARCON® PG150A as a practical example.



WHITE PAPER





MEETING THE DEMANDS OF MODERN THERMAL INTERFACES

Electronic systems continue to generate more heat within smaller spaces.

Artificial intelligence hardware, data centers, automotive electronics, medical devices, aerospace systems, handheld electronics, and high-power industrial equipment all require effective methods of transferring heat away from sensitive components. In many applications, the challenge is not simply achieving high thermal conductivity.

The thermal interface must also compensate for:

- ▶ Component-height variation
- ▶ Uneven or nonparallel surfaces
- ▶ Manufacturing tolerances
- ▶ Limited assembly pressure
- ▶ Board deflection
- ▶ Irregular component layouts
- ▶ Changing gap dimensions
- ▶ Mechanical stress on sensitive devices

For this reason, engineers must evaluate the complete mechanical and thermal interface rather than selecting a material from conductivity data alone.

The Role of Mechanical Compliance

A thermal interface material must make sufficient contact with both the heat-generating component and the heat-dissipating surface. Microscopic irregularities and larger dimensional variations can leave air pockets within the interface. Because air is a poor conductor of heat, these gaps increase thermal resistance.

Softer materials can conform more readily to surface irregularities and accommodate variation across an assembly. Putty pads are designed specifically for applications where greater compliance is required. Compared with conventional gap filler pads, they generally contain less crosslinking within the silicone structure. This allows the material to deform and spread more easily under pressure. The result is a thermal interface that can accommodate wider gap tolerances while exerting less mechanical stress on surrounding components.

Conductivity Is Only One Part of Performance

A high-conductivity material cannot perform effectively if it fails to make reliable contact with the surfaces it is intended to connect.

Introducing PG150A

Fujipoly developed SARCON® PG150A as a next-generation putty pad for demanding thermal applications. The material offers a reported thermal conductivity of 15 W/m-K while remaining soft, compliant, and electrically nonconductive. Ceramic fillers provide the thermal pathway without creating electrical conductivity through the material.

PG150A is designed for applications that require both high thermal performance and the ability to accommodate substantial mechanical variation.

UNDERSTANDING PUTTY PAD TECHNOLOGY

Gap filler pads and putty pads are both used to bridge spaces between heat-generating components and cooling surfaces. The primary difference is mechanical behavior.

Gap Filler Pads

Conventional gap filler pads are viscoelastic materials with enough internal structure to recover some of their original shape after compression. They are commonly used when:

- ▶ The gap is relatively consistent
- ▶ Moderate compression is available
- ▶ The material must maintain dimensional stability
- ▶ Handling and placement are important
- ▶ Reworkability may be required

Putty Pads

Putty pads contain less crosslinking and are therefore more deformable. Rather than primarily compressing downward, the material can spread laterally as pressure is applied. This behavior allows it to conform to complex surfaces and compensate for wide tolerance ranges. Putty pads may be preferred when:

- ▶ The assembly includes components of different heights
- ▶ The gap varies significantly across the device
- ▶ Compression may exceed 30 percent
- ▶ Low assembly force is required
- ▶ Board or component stress must be minimized
- ▶ A very soft material is needed to maintain surface contact

A practical guideline is:

- ▶ 10 to 30 percent compression: Consider a conventional gap filler pad
- ▶ 30 to 50 percent compression or more: Consider a putty pad

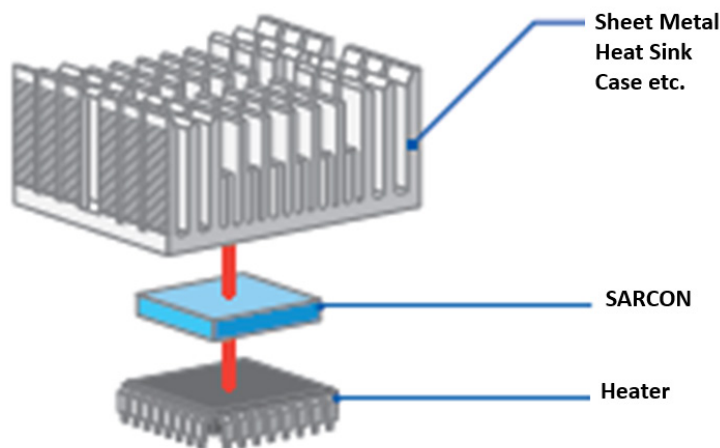
This guideline should not replace application testing, but it provides a useful starting point when evaluating material type.

High-Performance PG150A Material Characteristics

PG150A combines high thermal conductivity with the compliance expected from a putty pad. Key characteristics include:

- ▶ Thermal conductivity of 15 W/m-K
- ▶ Electrically nonconductive ceramic filler system
- ▶ Naturally tacky surfaces
- ▶ No separate adhesive layer
- ▶ Standard sheet size of 200 mm by 300 mm
- ▶ Standard thicknesses of 0.3, 0.5, 1.0, 1.5, and 2.0 mm
- ▶ Custom thickness and sheet-size options
- ▶ Recommended operating range of -40°C to 150°C
- ▶ Internal UL 94 V-0-equivalent test results

The naturally tacky surface supports placement without an additional adhesive layer. Avoiding adhesive also eliminates a potential source of added thermal resistance. Although PG150A is very soft, it can be handled manually. It may be placed with both liners removed or installed with one liner remaining in place until final positioning.



DESIGNING FOR GAP TOLERANCE AND COMPRESSION

The proper material thickness should be selected using the full dimensional tolerance of the assembly rather than the nominal gap alone.

Evaluate the Maximum and Minimum Gap

Consider an application with a nominal gap of 1.25 mm and a tolerance of plus or minus 0.30 mm. The actual gap may range from:

- ▶ Minimum gap: 0.95 mm
- ▶ Maximum gap: 1.55 mm

A material must be thick enough to maintain contact at the maximum gap.

If a 2.0 mm putty pad is selected, the material would experience approximately 22 to 53 percent compression across the tolerance range. Because the compression exceeds the typical range recommended for a conventional gap filler pad, a putty pad is better suited to the application.

Designing by Material Volume

Putty pads spread as they are compressed.

For that reason, engineers can use the final gap volume to estimate the pad dimensions required to cover a specific area. For example, assume the final interface must cover an area of 15 mm by 15 mm at a compressed gap of 0.4 mm. The required material volume is: $15 \text{ mm} \times 15 \text{ mm} \times 0.4 \text{ mm} = 90 \text{ mm}^3$

If the selected PG150A material is 1.0 mm thick, the uncompressed pad must have an area of approximately: $90 \text{ mm}^3 \div 1.0 \text{ mm} = 90 \text{ mm}^2$. The square root of 90 mm^2 is approximately 9.49 mm. For practical manufacturing, the pad could therefore be designed at approximately: $9.5 \text{ mm} \times 9.5 \text{ mm} \times 1.0 \text{ mm}$

As the material is compressed, it spreads to fill the larger 15 mm by 15 mm interface.

Thicker Material May Require Less Force It may

seem intuitive that a thicker pad would always require more compression force. Testing presented demonstrated that this is not necessarily the case with putty materials.

When two PG150A samples were compressed to the same final gap of 0.25 mm:

- ▶ A 0.5 mm-thick sample with a diameter of approximately 20 mm
- ▶ A 2.0 mm-thick sample with a diameter of approximately 10 mm

Both samples produced nearly the same final coverage area. However, the thicker, smaller-diameter sample required less force to reach the final gap, even though it experienced a much greater percentage of compression. This illustrates why putty pad design should be based on material volume, compression behavior, target coverage, and available assembly force rather than thickness alone.

To determine the size and volume of SARCON Putty Type to be used, follow this helpful example:



EX.

**Original Gap : $V=90.0\text{mm}^3$
(0.4mm H x 15mm W x 15mm L)**

Decide Thickness of SARCON depend on the compression force
e.g. Decided Thickness = 1.0mm

$$\sqrt{90.0(V) / 1 (T)} = 9.486 \text{ mm}$$

⇒ **use ; 9.5 mm x 9.5 mm x 1.0 mmT**

BOND-LINE CONSIDERATIONS

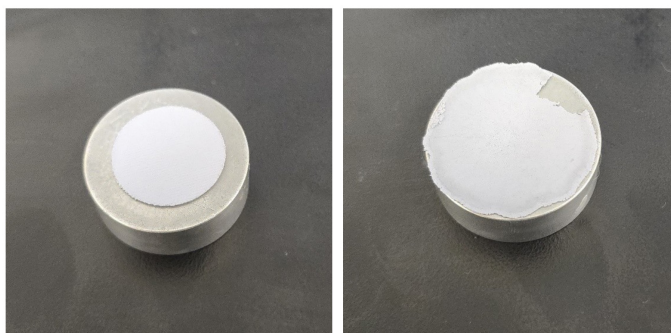
PG150A has an estimated minimum bond-line thickness of approximately 0.1 mm, although designing directly to that minimum is not recommended.

Aiming for an extremely thin final gap may:

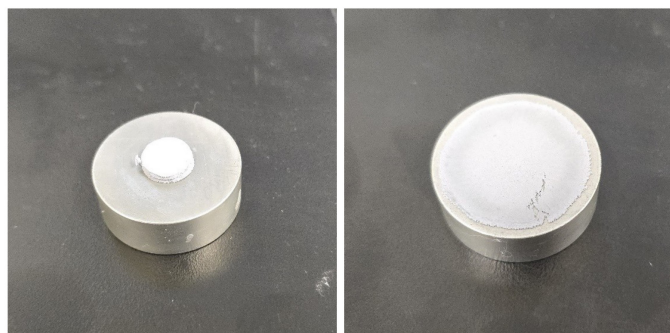
- ▶ Require excessive pressure
- ▶ Increase material displacement
- ▶ Reduce manufacturing tolerance
- ▶ Create inconsistent coverage
- ▶ Increase stress on surrounding components

The target bond line should provide adequate thermal performance while remaining practical for the mechanical design and production process.

PG150A-00-50GY



PG150A-00-200GY



Evaluating Performance Beyond Conductivity

Thermal conductivity is a bulk material property. The actual performance of a TIM within an assembly is better represented by thermal resistance, which accounts for the material thickness and the quality of contact at the interfaces. Mechanical compliance can significantly influence this performance. A softer material may produce lower thermal resistance because it conforms more effectively and reduces contact resistance, even when competing materials have equal or higher published conductivity.

Compression-Force Testing

Fujipoly compared 1.0 mm-thick PG150A samples with three competitive putty pad materials rated at:

- ▶ 15 W/m-K
- ▶ 17 W/m-K
- ▶ 18 W/m-K

The materials were compressed from 10 to 50 percent, followed by a 60-second hold at 50 percent compression to evaluate material relaxation. The competitor's 15 W/m-K material required substantially greater compression force than the other materials throughout the test. The 17 W/m-K material initially demonstrated low force, but its compression force increased considerably above approximately 20 to 30 percent compression.

PG150A and the competitor's 18 W/m-K material demonstrated similar mechanical behavior and remained more compliant through the test range. These results reinforce the importance of comparing force-deflection behavior rather than assuming that materials with similar thermal ratings will behave similarly during assembly.

THERMAL-RESISTANCE TESTING

The same materials were evaluated at pressures of 100, 300, and 500 kPa.

Under the reported test conditions, PG150A produced the lowest thermal resistance across the pressure range.

Material	Thermal Resistance
PG150A	0.27 K-cm ² /W
Competitor 15 W/m-K	0.89 K-cm ² /W
Competitor 17 W/m-K	0.78 K-cm ² /W
Competitor 18 W/m-K	0.35 K-cm ² /W

The materials were also compared at the same percentage of compression.

At 50 percent compression, the reported thermal-resistance values were:

Material	Thermal Resistance
PG150A	0.467 K-cm ² /W
Competitor 15 W/m-K	0.647 K-cm ² /W
Competitor 17 W/m-K	0.627 K-cm ² /W
Competitor 18 W/m-K	0.607 K-cm ² /W

These results do not mean that one material will always outperform another in every application. They demonstrate why testing should reflect the actual gap, pressure, and mechanical conditions of the intended assembly.

Reworkability and Surface Treatments

Standard PG150A is not intended to be reused after an assembly has been separated.

Its low rigidity can cause the material to deform during removal. However, it can generally be peeled or scraped from surfaces, allowing new material to be installed.

For applications requiring improved release or sliding during assembly, Fujipoly offers laminated surface options:

- ▶ PET film surface
- ▶ Aluminum foil surface

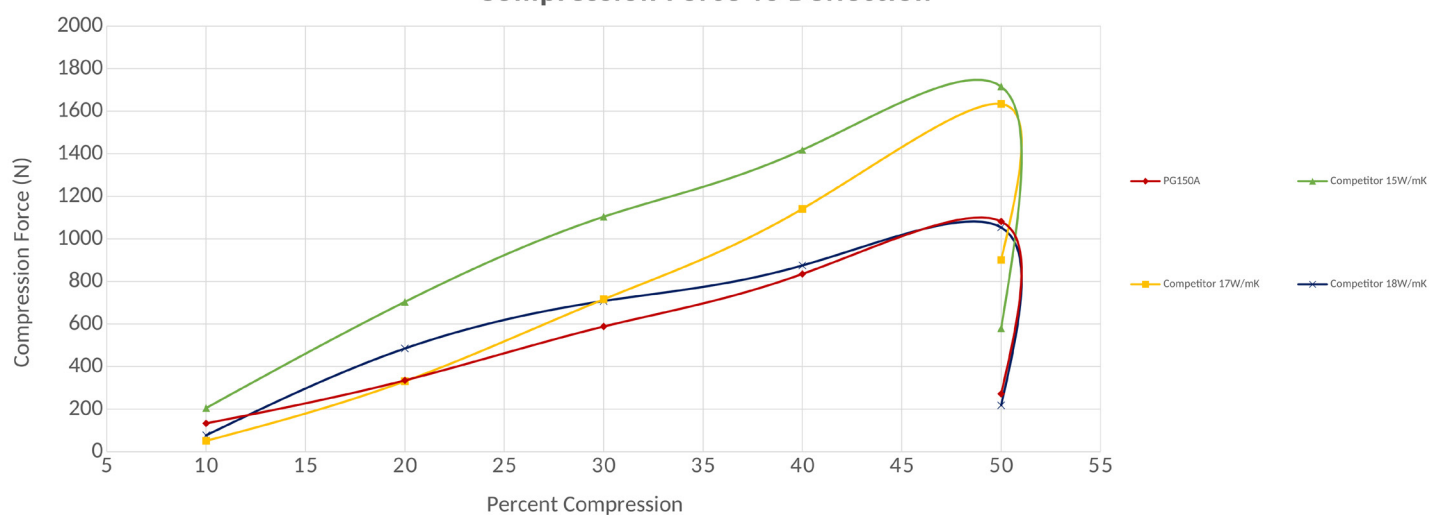
The PET surface provides greater durability, while the aluminum surface generally offers better thermal performance.

However, testing with a 1.0 mm PG150A sample showed that the aluminum surface increased thermal resistance. At 100 kPa, the untreated material produced a reported resistance of 0.51 K-cm²/W, compared with 1.18 K-cm²/W for the aluminum-laminated construction.

This difference was attributed in part to the softness of PG150A, which may not generate enough pressure against the aluminum layer to minimize contact resistance.

Surface treatments should therefore be used only when their assembly or rework benefits outweigh the associated thermal-performance tradeoff.

Compression Force vs Deflection



ENGINEERING DESIGN RECOMMENDATIONS

Next-generation putty pads offer valuable advantages, but their performance depends on how well they are matched to the application.

1. Design for the Full Gap Range

Use the maximum and minimum possible gap rather than relying on the nominal dimension.

The TIM must maintain contact at the maximum gap without creating excessive force at the minimum gap.

2. Evaluate Compression Force

Determine how much force the component, circuit board, housing, and mounting system can safely tolerate.

A material with high conductivity but excessive stiffness may create mechanical problems or fail to conform adequately.

3. Consider Material Volume

Putty pads spread as they compress.

Pad dimensions should be based on the volume required to fill the final interface, not simply the size of the heat-generating component.

4. Compare Thermal Resistance

Published conductivity is useful for preliminary screening, but thermal resistance provides a better indication of application performance.

Whenever possible, compare candidate materials at:

- ▶ Representative gap thicknesses
- ▶ Realistic compression levels
- ▶ Equivalent pressure
- ▶ Comparable surface conditions
- ▶ Expected operating temperatures

5. Account for Manufacturing

Consider how the material will be:

- ▶ Cut
- ▶ Lined
- ▶ Handled
- ▶ Positioned
- ▶ Compressed
- ▶ Inspected
- ▶ Removed
- ▶ Replaced

A material must provide consistent thermal performance without creating unnecessary complexity during production.

6. Evaluate Surface Treatments Carefully

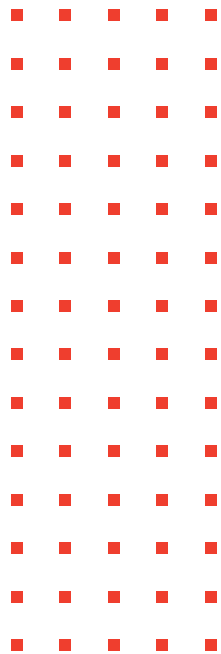
Laminated films and foils can improve handling, sliding, or release characteristics, but they may also increase contact resistance.

Any surface treatment should be evaluated within the complete assembly.

7. Validate the Final Design

Application-specific testing remains essential.

The final design should be evaluated under representative mechanical, thermal, and environmental conditions before production.



CONCLUSION

Shrinking electronic systems and increasing power output are creating thermal interfaces that must manage both greater heat density and more complex mechanical conditions. In these applications, thermal conductivity alone is not an adequate basis for selecting a thermal interface material.

Engineers must also consider compliance, compression force, gap tolerance, material thickness, contact resistance, bond-line behavior, handling, and manufacturability. Putty pad materials provide a practical solution for assemblies with wide gap tolerances, uneven surfaces, or limited compression force. Their ability to deform and spread under pressure can help maintain reliable contact while reducing mechanical stress on sensitive components.

Fujipoly's SARCON® PG150A demonstrates how high thermal conductivity and low mechanical resistance can be combined within a single material. Under the testing conditions presented, PG150A maintained strong compliance while producing lower measured thermal resistance than the competitive materials evaluated.

The most effective thermal interface is not necessarily the material with the highest value on a data sheet. It is the material that provides the best balance of thermal performance, mechanical behavior, and manufacturing reliability within the actual application.

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James Paydo is a graduate of the Mechanical Engineering program at San Jose State University and has more than 10 years of experience working with thermal interface materials. He supports customers in automotive, medical, aerospace, handheld electronics, and other industries by helping evaluate thermal-interface challenges and identify practical material solutions.

He is based at Fujipoly's Customer Engineering Resource Center in San Jose, California, where he is also involved in establishing dispensable-material research and development capabilities.

LEARN MORE

Need help evaluating a thermal interface material for a challenging gap application?

Fujipoly's engineering team can assist with material selection, thermal and mechanical testing, custom samples, converted components, and application-specific recommendations.

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