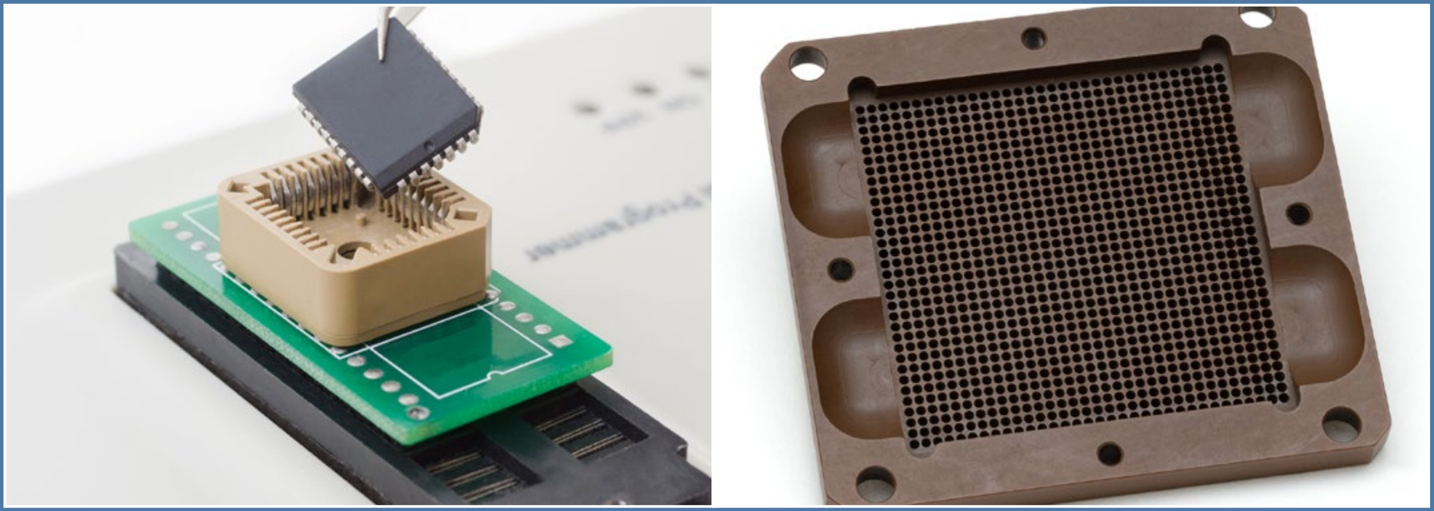
PLASTICS FOR SEMICONDUCTOR TEST SOCKETS



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TEST SOCKET CHALLENGES

If you're reading this, semiconductors have some impact on your life. Indeed, microchips are no longer only found in high-end computers, but have become deeply ingrained in our daily lives. Beyond the obvious like smart phones and video game systems, microchips are now used in everything from cars to home appliances to kids' toys. As crazy as it sounds, they may even be implanted in humans in the near future.

Given the widespread use and increasingly critical nature of microchip applications, it comes as no surprise that the demands on testing equipment are reaching new heights. Traditionally, IC inspection sockets were separated into two categories: test and burn-in. While that division continues for established programs, recent advancements have led to the development of sockets offering combination test and burn-in functionality.

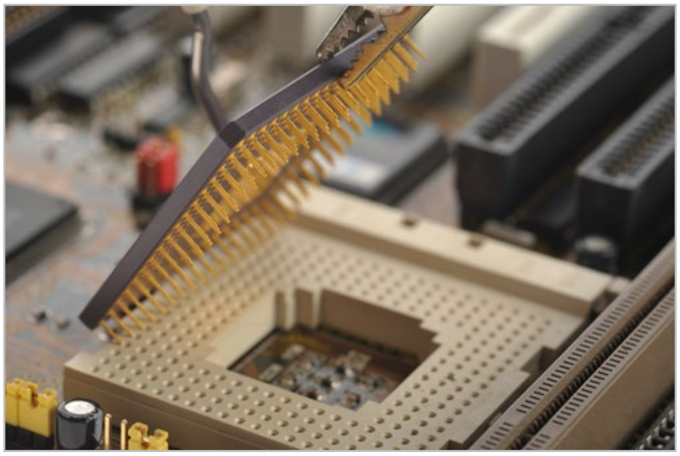
Engineering plastics like DuPont™ Vespel® PI, Torlon® PAI, Ultem® PEI, and PEEK have long-been utilized by back-end socket designers due to their dimensional stability, elevated temperature capabilities, and electrical properties. In recent years, designers have been under constant pressure to produce sockets with larger numbers of smaller, tighter-tolerance holes that are closer together from thinner cross-sections. Moreover, modern testing practices call for reduced cycle times leading to higher temperatures and faster thermal cycling, introducing additional material selection considerations.

A variety of engineering plastics are utilized to solve test socket engineering challenges.

PEEK AND TORLON®

In some cases, new application requirements have exceeded the performance limits of historically popular engineering materials like PEEK and Torlon®. Even so, both materials are widely specified for use in new and legacy products alike. Unfilled PEEK offers the advantage of being roughly one-half the cost of Torlon® 4203; however, specialty grades of PEEK formulated for socket applications can cost more than double a Torlon® 4203 sheet of the same size.

Despite an oft-cited continuous use temperature of 480°F, PEEK exhibits a glass transition temperature (Tg) of around 289°F. Beyond this point, its stiffness drops rapidly, and its coefficient of thermal expansion increases by roughly three-fold [1, 2]. For more extreme application environments, ceramic-filled grades of PEEK, such as TECAPEEK® CMF or Etrox® V, are generally preferred for maintaining stiffness and dimensional stability both in-service and during heat-generating, high-precision machining operations. The ceramic additives enhance the rigidity and dimensional stability of the PEEK compound, even at temperatures above its Tg. On the other hand, beyond increasing cost, loading PEEK in this way causes it to embrittle considerably and may increase burr-generation, potentially resulting in costly secondary operations, high scrap rates, wasted machine time, and unpredictable cycle times. Harder and stiffer ceramic-filled materials also wear out tooling more quickly than unfilled plastic materials.



PEEK socket components performing as intended.

At around 527°F, Torlon® exhibits a considerably higher Tg than PEEK [3]. Unlike PEEK, the molecular structure of Torlon® lacks regions of significant order, and, therefore, abruptly loses all load-bearing capability at its Tg. At temperatures below its Tg, however, Torlon® PAI is among the strongest and stiffest unfilled polymers in existence. It also exhibits an extremely low coefficient of thermal expansion for a polymer. **Table 1** compares select datasheet properties of unfilled PEEK, ceramic-filled PEEK (TECAPEEK® CMF), Torlon® 4203, and Torlon® 5030 (30% glass-filled extruded PAI).

Table 1. PEEK and PAI Property Comparison

Material	Flex Modulus	Elongation at Break	CLTE	Water Uptake at 24 hrs	Surface Resistivity
PEEK	550,000 psi	50%	2.5×10^{-6}/°F	0.03%	1×10^{16} Ω
Ceramic-filled PEEK (TECAPEEK® CMF)	780,000 psi	3%	2.2×10^{-6}/°F	0.03%	5×10^{15} Ω
PAI (Torlon® 4203)	730,000 psi	8%	1.7×10^{-6}/°F	0.33%	5×10^{18} Ω
Glass-filled PAI (Torlon® 5030)	1,700,000 psi	2%	0.9×10^{-6}/°F	0.25%	1×10^{18} Ω

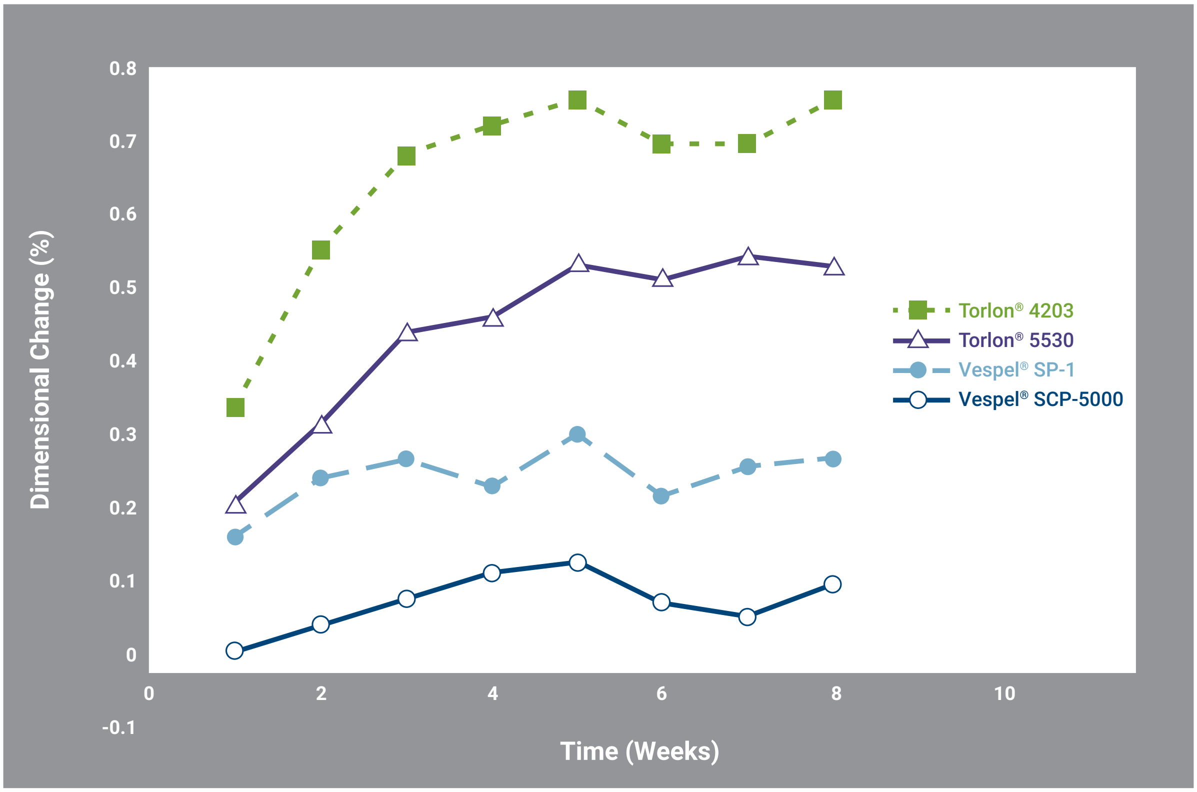
Property comparison of popular PEEK and PAI socket materials. Typical values not intended for specification purposes based on published data by industry-standard grades [2, 3, 4].

As implied in **Table 1**, Torlon® materials are relatively hygroscopic. As temperature rises and relative humidity increases, the amount of water that Torlon® will absorb by weight also tends to increase. Specifically, it is reported that at 110°F and 90% relative humidity (RH) that Torlon® 4203 will undergo a roughly 4% weight increase which corresponds to a dimensional change of over 0.5% [3].

TORLON® AND DUPONT™ VESPEL®

In a presentation at the 2004 Burn-In & Test Socket (BiTS) Workshop, Kane and Bloom compared the dimensional changes of Torlon® and Vespel® materials attributable to moisture uptake on machined socket coupons with and without holes. They concluded that the rate of growth caused by moisture increases with the presence of holes and that Vespel® materials, especially Vespel® SCP-5000, experienced lower dimensional change than Torlon® materials. **Figure 1** is adapted from their research and explores the dimension-altering effects of moisture over time on socket coupons made from Torlon® and Vespel® [5].

Figure 1. Dimensional Change vs. Exposure Time, 100°F/90% RH – 1" x 1" x ⅛" Coupon with Holes

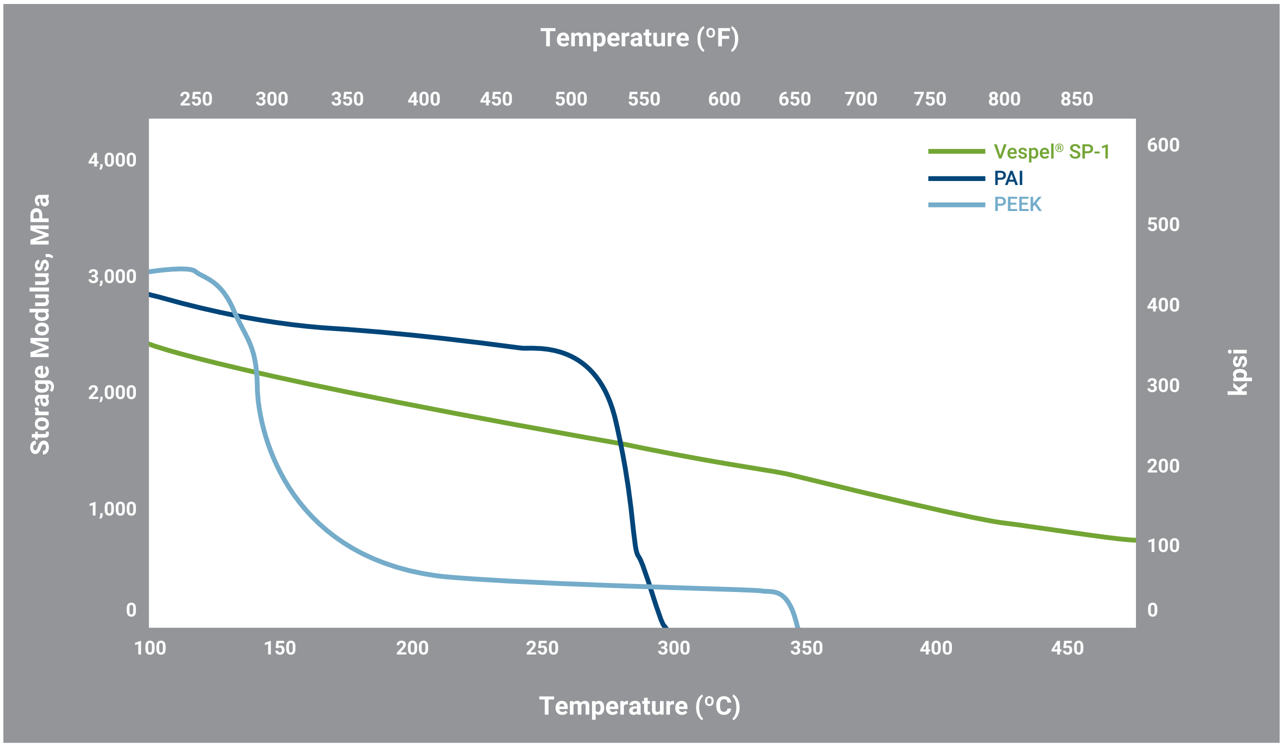


The dimensional change of Torlon® and DuPont™ Vespel® 1" x 1" x ⅛" thick socket coupons with machined-in holes over time at 90% RH and 100°F.

Torlon® 5530 is a compression molded 30% glass-filled grade of Torlon®. Compression molded materials tend to exhibit lower levels of residual stress than their extruded counterparts, which can offer machining benefits for tight-tolerance parts prone to warping. Because they are not melt-processible, Vespel® SP-1 and SCP-5000 shapes are standardly available as compression molded plaques.

Vespel® SP-1 has been specified for use in socket components for decades. Even though it costs substantially more than Torlon®, the superior thermal capabilities of DuPont™ Vespel® polymers allow them to be machined to extremely precise tolerances and provide reliable performance over extended life cycles under aggressive application conditions. Notably, Vespel® SP-1 exhibits no observable Tg, which translates into consistent and predictable mechanical behavior across a broad temperature range. Side-by-side Dynamic Mechanical Analyses (DMA) of DuPont™ Vespel®, Torlon®, and PEEK are shown in **Figure 2** [6].

Figure 2. Side-by-side Dynamic Mechanical Analyses (DMA) of DuPont™ Vespel®, Torlon®, and PEEK



For the most demanding socket applications, Vespel® SCP-5000 combines the mechanical properties of other reinforced polymers with the ultra-high temperature capability of the Vespel® line. Vespel® SCP-5000 is also significantly less hygroscopic than SP-1. Because Vespel® SCP-5000 is unfilled, it is relatively isotropic and does not pose the same machining challenges as heterogeneous filled plastics. This special class of polymer has been successfully utilized in thin cross-section machining of sockets with pitches of 0.3 mm. Perhaps, you can take it further? **Table 2** displays select mechanical properties of Vespel® SP-1 and SCP-5000.

Table 2. Vespel® SP-1 and SCP-5000 Property Comparison

Material	Flex Modulus	Elongation at Break	CLTE	Water Uptake at 24 hrs	Surface Resistivity
SP-1	450,000 psi	8%	3.0×10^{-6}/°F	0.24%	$1 \times 10^{15\text{-}16}$ Ω
SCP-5000	825,000 psi	7%	2.4×10^{-6}/°F	0.08%	1×10^{15} Ω

Property comparison of Vespel® SP-1 and SCP-5000. Typical values not intended for specification purposes based on published data [7].

As socket applications continue to grow in complexity, it seems likely that ultra-high performance polymers such as DuPont™ Vespel® will continue to grow in importance. Contact us today to discuss engineering plastic materials for your latest designs.

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4. *TECAPEEK® CMF white – Stock Shapes (rods, plates, tubes)*. A2 ed., Ensinger Inc., 2023.

5. Kane, Paul, and Joy Bloom. *Dimensional Stability and High Frequency Properties of Polymeric Materials for Machined Test Sockets*. BiTS Workshop, 2004.

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TECHNICAL EXPERTISE

Curbell white papers are intended to provide engineers and designers with basic information about the engineering polymers available as sheet, rod, tube, and film stock from Curbell Plastics. We invite you to contact Curbell via e-mail at **technicalsupport@curbellplastics.com** to discuss applications in detail

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For more than 80 years, Curbell Plastics has been one of the nation's leading providers of plastic sheets, rods, tubes, and films, as well as fabricated parts, adhesives, and prototyping materials. Our customers range from small local businesses to large *Fortune* 500 companies and government agencies. We partner with organizations in dozens of industries, including aerospace, pharmaceutical, machinery manufacturers and sign fabricators. At Curbell, we understand the unique demands of each market and we have the expertise to help you meet your business needs. Whether your objective is to reduce manufacturing costs, improve productivity, or increase product reliability, Curbell can help.

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At Curbell, we are committed to providing the highest level of service to our customers. We recognize the urgency of customer needs, and we pride ourselves on providing quick and proactive solutions. Our tag line says it all – we appreciate the opportunity to earn your business and we invite you to ***"Put us to work for you!™"***

ABOUT THE AUTHOR

Dave Seiler is Business Development Manager for Curbell Plastics focusing on high-performance engineering plastics. Dave has an extensive background in polyetheretherketones and handles Curbell's DuPont™ Vespel® product line outside of the West Coast. His work involves helping companies identify the best plastic materials for their applications in order to achieve quality improvements and cost savings.
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