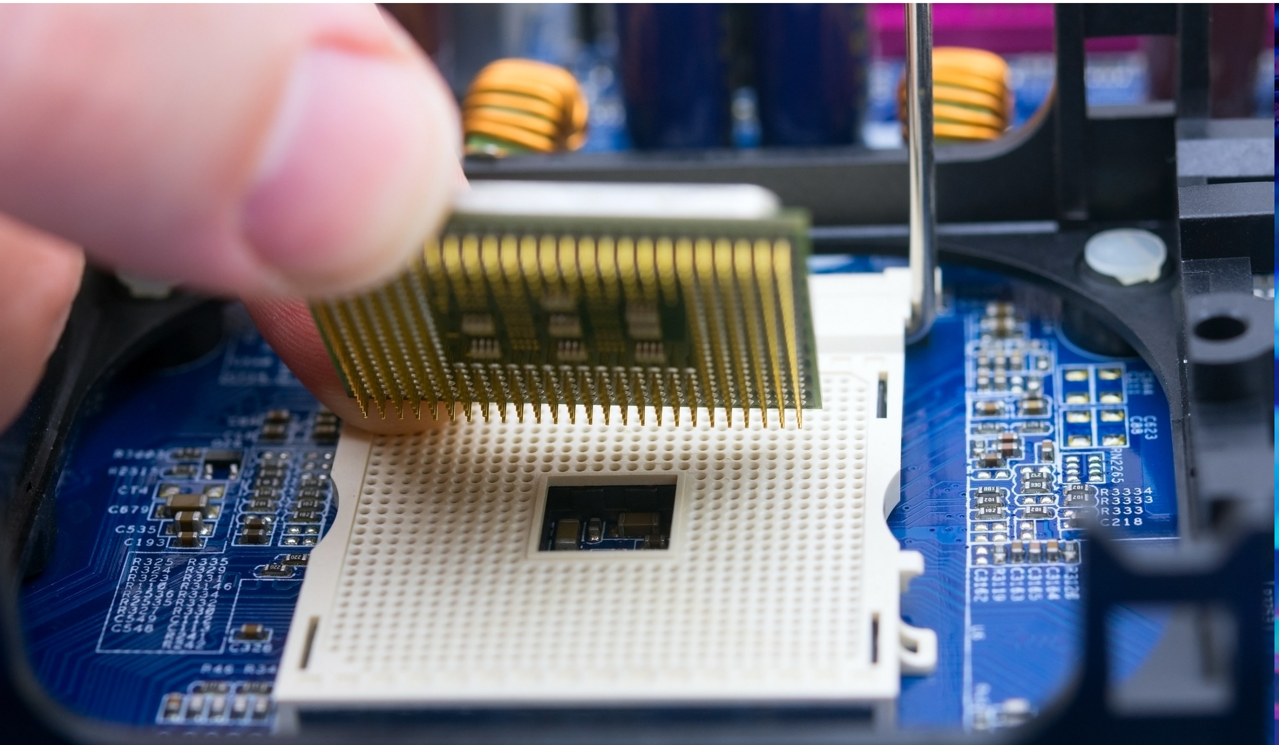
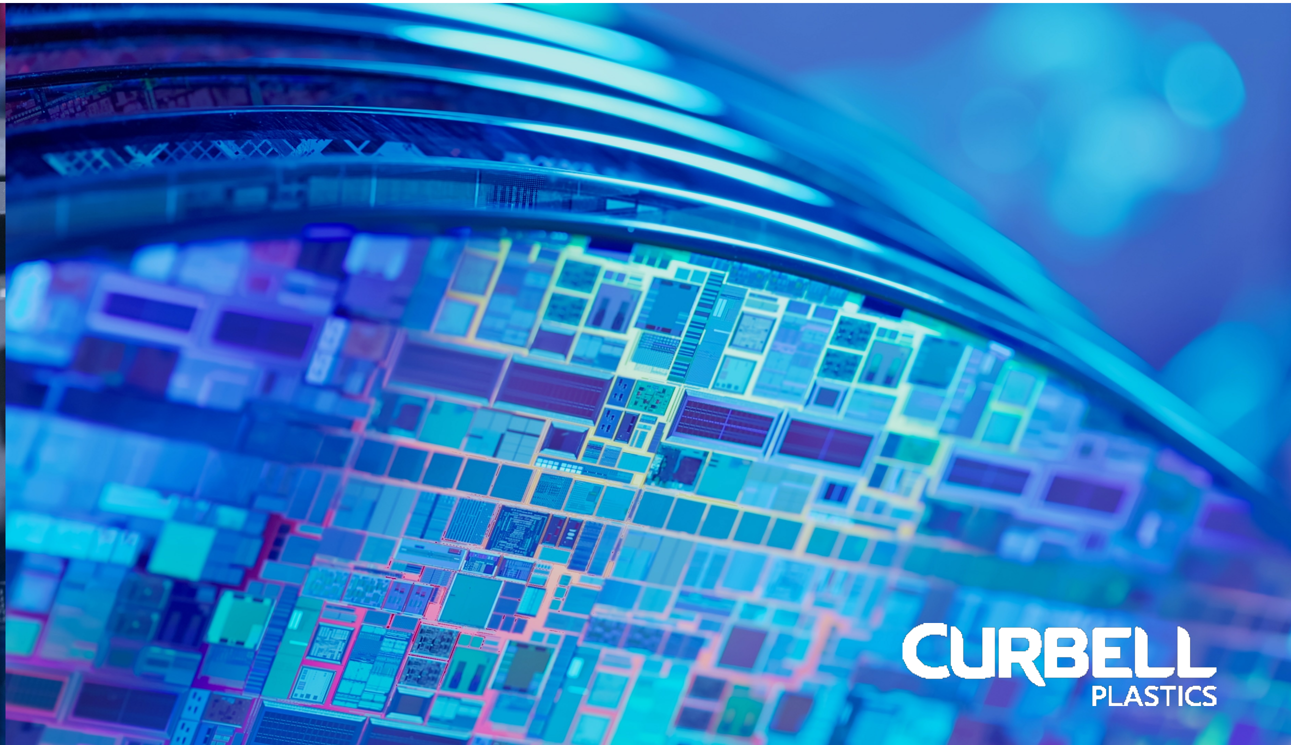
Selecting High Performance Plastics for Semiconductor Applications

Webinar Presented by Curbell Plastics





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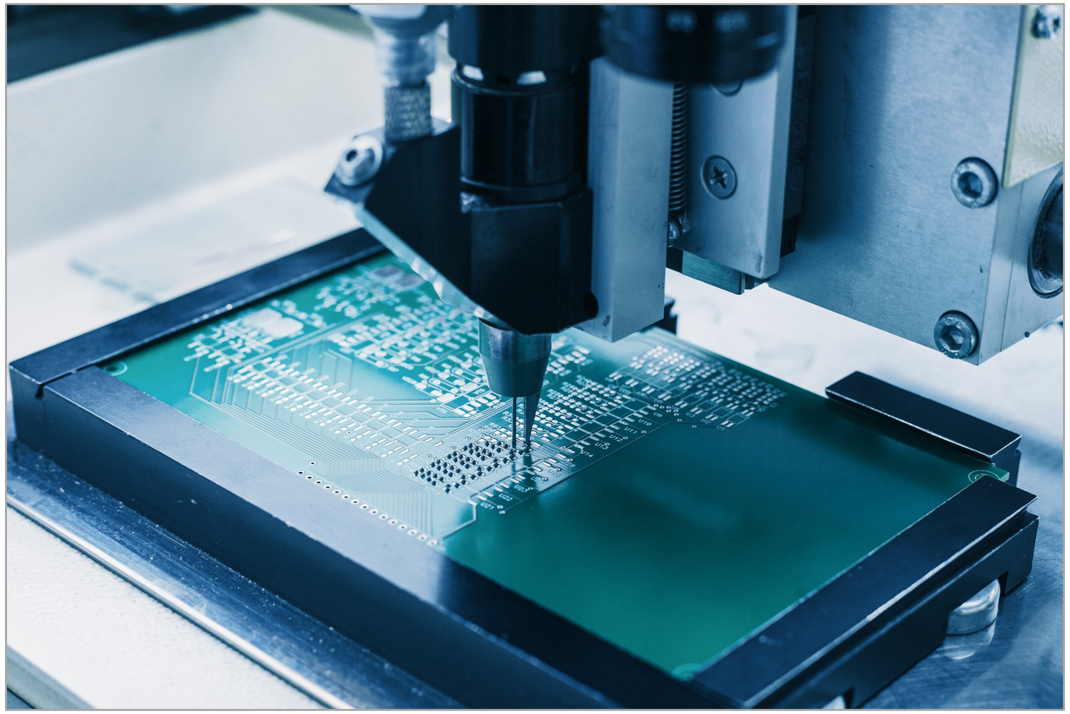
Why Do We Care About the Semiconductor Market?

- Chips are everywhere!

There are Many Steps Involved in Making Chips

- Many fabrication processes are involved in the manufacture of chips
  - Etch
  - CMP
  - Burn-In Testing
- Material requirements vary broadly between applications
  - Purity often critical



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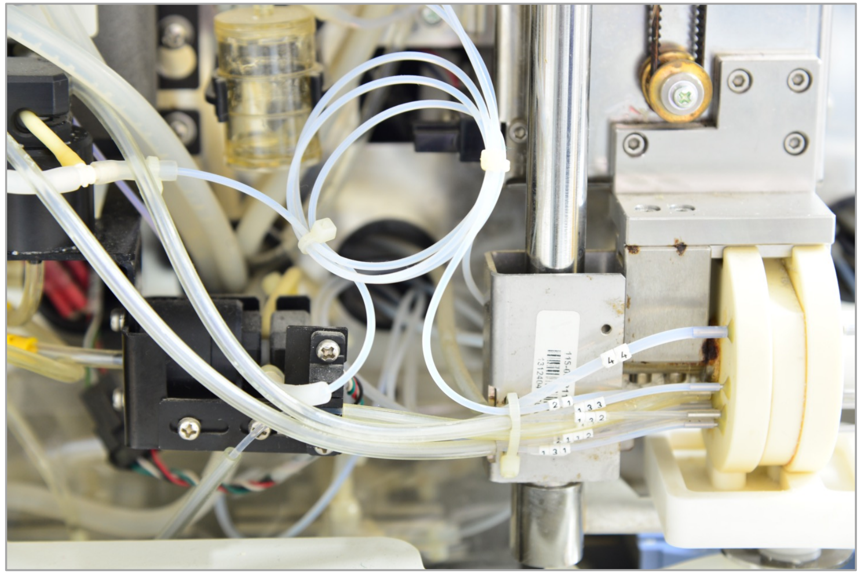
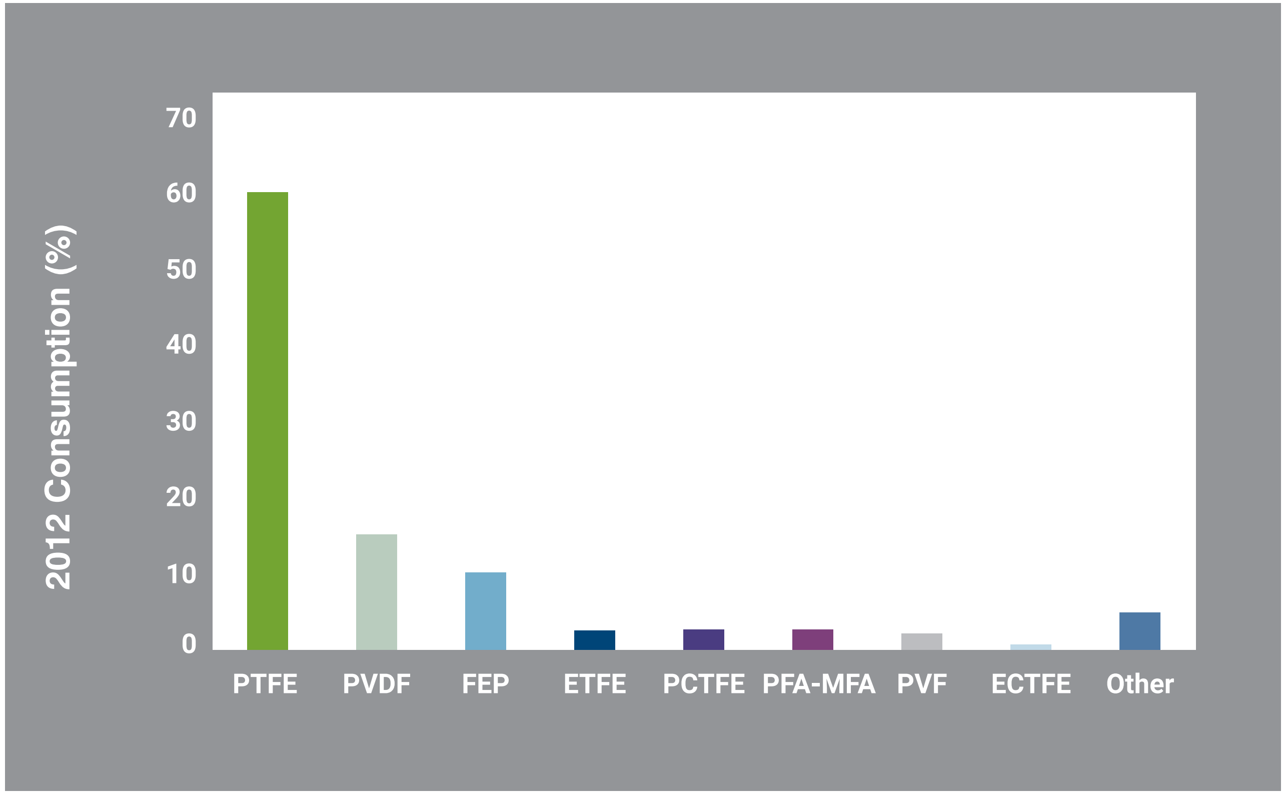
Fluoropolymers

- Fluoropolymers are known for their chemical inertness and purity



2012 Consumption Data of Various Fluoropolymers



Source: Fluoroplastics, Vol. 1

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PTFE Chemical Compatibility

- There are NO chemicals on Curbell's website that PTFE is not compatible with

■ = Resistant ● = Limited Resistance ▲ = Not Resistant * Resistance also dependent upon concetration, time, and temperature

AGENTS, CONCENTRATION: WEIGHT-% / MATERIAL	ABS	Acetal (copolymer)	Acetal (homopolymer)	Noryl®	Nylon 6	PBT	PEEK	PET	Polycarbonate	Polyethylene	Polypropylene (homopolymer)	PPS	PPSU (Radel® R)	PSU (polysulfone)	PTFE	PVDF	Ultem®	Vespel® SP-1
Acetamide 50%	■		■		■										■	■		
Acetic acid, aqueous solution 5%	■	■	●	■	■	■	■	■	■	■	■	■	■	■	■	■		
Acetic acid, aqueous solution 10%	■	■	●	■	▲	●	■	●	■	■	■	■	■	■	■	■	■	●
Acetic acid, concentrated	▲	●	▲	■	▲	▲	▲	▲	▲	■	■	■		■	■			
Acetone	▲	■	■	▲	●	▲	■	▲	▲	●	■	■	▲	▲	■	●		■
Ammonia solution 10%	■	■	●	■	■	■	■	■	▲	■	■	■		●	■	■	▲	▲
Anone			■		■				▲	●	■				■	●		
Benzene	▲	■	■	▲	■	●		●	▲	●	●	●	●	▲	■	■		■
Benzine	●	■	■	▲	■	■	■	■	▲	●	●	■	■	■	■	■	■	
Bitumen		■	■		●				▲	●	●				■			
Boric acid, aqueous solution 10%	■	▲	■		■		■		■	■	■				■	■		●
Butyl acetate	▲	■	■		■	■		■	▲	●	●	■	■	●	■	■		
Calcium chloride, solution 10%		●	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■
Carbon trachloride	▲	■	●	▲	■	■		■	▲	▲	▲			●	■	■		
Chlorbenzene	▲	■	■		■	▲		▲	▲	▲	■	●			■		■	
Chloroform	▲	▲	▲	▲	▲	▲		▲	▲	▲	●	●		▲	■	■		●
Citric acid, aqueous solution 10%	■	●	▲	■	●	■	■	■	■	■	■		■	■	■	■		■
Clophene A60, 50%		■	●		■	■		■		■					■			
Cupric sulphate 10%	■	■	▲	■	■		■		■	■	■	■			■	■		
Cyclohexane	■	■	■	■	■				▲	■	■	■	■	■	■	■		■
Cyclohexanone	▲	■	■	■	■				●	■	■	■			■	●		
Decalin	▲	■	■	■	■				●	■	■				■			
Diesel Oil	■	■	■	■	■	■		■	●	■	●	■		■	■	■	■	
Dimethyl formamide	▲	■	▲		■				▲	■	■	■			■			
Diocthyl phthalate		■	■	■	■				●	■	■	●		■	■			
Dioxane		●	■	●	■	●		●	▲	●	■	■			■	■	■	
Edible fats, Edible oils			■	■	■				■	■	■	■			■	■	■	
Ethanol 96%	■	■	■	■	■	■	■	■	●	■	■	■	■	■	■	■	■	
Ethyl acetate		●	■	■	■	●		●	▲	■	■			▲	■	■	■	■
Ethyl ether		■	■		■	■		■	▲	■	■		■	■	■	■		
Ethylene chloride	▲	▲	▲		■	▲		▲	▲	●	■				■		■	●
Formaldehye, aqueous solution 30%	■	■	▲	■	■		■			■	■	■	■		■	■	■	
Formamide			●		■					●					■			
Formic acid, aqueous solution 10%	■	■	▲	■	▲	■	■	■	■	■	■	■			■	■	▲	●

Partially-Fluorinated vs. Fully-Fluorinated Materials

- Partially-fluorinated materials tend to exhibit enhanced permeation resistance relative to fully-flourinated

	PTFE	PFA	FEP	ETFE	CTFE	ECTFE	PVDF
Water Vapor g/m^2.d.bar	5	8	1	2	1	2	2
Air cm^3/m^2.d.bar	2000	1150	600	175	X	40	7
Oxygen cm^3/m^2.d.bar	1500	X	2900	350	60	100	20
Nitrogen cm^3/m^2.d.bar	500	X	1200	120	10	40	30
Helium cm^3/m^2.d.bar	3500	17000	18000	3700	X	3500	600
Carbon Dioxide cm^3/m^2.d.bar	15000	7000	4700	1300	150	400	100

Data published in 1980 Kunstsoffee paper entitled Fluorocarbon Films-Present Situation and Future Outlook.
X = Not tested.

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Not All Plastics Meet Stringent Flammability Standards

- FM4910 is the flammability standard created by the Factory Mutual Insurance Company for materials used in clean rooms
  - Common requirement for wet benches and tank materials
- Example FM4910 listed materials
  - Fluoropolymers such as PVDF, ECTFE, PFA
  - Specific grades of PP, PVC, and CPVC

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Electrical Properties of Plastics Can Be Tailored with Fillers

SURFACE RESISTIVITY RANGES FOR ESD PLASTICS				
	Conductive Plastics	Static Dissipative Plastics	Antistatic Plastics	Unfilled Plastics
Surface Resistivity Range (Ohms/sq)	10^1 to 10^6	10^6 to 10^9	10^9 to 10^{12}	$>10^{12}$

- Unfilled plastics and laminates like GPO-3 are widely used for electrical insulating applications
- Fillers can be added to polymeric materials to modify their electrical conductance properties
  - Often dealing with carbon (or graphite), but hygroscopic fillers or more conductive substances such as metallic fibers are used

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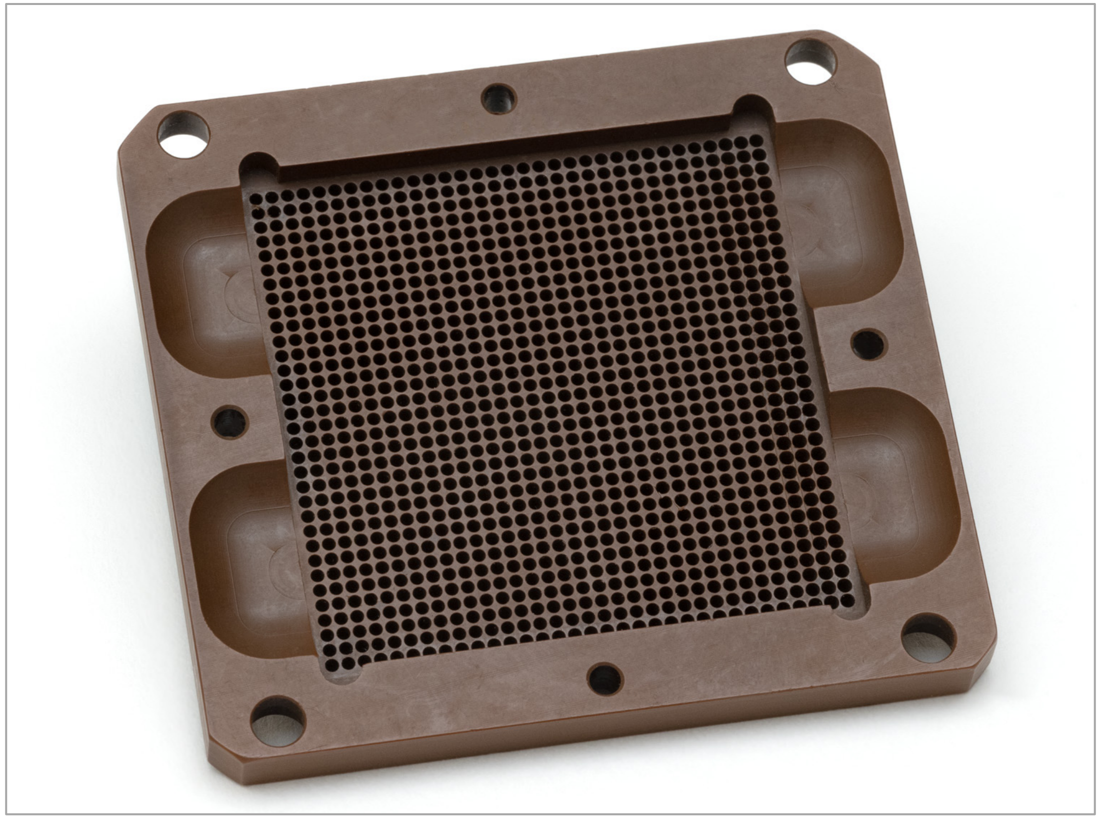
Challenge – Maintaining Dimensional Stability

- Maintaining dimensional stability is a common challenge for precision plastic components
  - Components with ultra-precise tolerance requirements, such as test sockets, require extremely stable materials
  - Traditionally, filled plastics, such as ceramic-filled PEEK, have been utilized, but with extremely precise features, their behavior can prove unpredictable



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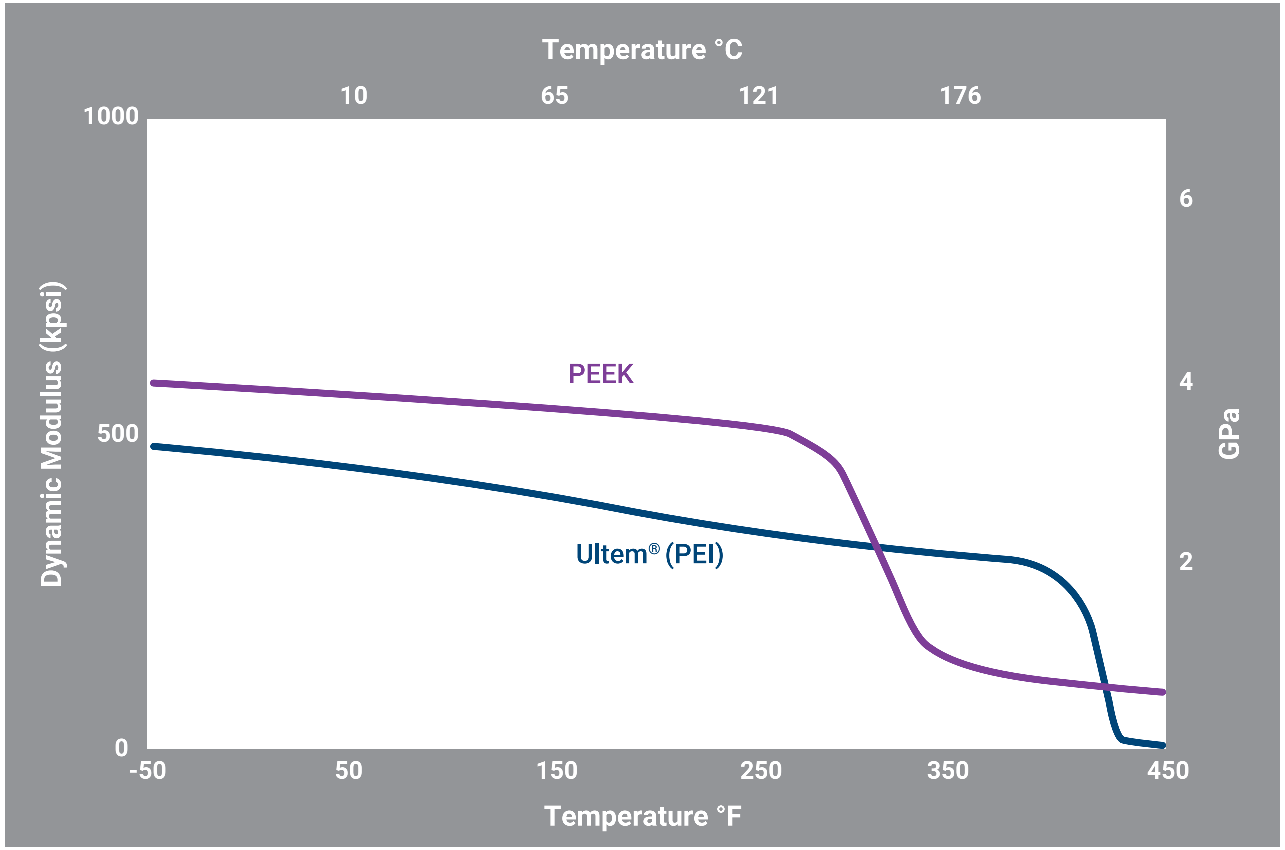
Temperature – Amorphous vs. Semi-Crystalline Materials

- Amorphous and semi-crystalline materials behave differently with respect to temperature



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Directionality Induced by Manufacturing Process

SEMI-CRYSTALLINE DIRECTIONALITY EXAMPLE BELOW T_g		
Material	**CTE - Flow Direction, Below T_g**	**CTE Average, Below T_g (all directions)**
PEEK 450G (Unfilled)	$4.5 \times 10^{-5}/°C$	$5.5 \times 10^{-5}/°C$
PEEK 450GL30 (30% GF)	$1.8 \times 10^{-5}/°C$	$4.5 \times 10^{-5}/°C$

SEMI-CRYSTALLINE DIRECTIONALITY EXAMPLE ABOVE T_g		
Material	**CTE - Flow Direction, Above T_g**	**CTE Average, Above T_g (all directions)**
PEEK 450G (Unfilled)	$12.0 \times 10^{-5}/°C$	$14.0 \times 10^{-5}/°C$
PEEK 450GL30 (30% GF)	$1.8 \times 10^{-5}/°C$	$11.0 \times 10^{-5}/°C$

Sources: Victrex PEEK 450G and Victrex PEEK 450GL30 Datasheets, Victrex.

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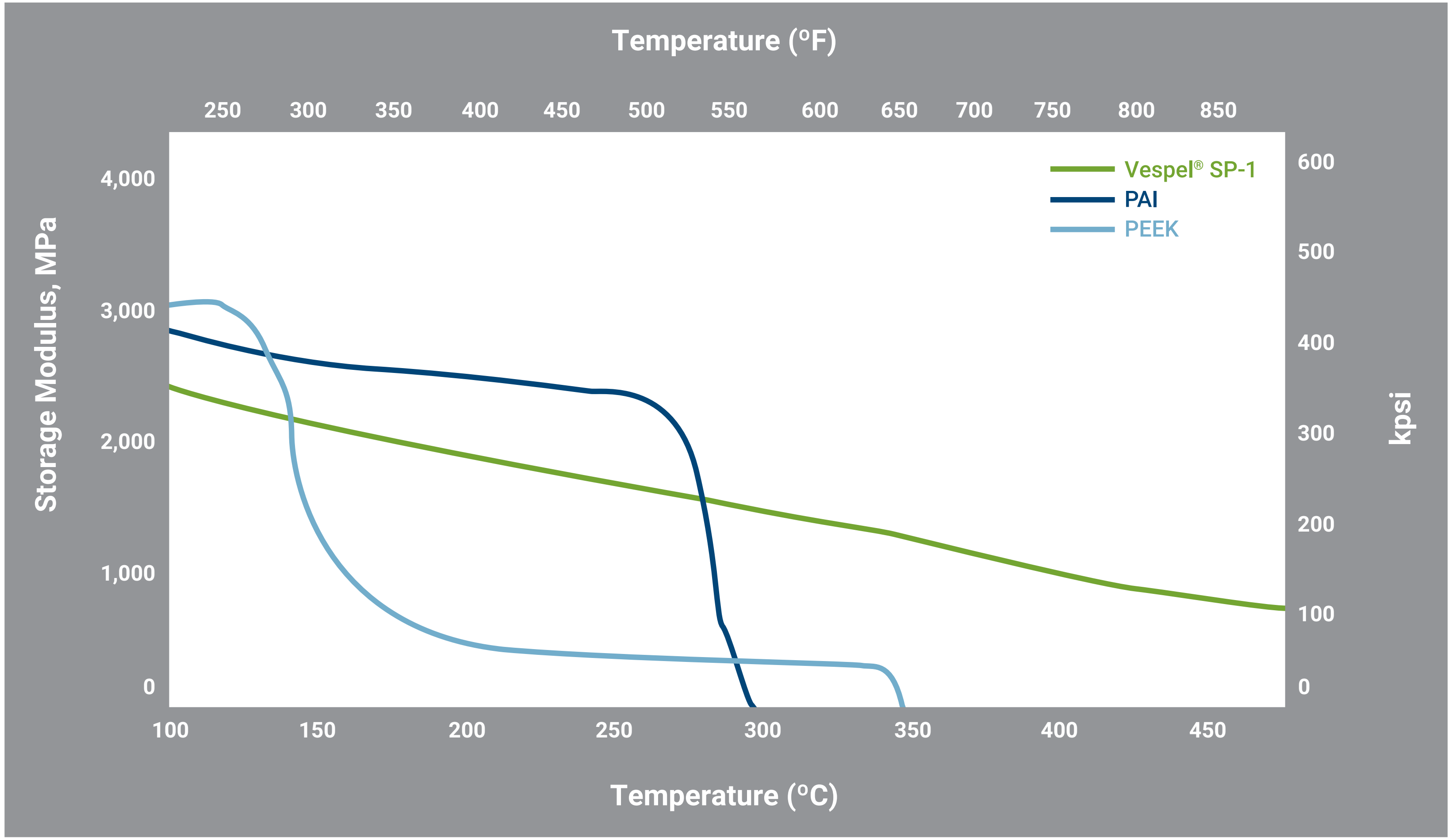
Other Popular Test Socket Materials

REPORTED TYPICAL PROPERTIES OF TORLON® 4203, VESPEL® SP-1, AND VESPEL® SCP-5000					
Material	**Specific Gravity (ASTM D792)**	**Tensile Strength (ASTM D638)**	**Elongation, at break (ASTM D638)**	**Flexural Modulus (ASTM D790)**	**Water Absorption, 24 hours**
Torlon® 4203	1.42	22,000 psi	7.6%	725,000 psi	0.33%
Vespel® SP-1	1.43	12,500 psi	7.5%	450,000 psi	0.24%
Vespel® SCP-5000	1.46	23,600 psi	7.5%	836,000 psi	0.08%

Sources: Torlon® PAI: Design Guide and Dupont™ Vespel® S Line: Design Handbook

Elevated Temperature Performance

Modulus of PEEK, Torlon® 4203, and Vespel® SP-1 with Respect to Temperature



Source: Adapted from Dupont™ Vespel® Sealing Solutions

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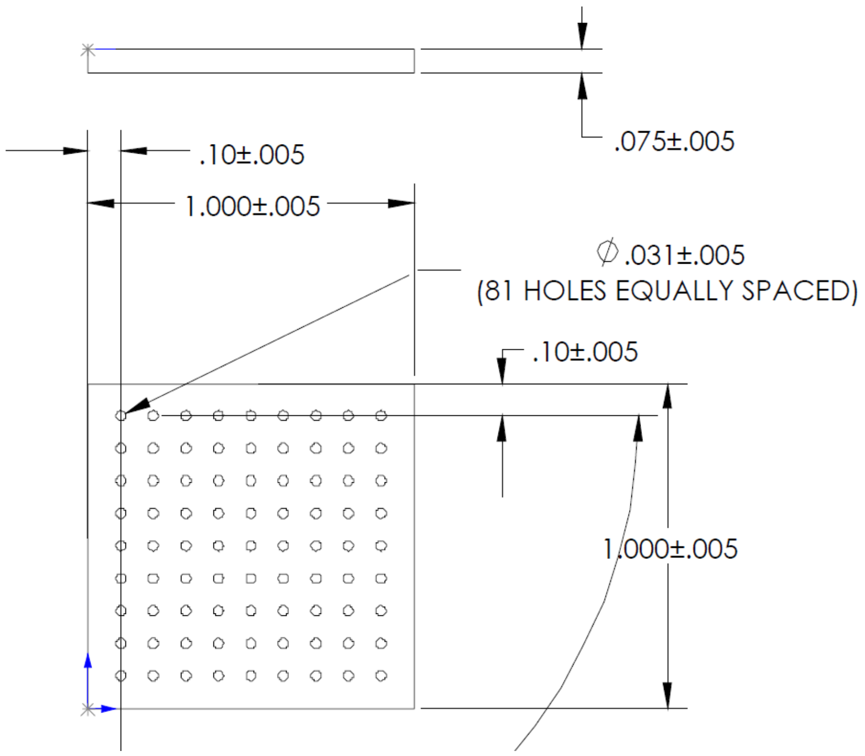
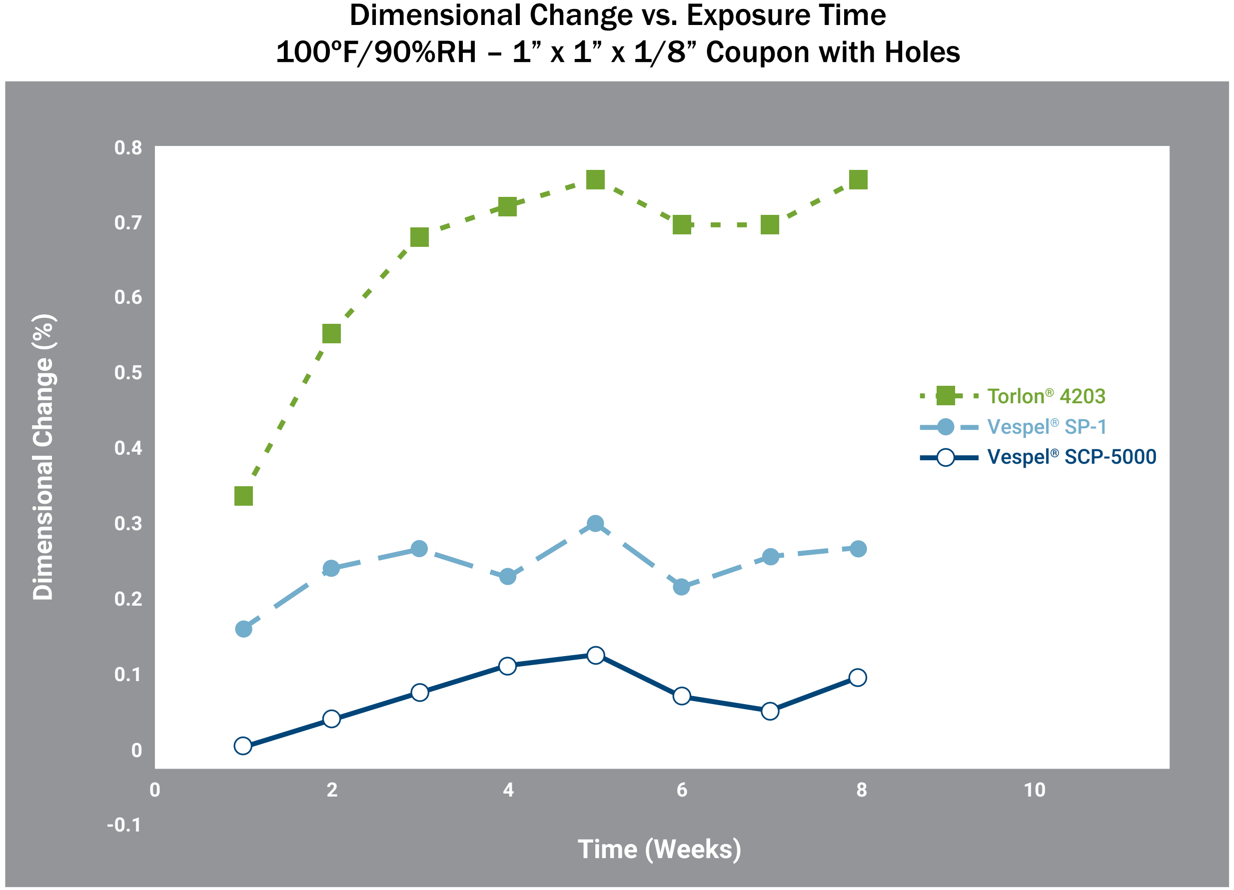
Torlon® vs. Vespel® for Precision Sockets

Moisture Sample with Holes Example Design



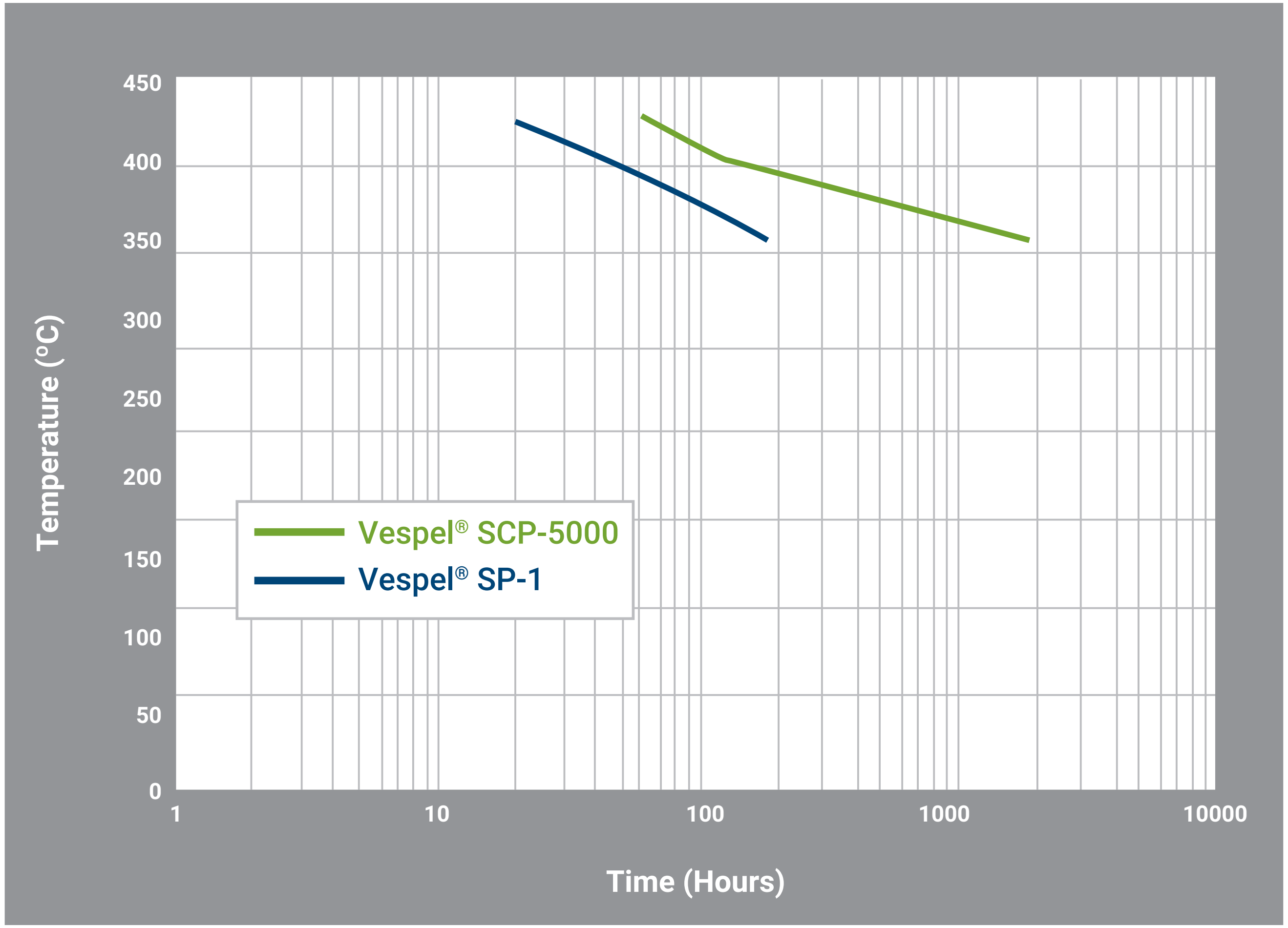
Source: *Kane, Paul, and Joy Bloom (above), BiTS Workshop. 2004 (right)*

Dimensional Change of 1" x 1" x 1/8" Coupons at 90% RH and 100 °F with Respect to Time



Vespel® SP vs. Vespel® SCP Thermal Stability

Time to 50% Reduction in Tensile Strength of Vespel® Materials Due to Heat Aging



Source: Dupont™ Vespel® Parts & Shapes: SCP-5000 Technical Bulletin

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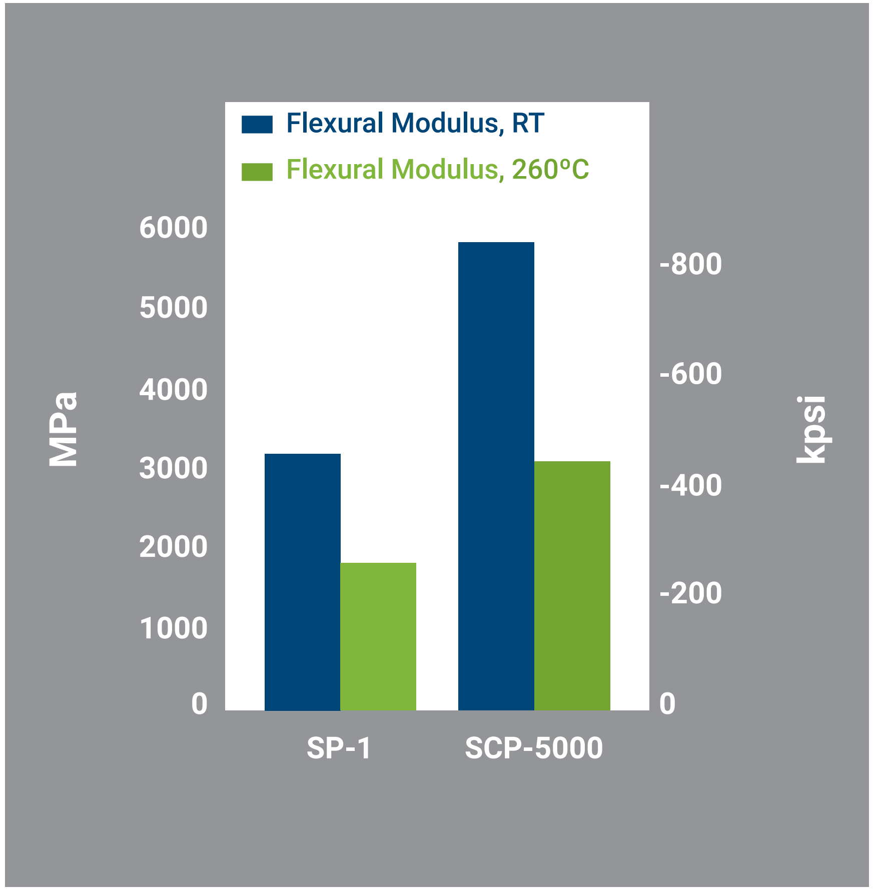
Vespel® SCP-5000 Offers Increased Strength / Stiffness



Source: Adapted from Dupont™ Vespel® SCP Shapes Family of Products

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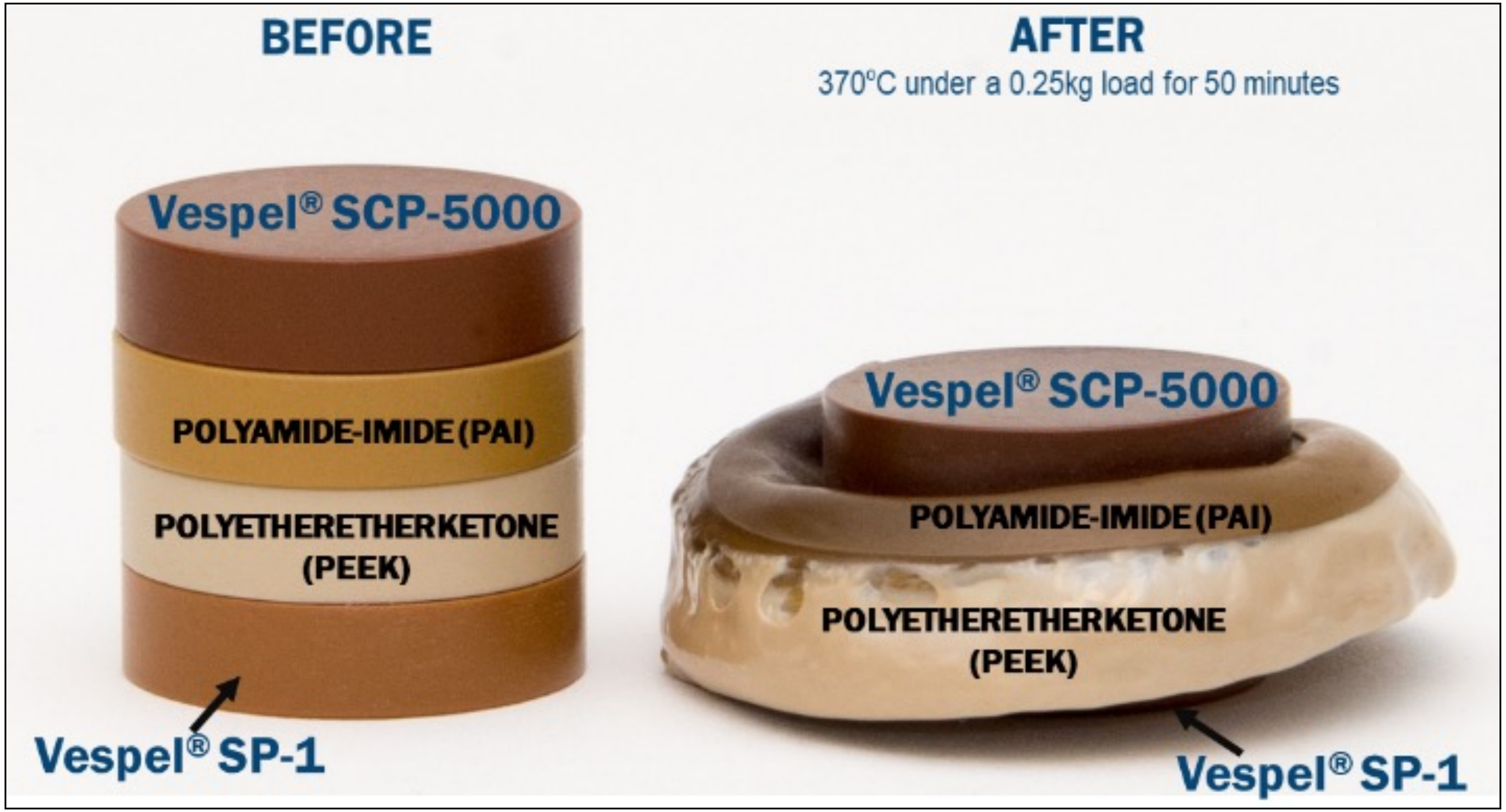
Conclusion: Higher-Priced Materials Can Reduce Costs



Source: Dupont™ Vespel® High Performance Parts - Taking the Heat Video

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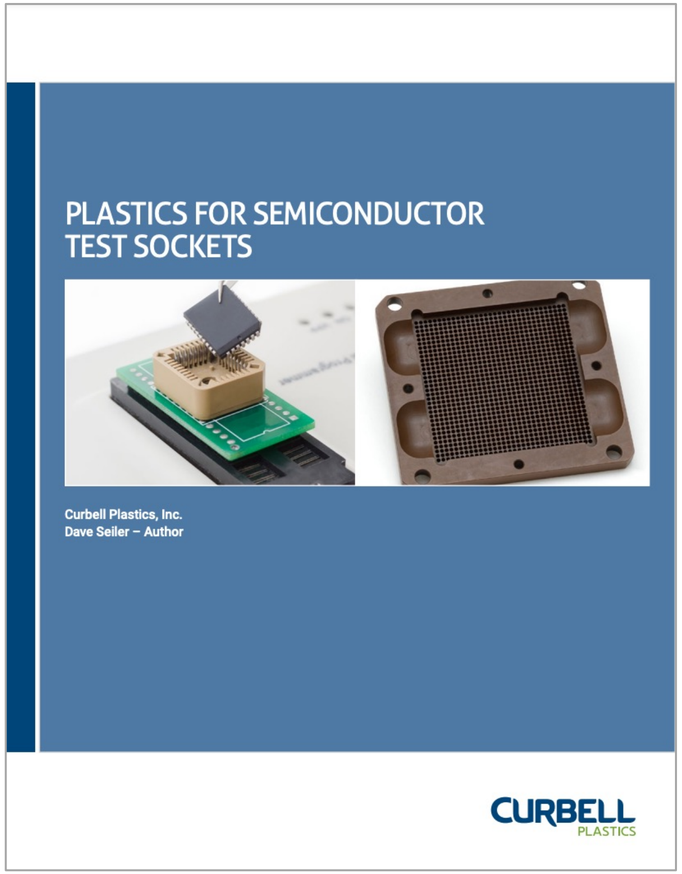
Test Socket Application White Paper

For information about plastic materials for today's test socket applications, read our white paper:

Plastics for Semiconductor Test Sockets



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Thank You for Your Time Today! Questions?

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- Access the **Ask a Plastics Expert** form on curbellplastics.com for help with your applications
- **Call Curbell Plastics at: 888-287-2355**

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References

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