ARCHIVE 2006

Session 1

Advanced Socket Materials

"Carbon Nanotube Polymer Composites For Socket Applications"
Mark Hyman, Tim Jozokos, Heidi Sardinha, Yuanheng Zhang
Hyperion Catalysis International, Inc.

"PEEK-based Solutions For Test Socket Applications"
John Walling, Sam Brahmbhatt — Victrex USA, Inc.

"Para-phenylene Rigid Rod Polymers And Their Unique Attributes For Burn-in And Test Sockets"
Lorenzo P. DiSano — Ensinger Industries, Inc.

Carbon Nanotube Polymer Composites for Socket Applications

2006 Burn-in & Test Socket Workshop
March 12 - 15, 2006

Mark Hyman, Tim Jozokos,
Yuanheng Zhang, Heidi Sardinha
Hyperion Catalysis International, Inc.

Introduction

- Electrostatic Discharge (ESD) Concern
- Carbon Nanotube Polymer Composites
- Requirements for Socket Applications
- Composite SEM Comparison
- Discussion
- Follow-up Work

Electrostatic Discharge Concern

- Increasing susceptibility of semiconductor devices
  - Smaller silicon features
  - Less on-chip ESD protection
- Machine Model (MM)
- Charged Device Model (CDM)

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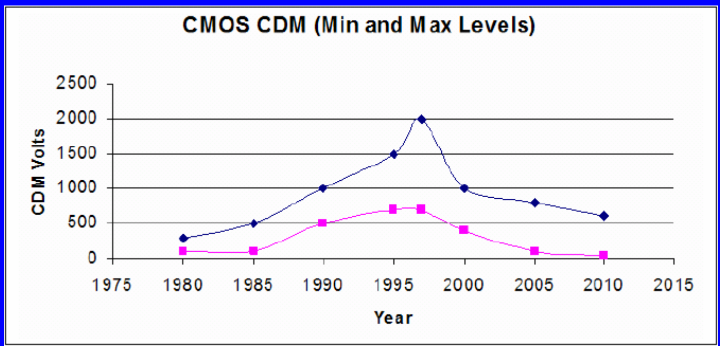
Charged Device Model Sensitivity



Source: Electrostatic Discharge Association, "Electrostatic Discharge Technology Roadmap", 2005

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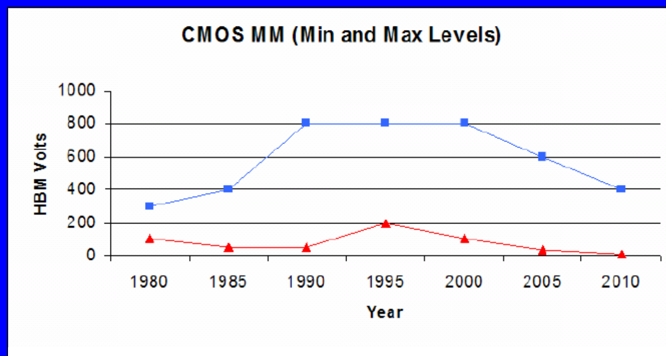
Machine Model Sensitivity



Source: Electrostatic Discharge Association, "Electrostatic Discharge Technology Roadmap", 2005

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ESD in Sockets

- ESD is managed throughout the device manufacturing process
- ESD management will have to extend to the burn-in and test arena
- Socket materials have traditionally been insulators
- Are socket performance and ESD management in conflict?

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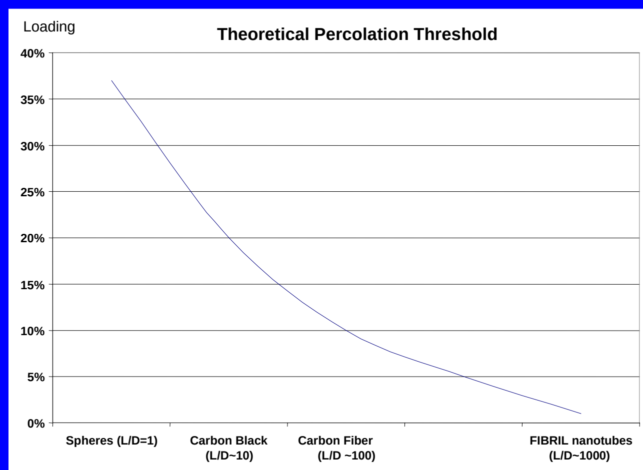
Conductive Fillers

Filler Loading vs. Aspect Ratio



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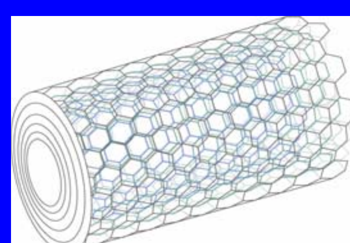
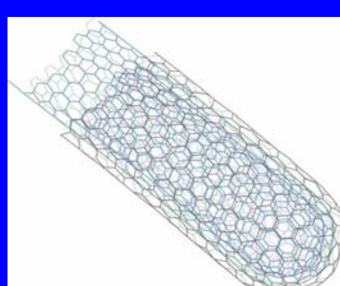
Structure of a FIBRIL Nanotube

- Graphitic wall structure
- Multilayer
- Hollow





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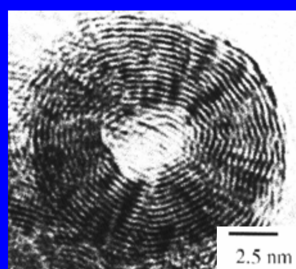
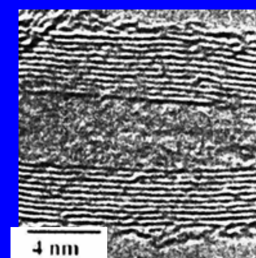
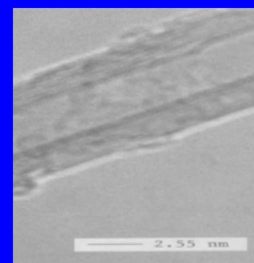
Carbon Nanotubes

- Diameter: 10 nanometers
- Length: 10,000 nanometers
- Aspect Ratio: L/D = 1000







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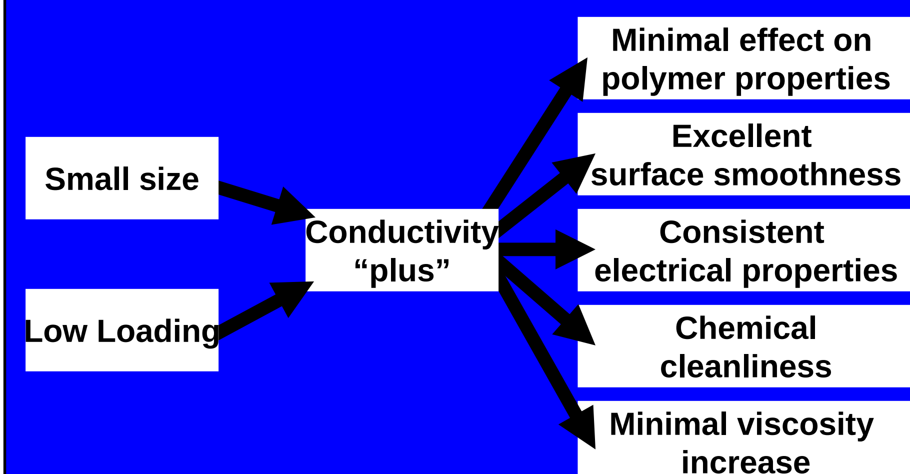
Unique Product Performance



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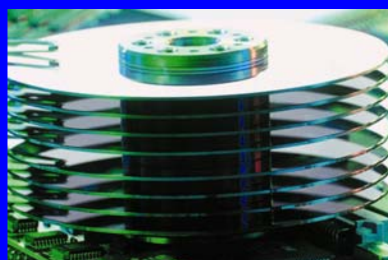
Commercially Successful

Hard Disk Drive

Semiconductor



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Requirements for Sockets
(some of them)

- Static dissipative
- Maintain sufficient electrical isolation between conductors
- Minimize crosstalk / leakage
- Processability
  - Injection molding
  - Machining

<u>While device pitch gets smaller</u>

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Samples

Commercially Available Stock Shapes

	Vr (ohm-cm)	Sr (ohm/sq.)
• PEI - Carbon Fiber	10^1	10^1
• PEI - Carbon Nanotubes	10^2	10^2
• PEEK - Carbon Fiber	10^7	10^7
• PEEK - Carbon Nanotubes	10^1	10^3
• PEEK - CNT and CF for comparison		

SEM of fractured surfaces

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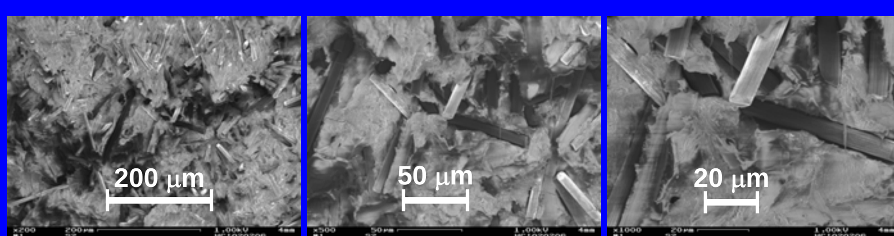
PEI with Carbon Fiber



x 200 x 500 x 1,000

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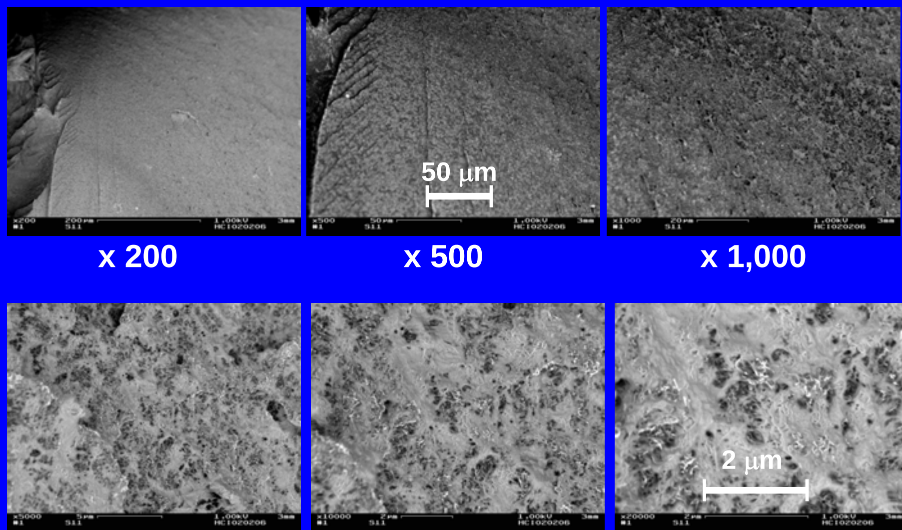
PEI with Carbon Nanotubes



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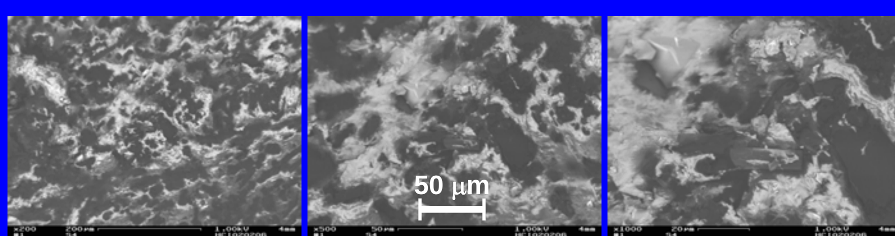
PEEK with Carbon Fiber



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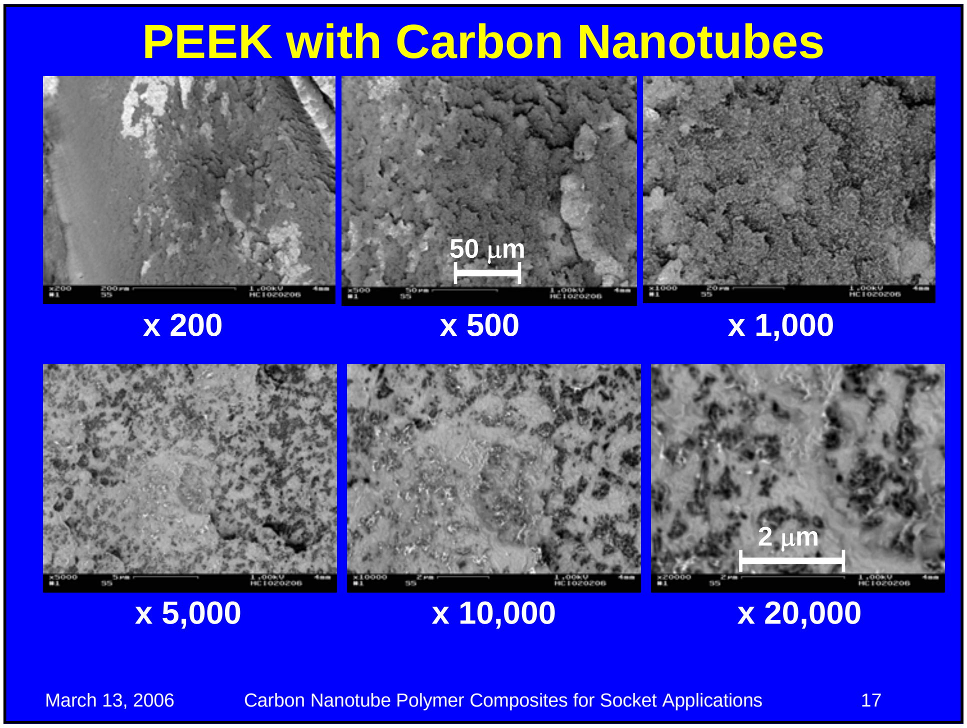
PEEK with Carbon Nanotubes
50 µm
x 200
x 500
x 1,000
2 µm
x 5,000
x 10,000
x 20,000
March 13, 2006
Carbon Nanotube Polymer Composites for Socket Applications
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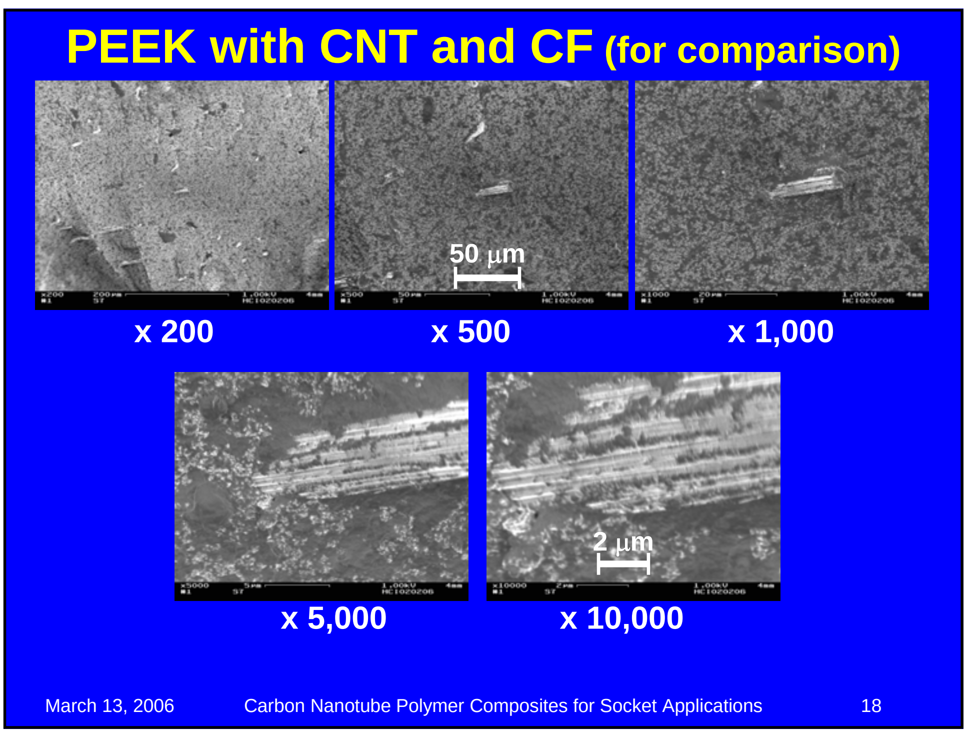
PEEK with CNT and CF (for comparison)
50 µm
x 200
x 500
x 1,000
2 µm
x 5,000
x 10,000
March 13, 2006
Carbon Nanotube Polymer Composites for Socket Applications
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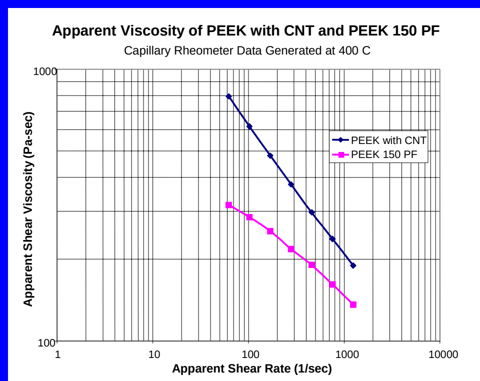
Processing – Ease of Molding



CNT-PEEK compound processes very much like unfilled PEEK at injection molding shear rates

Carbon Fiber

Carbon Black

Carbon Nanotubes

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Discussion

- **Resistivity is traditionally measured with macro-scale probes**
- **What happens when socket features approach the dimension of the carbon fiber filler?**
  - **Thinner walls separating socket holes**
  - **Carbon fiber directly conducting through wall thickness more likely**
  - **Signal cross-talk / leakage more likely**

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Discussion

- Injection molding aggravates electrical problems caused by carbon fiber
- ESD management is no longer optional
- Socket performance cannot be sacrificed

Carbon nanotubes provide an appropriately scaled microstructure for static dissipative sockets

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Follow Up Work

- Characterize electrical properties in fine pitch features
- Investigate injection molding effects on electrical uniformity
- Evaluate performance of finished sockets

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PEEK-based Solutions for Test Socket Applications

MADE WITH VICTREX PEEK POLYMER

Sam Brahmbhatt
John Walling
Victrex USA Inc.

BiTS Conference
March 2006

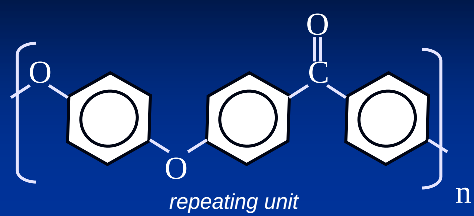
1

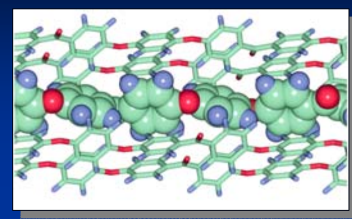
Today's Discussion…

- What is VICTREX® PEEK™?
- PEEK in the Semiconductor Industry
  - Examples of Front-end applications
  - Examples of Back-end applications
- Why is VICTREX PEEK specified?
  - PEEK performance
- BiTS application requirements
  - PEEK grades for BiTS applications
  - Case studies
  - Added value services

2

What is PEEK?





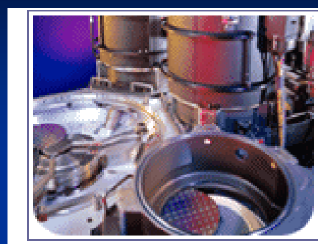
- Semi-crystalline polymer capable of withstanding extreme environments
- Readily modified with various filler technologies to enhance performance. i.e., carbon fiber, glass, ceramics, etc…
- Widely considered to be the highest performance, melt processable polymer

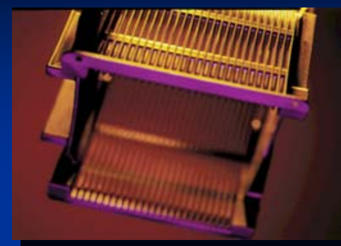
3

PEEK offers proven performance in the semiconductor industry

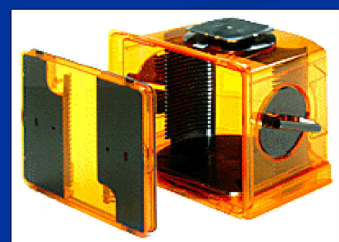
4

PEEK applications (front-end)


Etch Components


Wafer and Disk Carriers

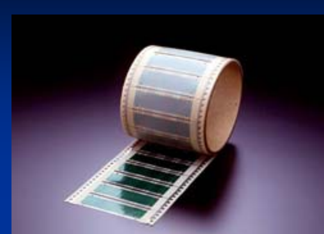

CMP Retaining Rings

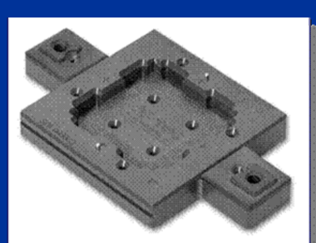

Silicon Wafer Pods

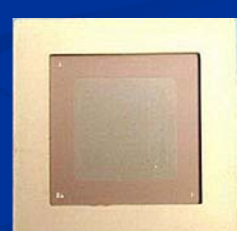
5

PEEK applications (back-end)


High Temperature Matrix Trays


Flexible Circuit Substrates


Test Sockets


Test Socket Alignment Plates

6

Why is PEEK specified?

7

PEEK performance

- **Machines to very tight tolerances**
  - Deburring easier with filled grades
- **Low moisture absorption**

PEEK	0.5%
PAI	4.4%
PI	2.0%

(at saturation)

- **Heat resistance exceeding 260˚C**
  - Withstands lead-free solder reflow process

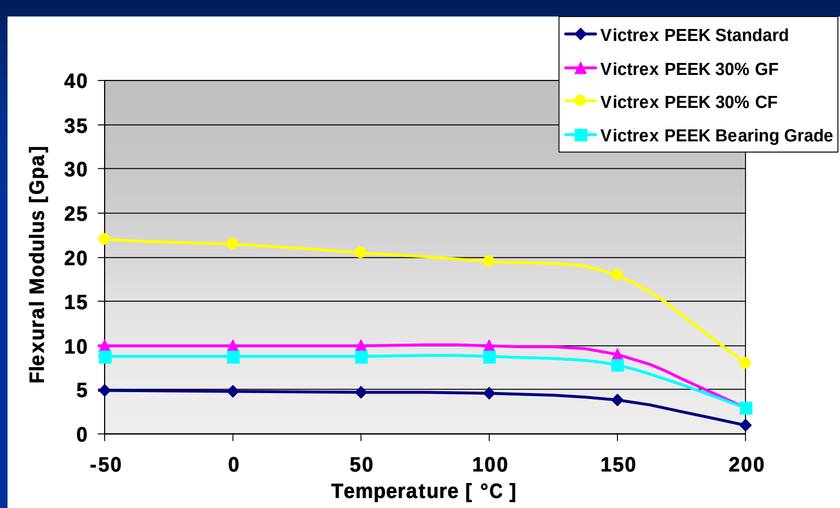
8

PEEK performance

- **Chemical resistance pH 2-14**
  - Insoluble in most common semiconductor chemicals
- **Excellent mechanical properties**
  - Stronger and stiffer thin-wall cross-sections
- **Outstanding wear resistance**
  - Longer life in aggressive environment

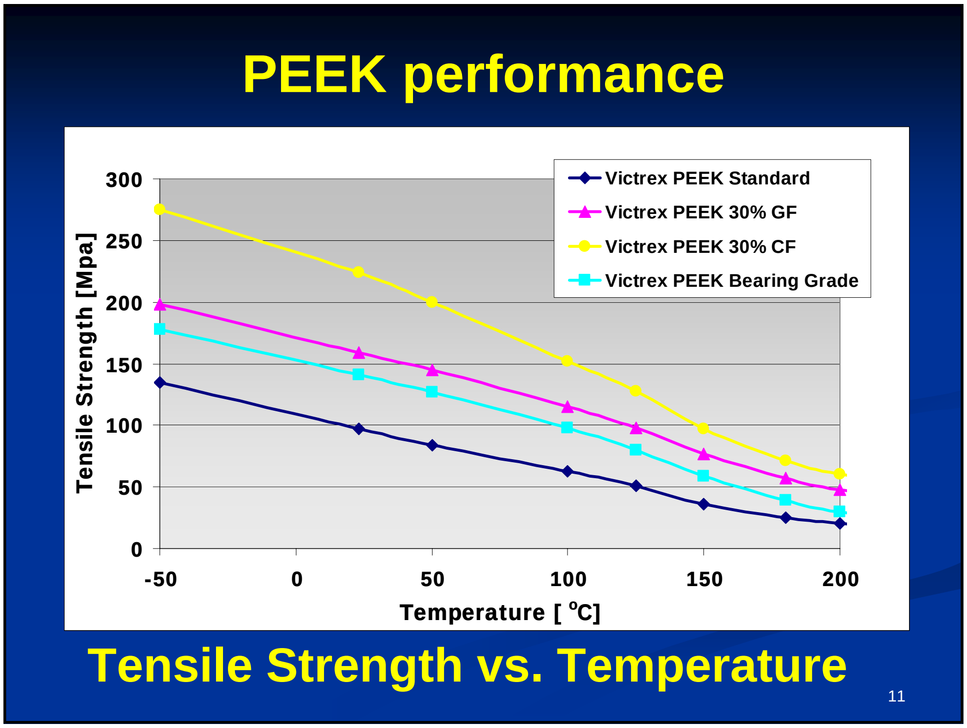
9

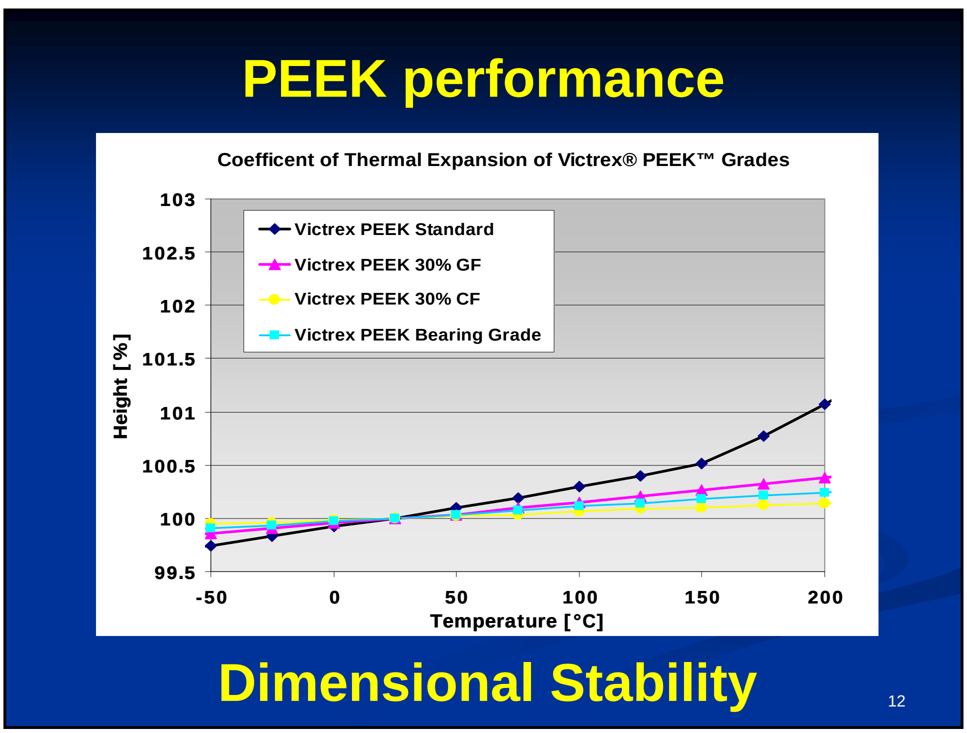
PEEK performance



Flexural Modulus vs. Temperature

10


PEEK performance
Victrex PEEK Standard
Victrex PEEK 30% GF
Victrex PEEK 30% CF
Victrex PEEK Bearing Grade
Tensile Strength [Mpa]
300
250
200
150
100
50
0
-50
0
50
100
150
200
Temperature [°C]
Tensile Strength vs. Temperature
11

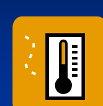

PEEK performance
Coefficent of Thermal Expansion of Victrex® PEEK™ Grades
Victrex PEEK Standard
Victrex PEEK 30% GF
Victrex PEEK 30% CF
Victrex PEEK Bearing Grade
Height [%]
103
102.5
102
101.5
101
100.5
100
99.5
-50
0
50
100
150
200
Temperature [°C]
Dimensional Stability
12

BiTS application requirements

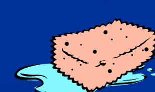
13

BiTS application requirements

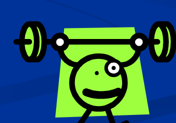
- Thermal performance
  - -55 to 155°C



- Dimensional stability
  - Low CTE, low moisture absorption



- Compression and shear strength
  - Strong and stable
  - Thin walls between holes



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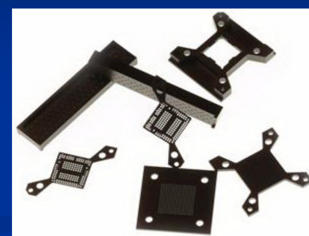
BiTS application requirements

- High wear resistance
  - Up to 100,000 pin insertions
- Processability
  - Thin-wall molding
  - Ease of machining
  - Low residual stresses
- Electrostatic dissipative
  - Does not generate static charge
  - Dissipate incoming static charge safely



15

Electrostatic Dissipative (ESD)

Surface Resistivity (Ω/sq)

Conductive Materials

Conductive
- Will not generate a static charge
- Grounds charges quickly (may damage component)
- Will shield sensitive components from electric fields

10^7

Dissipative
- Will not generate a static charge
- Will not allow a charge to remain localized on surface
- Can safely & quickly bleed electric charge to ground

10^9

Antistatic
- Low potential to generate a static charge
- Will not allow a charge to remain localized on surface
- Will slowly bleed an electric charge to ground

10^{11}

Insulative
- May generate static charge on surface
- Will allow a charge to remain localized on surface

Insulating Materials

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Product Solutions for BiTS applications

Socket Type →	Machined (stock shapes)	Molded (thick wall >2mm)	Molded (thin wall <2mm)
PEEK Base	450G	150G	90G
Conductive <E7 Ω/sq	Conductive filler	Conductive filler	Conductive filler
Dissipative E7-E9 Ω/sq	Conductive filler	Conductive filler	Conductive filler
Antistatic E9-E11 Ω/sq	Conductive filler	Conductive filler	Conductive filler
Insulative >E11 Ω/sq	Unfilled/Glass Mineral/Ceramic	Unfilled/Glass Mineral/Ceramic	Unfilled/Glass Mineral/Ceramic

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Case Study # 1

Molded test socket cover (top slide plate)

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Part description and requirements

- Flat plate with holes
- ~ 50 mm x 50 mm
- 0.8 – 1.0 mm thick
- Part was molded with PES
- ESD: SR E9-E11 ohms
- Improved fatigue and impact toughness

PEEK solution with unique material and filler technology to optimize rheological and ESD properties

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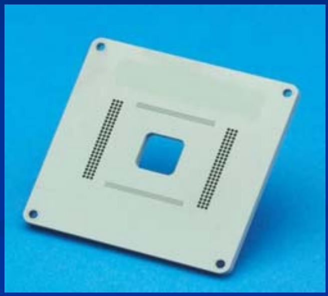
Case Study # 2

Machined test socket base plate

20

Part description and requirements

- Stock shape 3/8 in. thick with .010 in. & .030 in. holes
- Ease of machining
- Burr-free holes
- Dimensional stability
- Insertion wear resistance



PEEK solution with unique filler technology to optimize machining and dimensional stability

21

PEEK added value – Victrex

- Proven product performance – brand reliability
- Dedicated technical service support for on-site assistance
- Application development and prototype expertise
- In-depth product performance and processing data
- Machining expertise
- Global customer service network

Working hand-in-hand with channel partners and end users to reach new levels of performance and cost savings

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Para-phenylene Rigid Rod Polymers and Their Unique Attributes for Burn-in and Test Sockets

2006 Burn-in and Test Socket Workshop
March 12 - 15 2006

Lorenzo P. DiSano
Ensinger Ind. – Washington, PA USA

What are Para-phenylene Rigid Rod Polymers?

- Wholly aromatic.
- Benzene rings directly bonded to each other.
- Self Reinforcing at the molecular level.
- Isotropic
- Amorphous
- Extraordinarily hard, strong and stiff.
- Previously intractable
- Commercially available

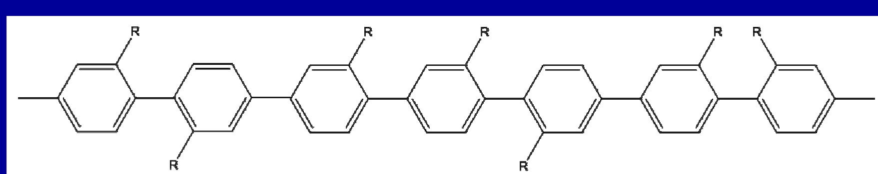
2

History of SRPs

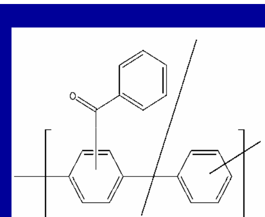
- Marvel and Vogel recognized the feasibility and potential of rigid rod polymers. (1950s)
- Under Air Force Research Laboratory sponsorship a number of chemical producers such as Dow Chemical and Hoechst Celanese validated SRPs. (1960s)
- Maxdem develops process-able SRPs. (1980s)
- Maxdem launches Mississippi Polymer Technology - MPT. (2000)
- MPT introduces Parmax® SRP, a new family of thermoplastic SRPs. (2003)
- Ensinger Industries commercializes Tecamax™ SRP compression molded and extruded shapes. (2004)
- Solvay purchases MPT and the Parmax® SRP product line. (2006)

3

Self Reinforcing Polymers (SRP) Parmax® 1200



R = Pendant Side Chain =

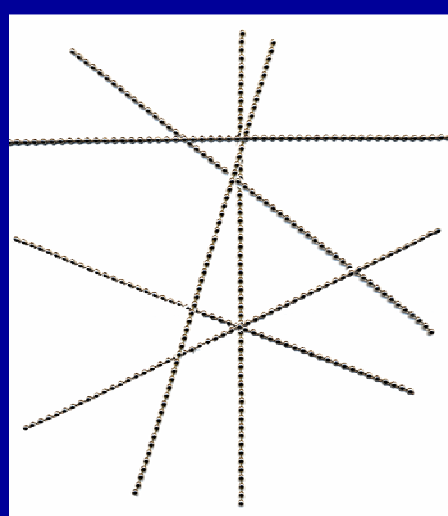


4

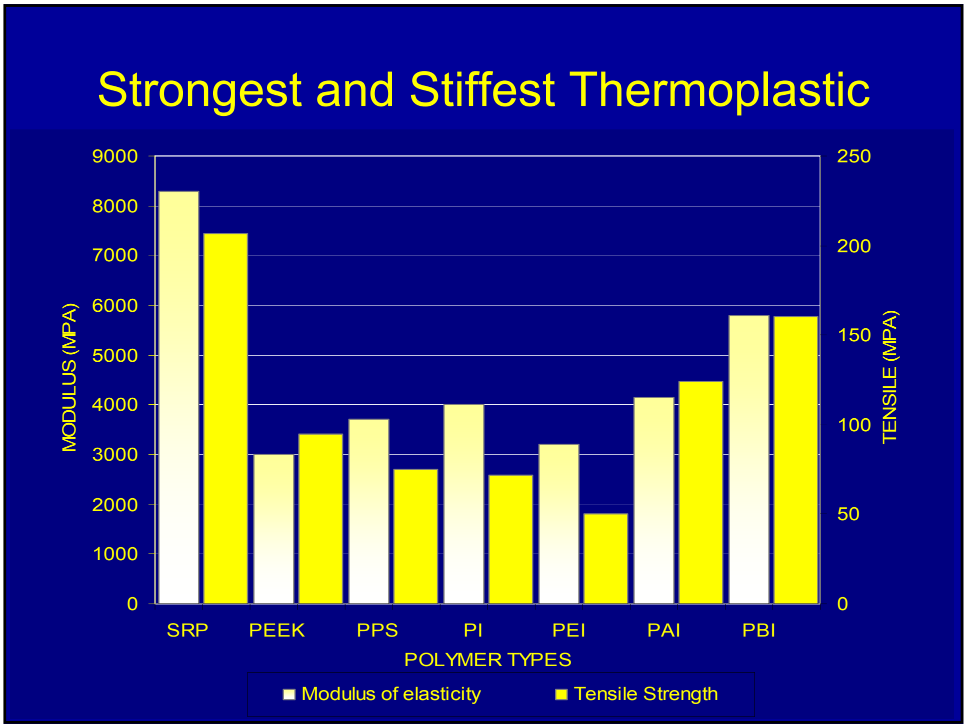
Most polymers are flexible

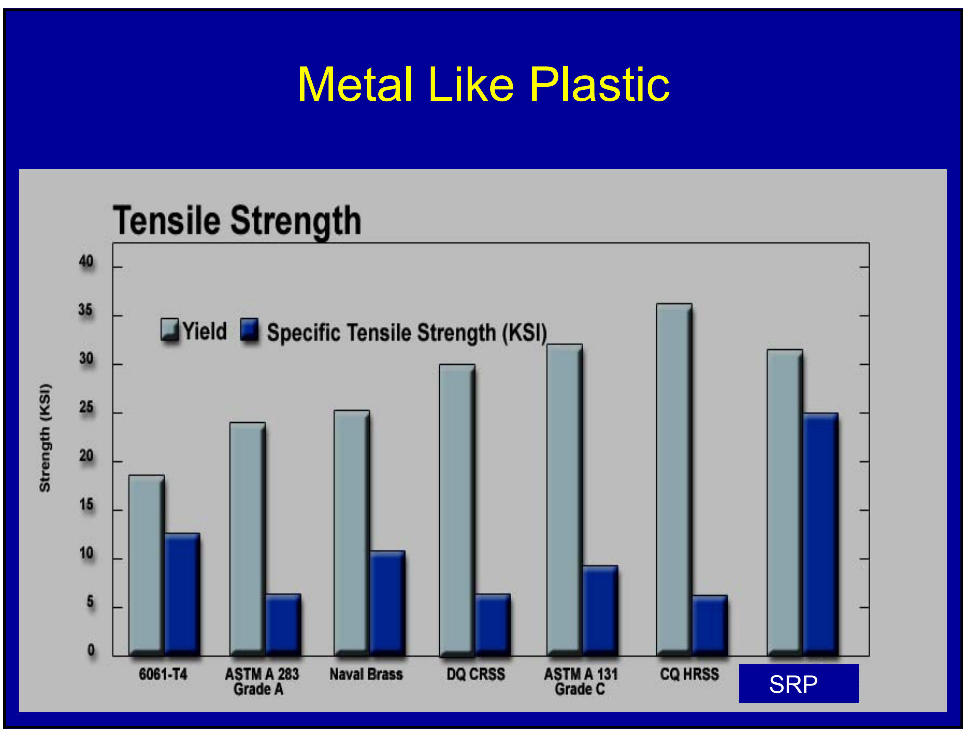
5

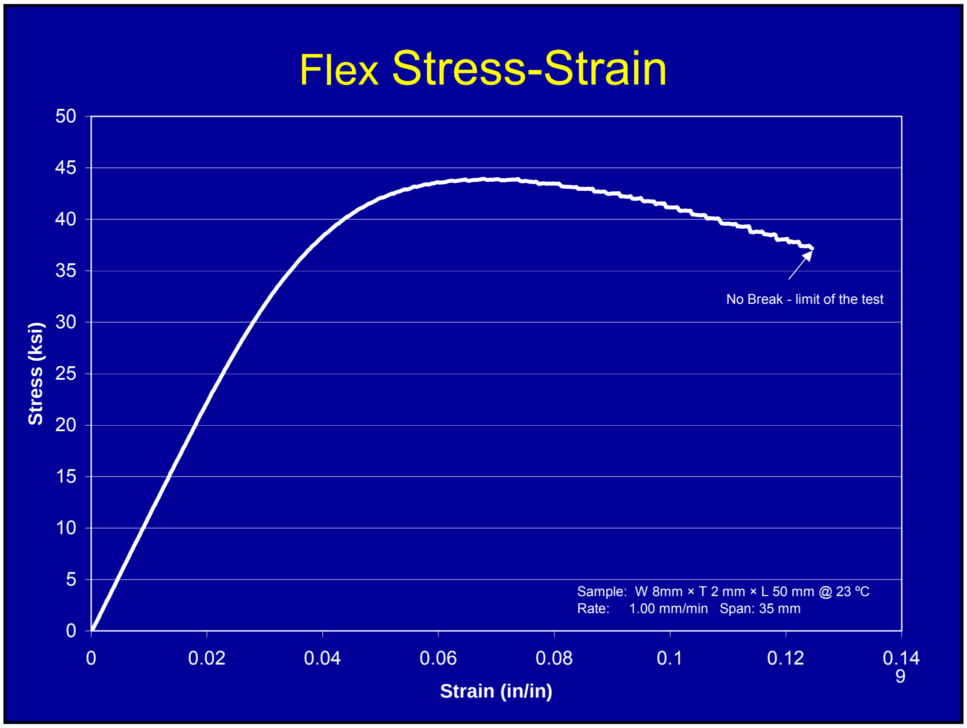
SRPs Have Rigid Chains

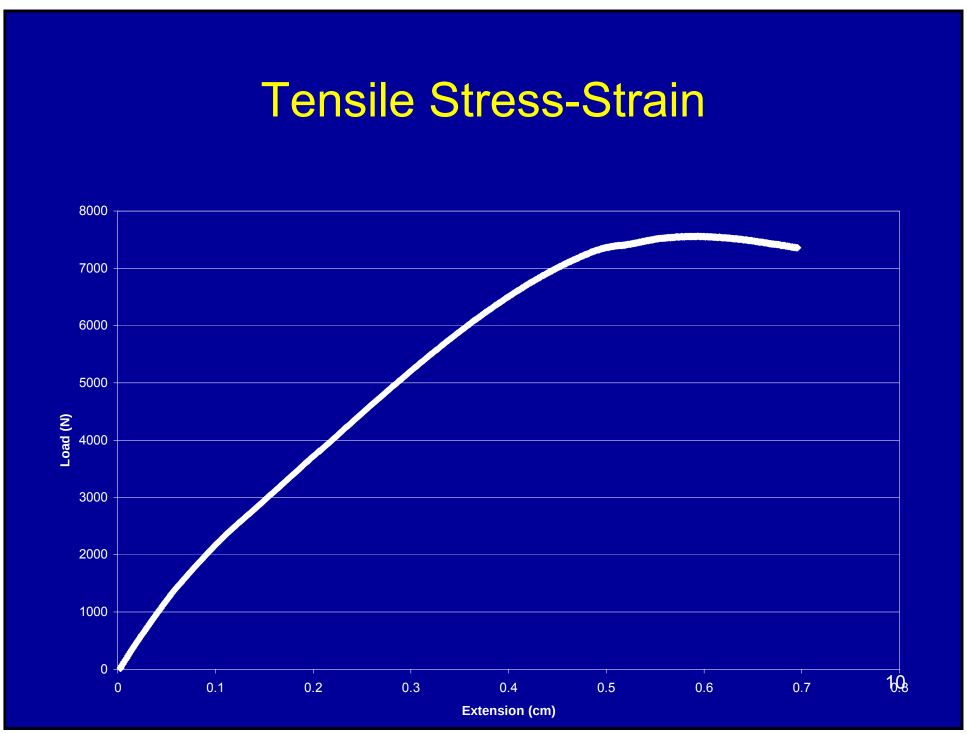


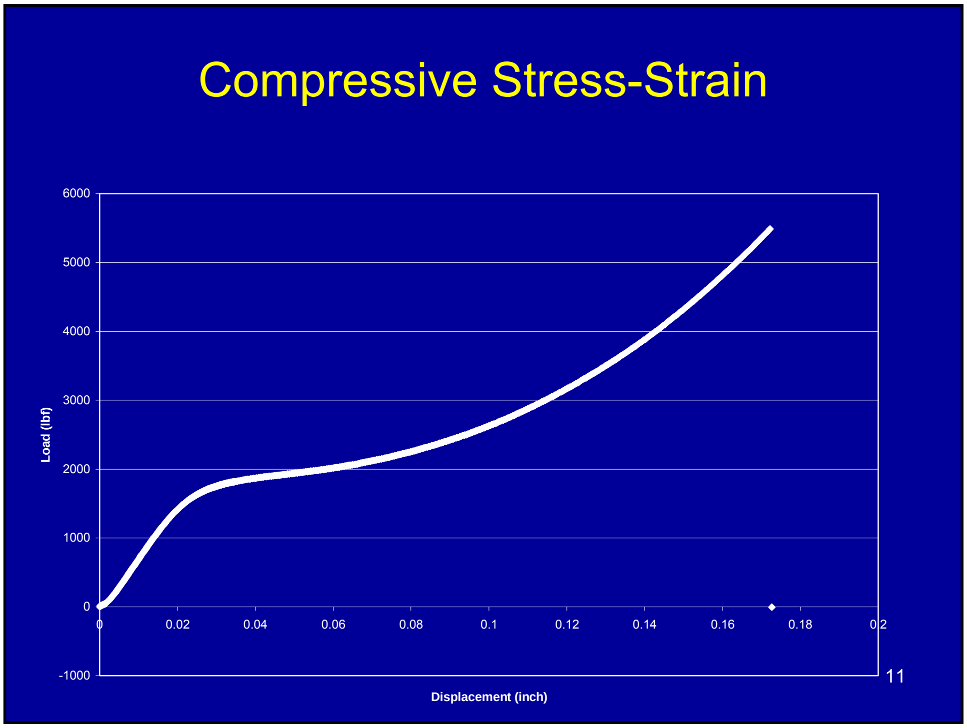
6

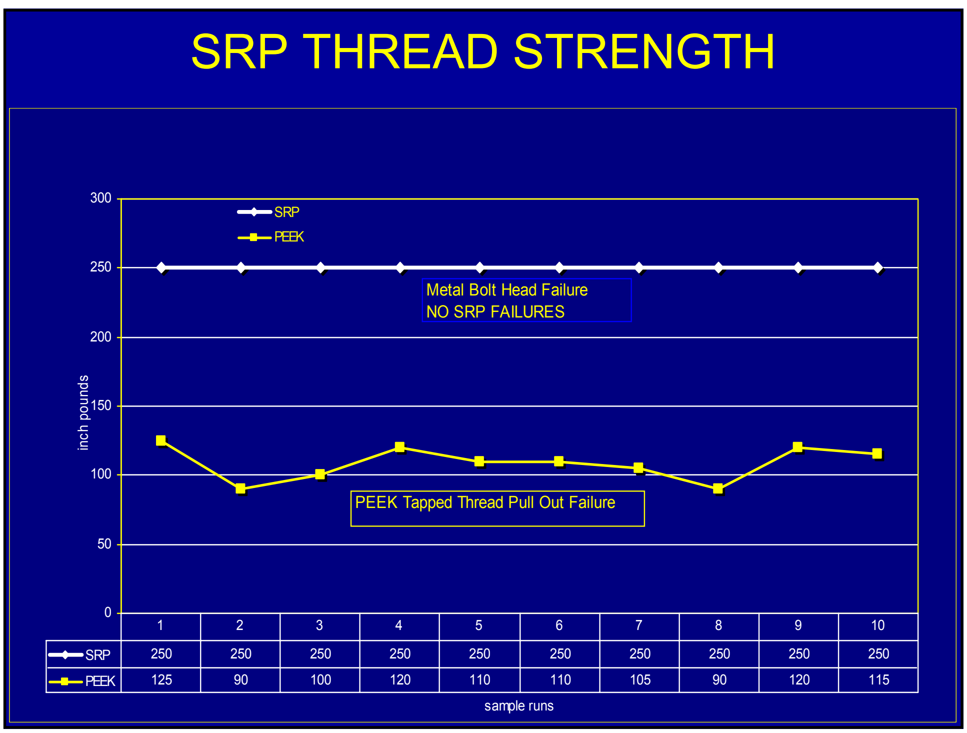

Strongest and Stiffest Thermoplastic
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
MODULUS (MPA)
250
200
150
100
50
0
TENSILE (MPA)
SRP
PEEK
PPS
PI
PEI
PAI
PBI
POLYMER TYPES
Modulus of elasticity
Tensile Strength


Metal Like Plastic
Tensile Strength
Yield
Specific Tensile Strength (KSI)
Strength (KSI)
40
35
30
25
20
15
10
5
0
6061-T4
ASTM A 283 Grade A
Naval Brass
DQ CRSS
ASTM A 131 Grade C
CQ HRSS
SRP


Flex Stress-Strain
Stress (ksi)
50
45
40
35
30
25
20
15
10
5
0
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Strain (in/in)
No Break - limit of the test
Sample: W 8mm × T 2 mm × L 50 mm @ 23 °C
Rate: 1.00 mm/min Span: 35 mm
9


Tensile Stress-Strain
Load (N)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Extension (cm)
10





	1	2	3	4	5	6	7	8	9	10
SRP	250	250	250	250	250	250	250	250	250	250
PEEK	125	90	100	120	110	110	105	90	120	115

SRP HARDNESS

	Hardness
Polycarbonate	B
Polycyclic Olefins	2H
PMMA	3H
SRP -1000	≥9H

Increasing Hardness

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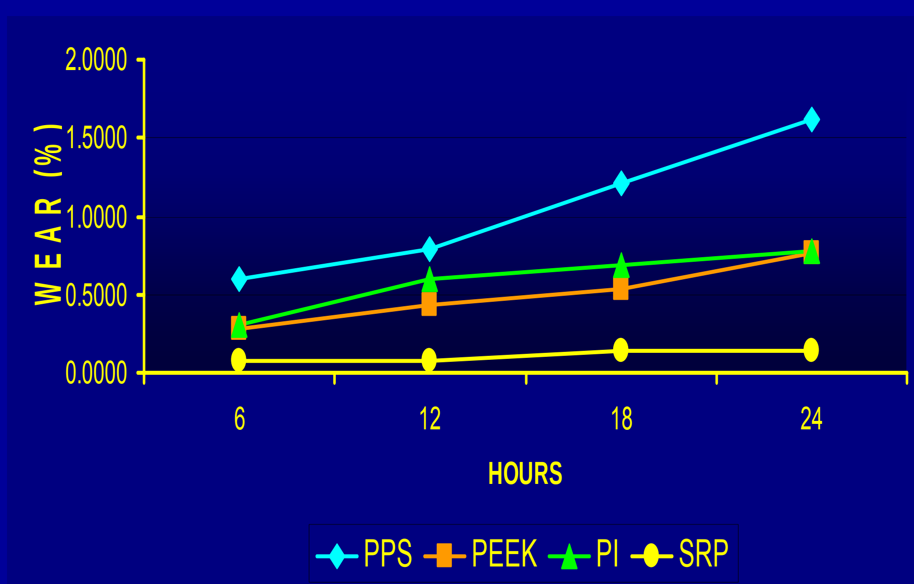
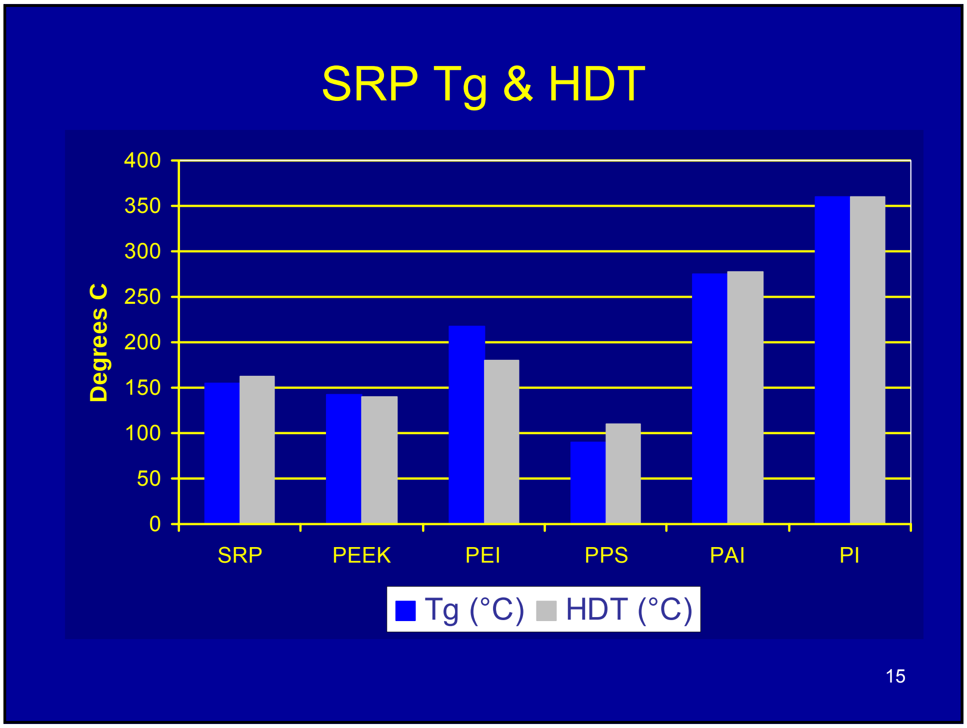
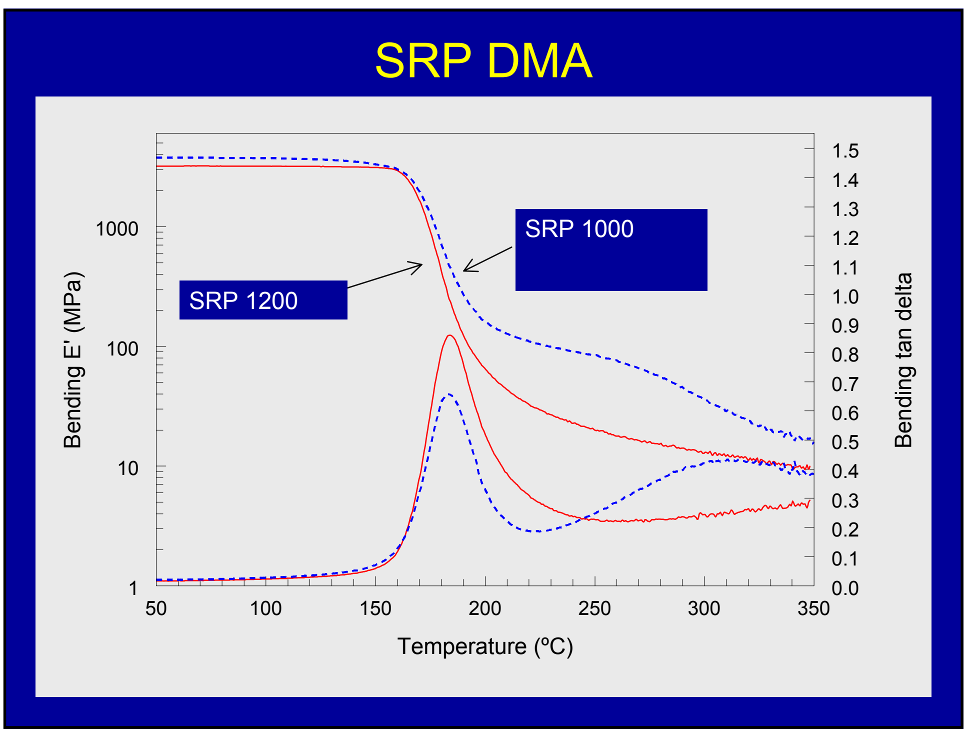
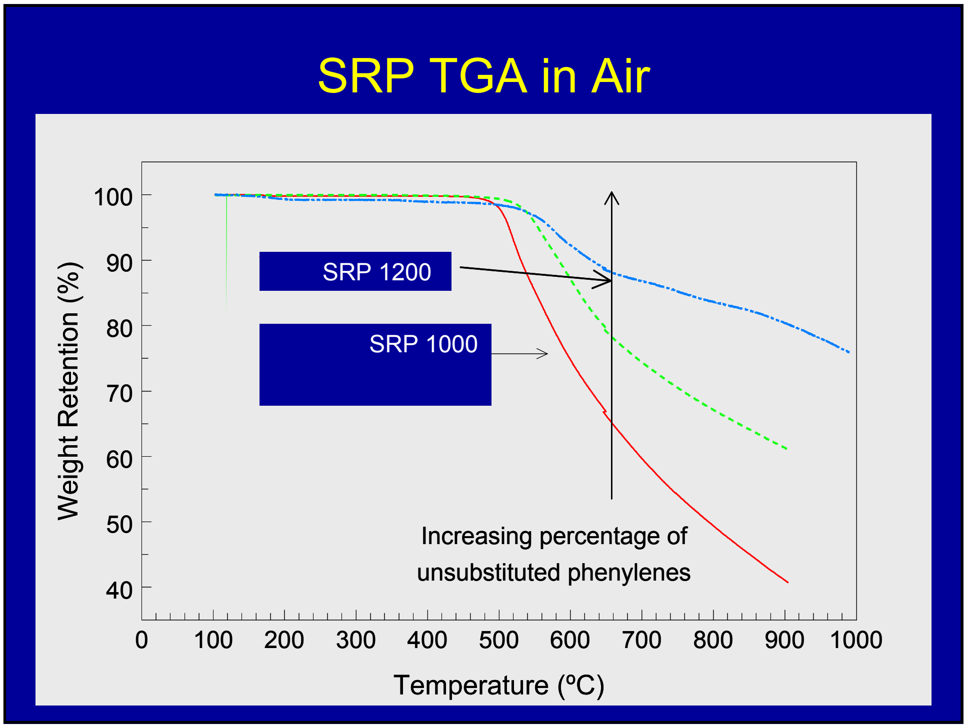
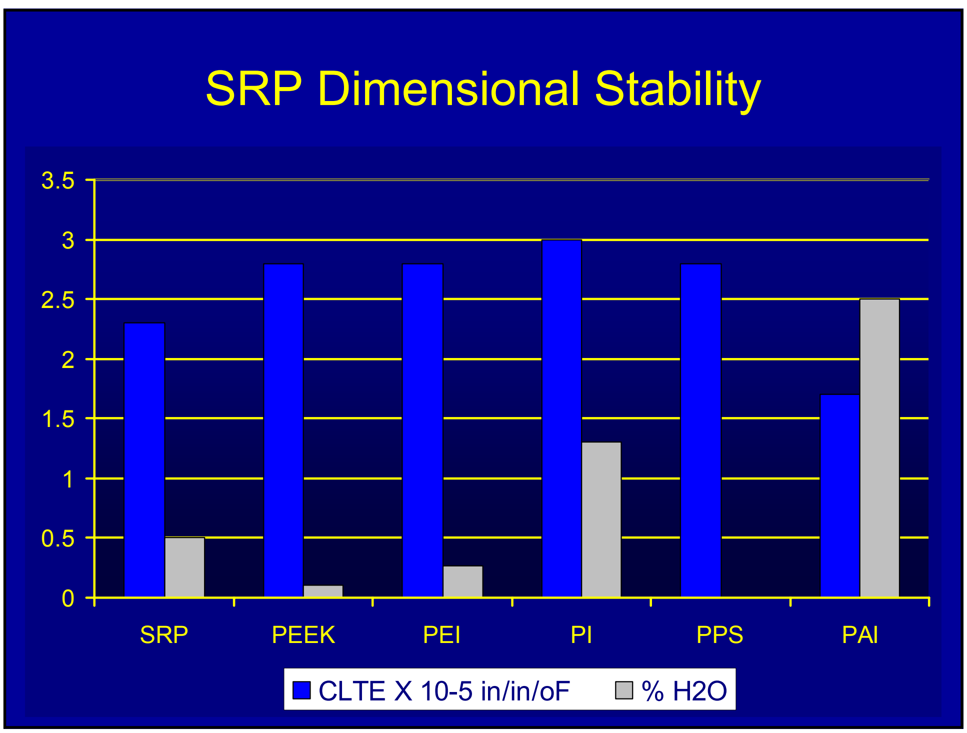
SRP Abrasion Wear Resistance




SRP Tg & HDT
Degrees C
400
350
300
250
200
150
100
50
0
SRP
PEEK
PEI
PPS
PAI
PI
Tg (°C)
HDT (°C)
15


SRP DMA
Bending E' (MPa)
1000
100
10
1
SRP 1200
SRP 1000
Bending tan delta
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
50
100
150
200
250
300
350
Temperature (ºC)


SRP TGA in Air
Weight Retention (%)
100
90
80
70
60
50
40
0
100
200
300
400
500
600
700
800
900
1000
Temperature (ºC)
SRP 1200
SRP 1000
Increasing percentage of
unsubstituted phenylenes


SRP Dimensional Stability
3.5
3
2.5
2
1.5
1
0.5
0
SRP
PEEK
PEI
PI
PPS
PAI
CLTE X 10-5 in/in/oF
% H2O

SRP Electrical Properties

- Dielectric Constant (ASTM 150) 3.1 (1MHz)
- Dielectric Strength (ASTM 149) 6.44 kV/mm
- Specific Volume Resistance (DIN IEC93) $6 \times 10^{15} \Omega$ cm
- Surface Resistance (DIN IEC 93) $2 \times 10^{16} \Omega$
- Resistance to Tracking (IEC 112) CTI 150

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SRP Machinability

- There is little evidence of internal cracking, crazing or deformation due to thermal expansion, material stress or out-gasing.
- Due to a nano rigid rod microstructure SRP mills, drills and turns like the best thermoplastics even though it has a low notched Izod impact value of 0.8 ft-lbs/in (un-notched Izod impact = 18.7 ft-lbs/in)
- Metal like hardness and isotropic behavior translates into minimal burring and little or no deformation under machining loads.

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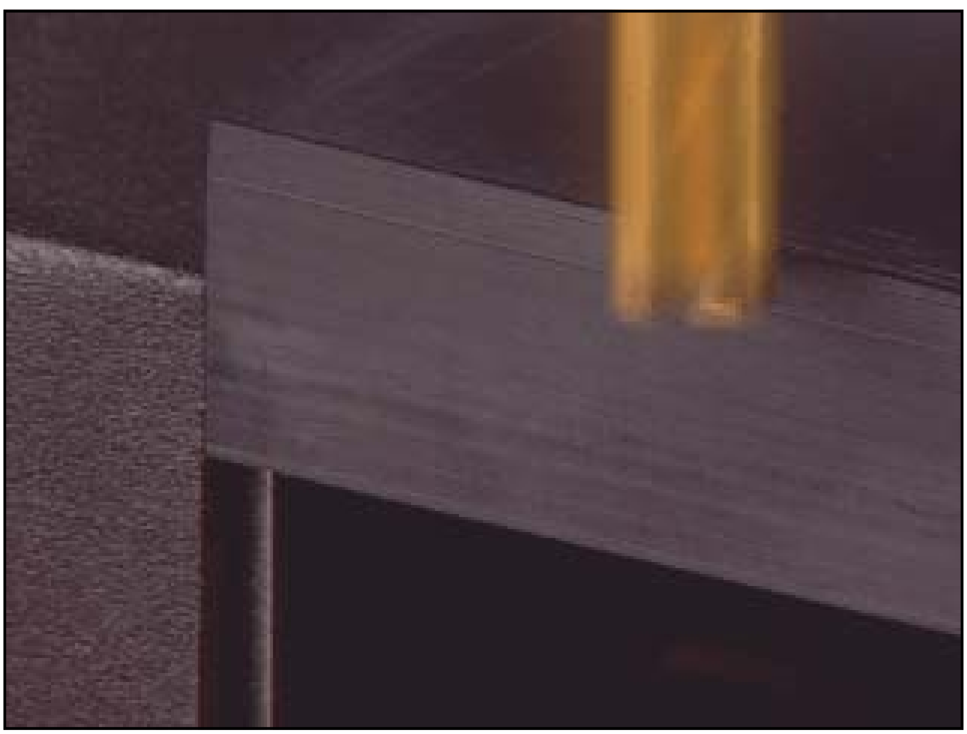

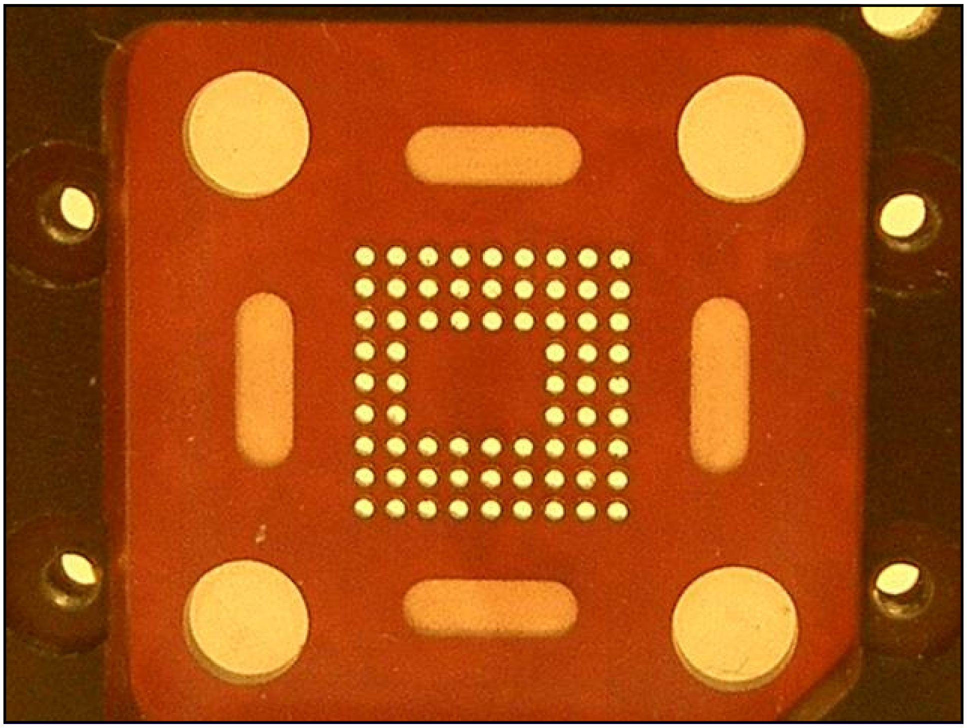

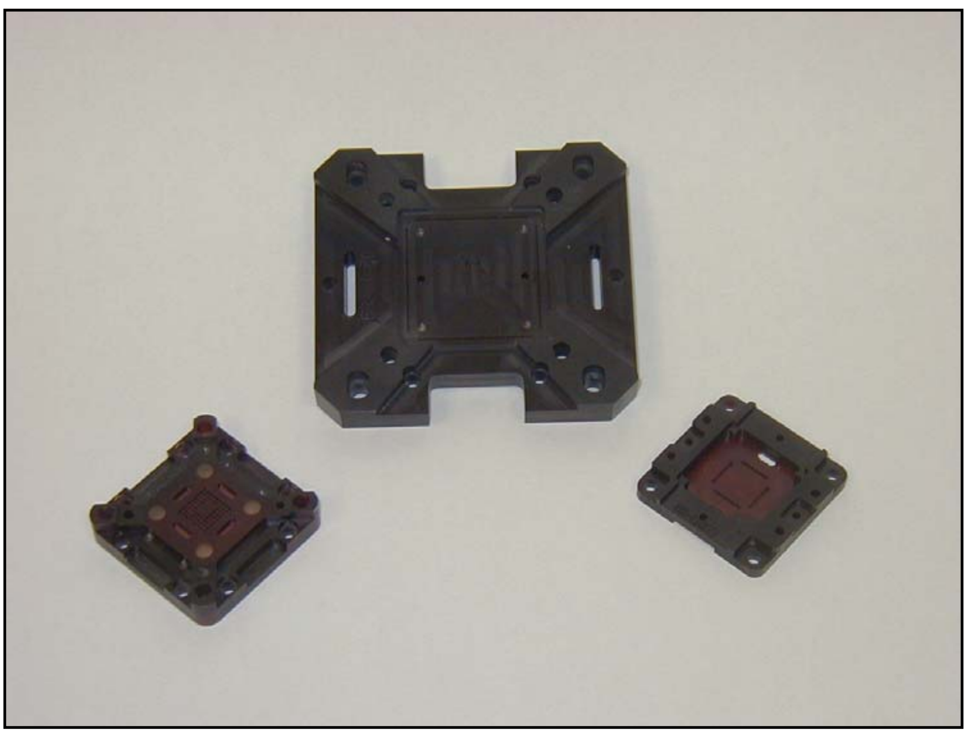

Key Attributes of SRPs for Burn-in & Test Sockets

- Excellent Machinability – Like Aluminum
- Homogenous, Amorphous & Isotropic
- High Modulus
- High Creep Resistance
- Low/Uniform CLTE
- Low Moisture Pick-Up
- Exceptional Abrasion Resistance

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