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Socket Material Characterization & Selection

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- Polymers & Composites Basic
- Key Considerations in Material Selection
- Socket Materials Comparison
- Material Selection Steps
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Material Selection: Challenge for Engineer

Many material options…

- Different categories & grades
- Reinforcement, Filling & Polyblends
- Different kinds of properties
- Different forming processing
- Different suppliers
- Efficiency & Cost…

Complicated applications…

- IC type, pin count & pitch
- WLP or End testing
- ATE, SLT or manual test
- Environment and duration time
- Electrical
- Precision & stability
- Wear, thermal concern
- Reliability
- Life

So many factors and concerns!!!

Material Selection: Challenge for Engineer

Material standard test data…

- Laboratory tests, ambient temperature / humidity
- ASTM test usually with variables fixed except the one being measured
- Not for predicting real-life results, but actually quality test for their own use

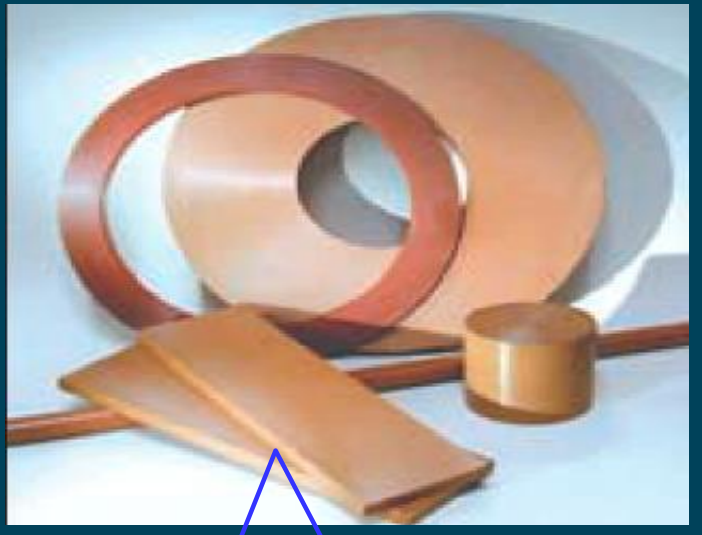
Real life application…

- Testing setting
- Combination of variables, temperature, varying loads, changing outside environments
- Creep and stress relaxation
- Interaction of different factors

Comparing the results of published specifications is not sufficient!

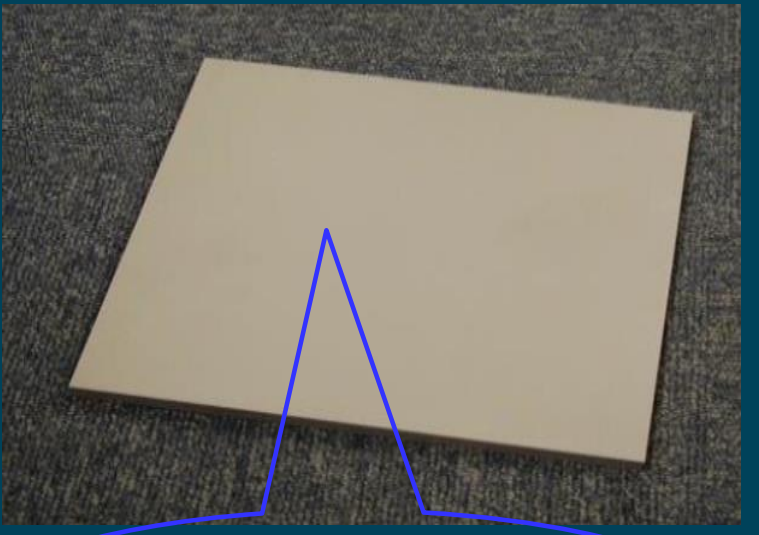
Material Selection: Challenge for Engineer

End-user's expectation



Customer: I want this…

Engineer's recommendation



Socket engineer: This one would be better…

Polymers & Composites Basic

- **Plastics - "Polymers"**

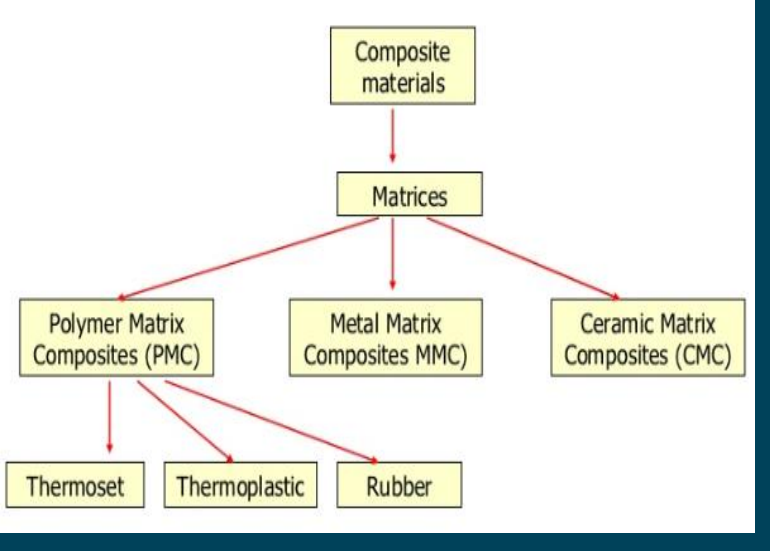
Poly (many) *Mer* (Unit):
A large molecule made up of one or more repeating units(mers) linked together by covalent chemical bonds.

- **Composites**

Polymer matrix, PMC / FRP
Ceramic matrix, CMC
Metal matrix, MMC

- **Metals,** *IM*
- **Ceramics**

Photoveel II, & "-S"



Polymers & Composites Basic

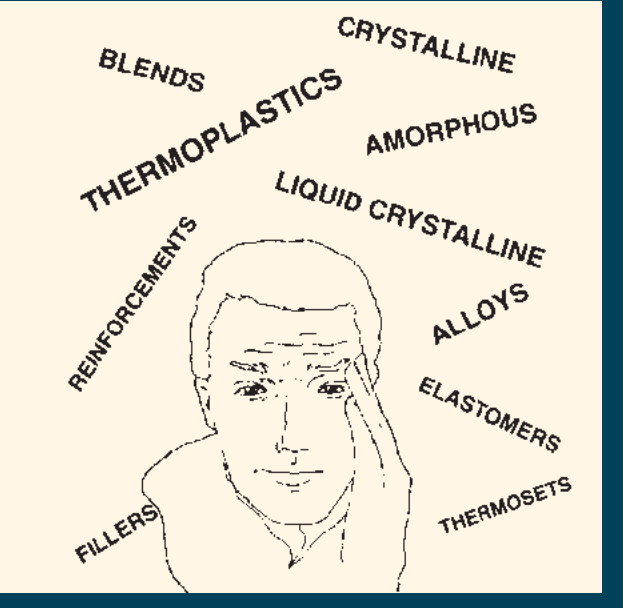
Plastics - "Polymers" classification: *extensive and confusing…*

- **Broad category**

  Thermoplastics & Thermosets
- **By Structure**

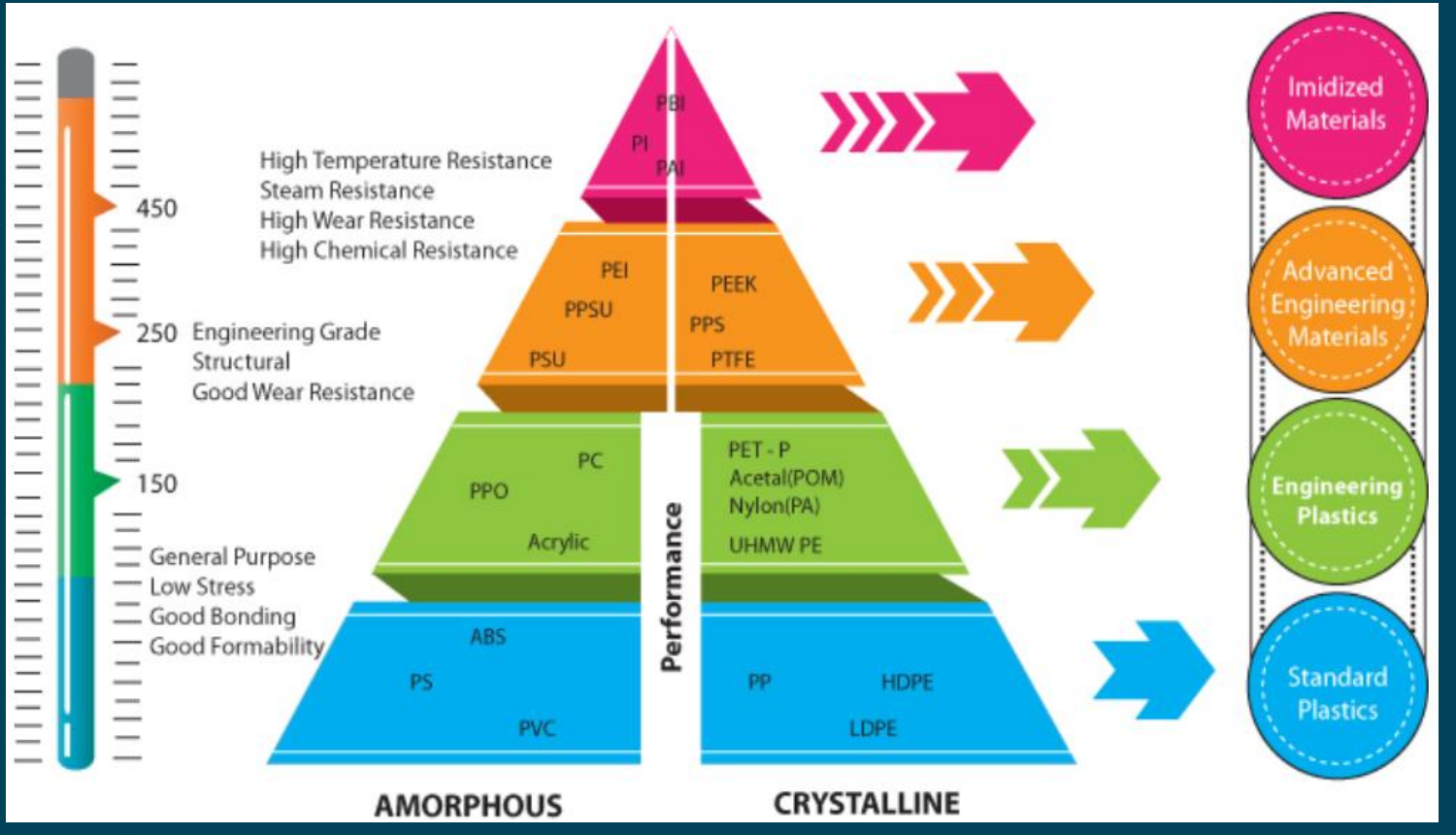
  Crystalline, amorphous & liquid crystalline
- **Others**

  Copolymers, alloys, elastomers



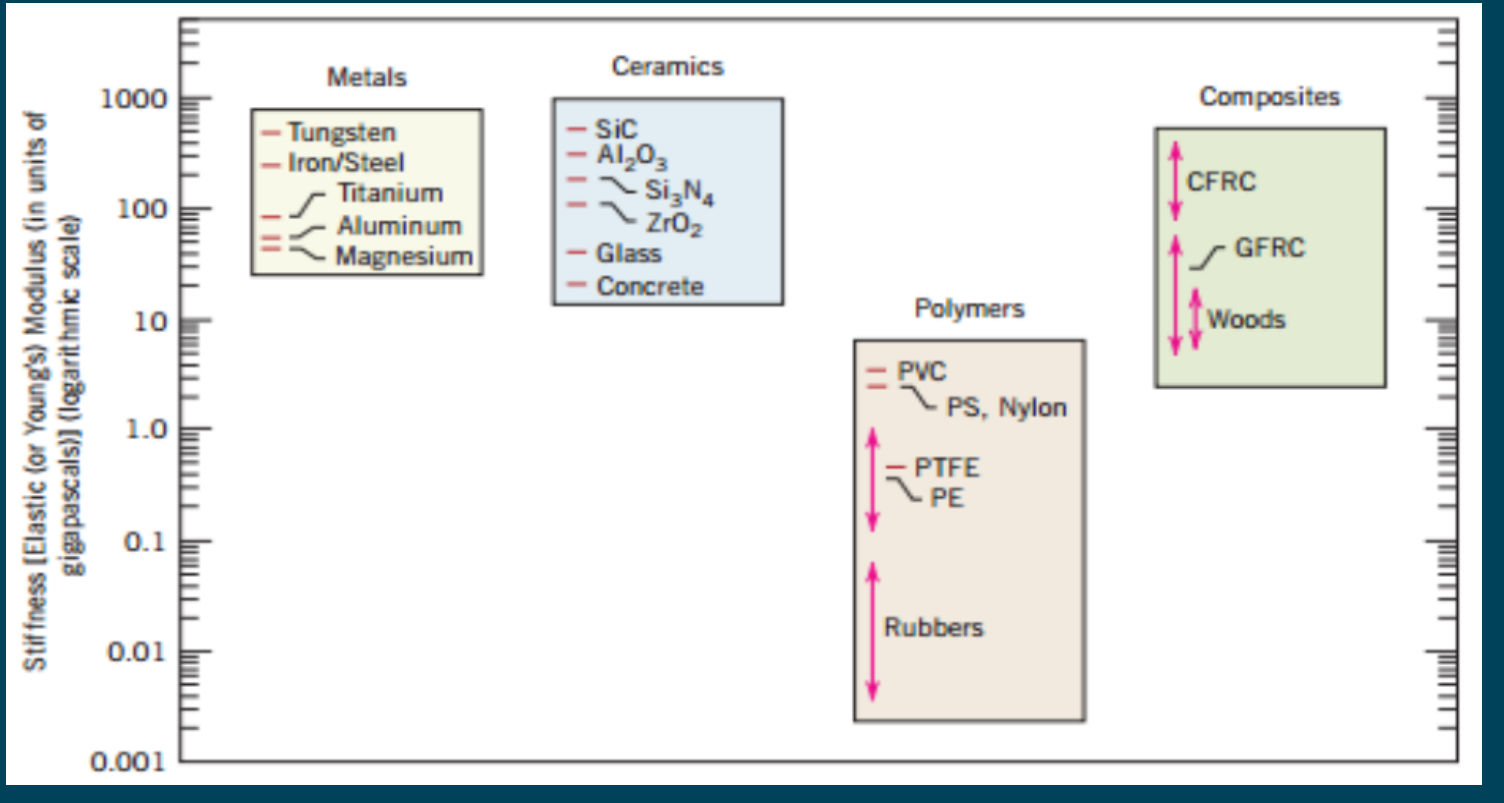
Polymers & Composites Basic

"Polymers" performance pyramid



Polymers & Composites Basic

Why Composites?



Composites with higher strength & stiffness than Polymers

Polymers & Composites Basic

- **Common Matrix for PMC / FRP**

Peek Polyetheretherketone
Ultem Polyetherimide (PEI)
Torlon Polyamide-imide (PAI)
Vespel Polyimide based (PI)

- **Additives, Reinforcements and Fillers**

  - *Physical properties modified*
  - *Mechanical Properties increased*

Fillers	Reinforcing Fibers	Other Additives
Glass Spheres	Glass Fibers	UV Stabilizers
Carbon Black	Carbon Fibers	Plasticizers
Metal Powders	Aramid Fibers	Lubricants
Silica Sand	Jute	Colorants
Wood Flour	Nylon Fibers	Flame Retardants
Ceramic Powders	Polyester Fibers	Antioxicants
Mica Flakes		Antistatics
Molybdenum Disulfide		Preservatives
		Processing Aids
		Fungicides
		Smoke Supressants
		Foaming Agents
		Viscosity Modifiers
		Impact Modifiers

Polymers & Composites Basic

Category		Peek	Ultem	Torlon	Vespel
Chemical name		Polyetheretherketone	Polyetherimide	Polyamide-imide	Polyimide based
Abbreviation		Peek	PEI	PAI	PI
中文译名		聚醚醚酮	聚醚酰亚胺	聚酰胺酰亚胺	聚酰亚胺
Characteristic		Semi-crystalline, organic, thermoplastic	Amorphous, thermoplastic	Amorphous, thermoplastic/thermosetting	Ring-shaped molecular, containing Nitrogen
Additives, Reinforcements and Fillers	Unfilled	Tecapeek	Ultem 1000	4203	SP1, SCP5000
	Glass Fiber	Peek GF20, Peek GF30	Utlem 2300	5030,5530 (30%)	N/A
	Carbon Fiber	Peek CF30	12%, 30%	7130 (30%)	N/A
	Carbon Nano Tube	Nano ESD PEEK; EKH-SS11	ESD ULTEM	Semitron ESD 520HR	N/A
	PTFE	Peek TF20, Peek TF15	Ultem 4000 (CF, Graphite)	4301,4501	SP-211 (with Graphite)
	Ceramic	Tecapeek CMF, EPM-2204U-W	N/A	N/A	N/A
	Graphite	N/A	Ultem 4000 (CF, PTFE)	4301, 4501	15% SP-21; 40% SP-22; SCP5009
	Others	***Peek Rigid***	N/A	N/A	SP3

Key Considerations in Material Selection

- Material Strength
- Dimensional Stability
- Wear Resistance
- Thermal Properties
- RF Performance
- Manufacturing Capability, Efficiency & Cost

Key Considerations in Material Selection

Material Strength

Main part subjected to loading:

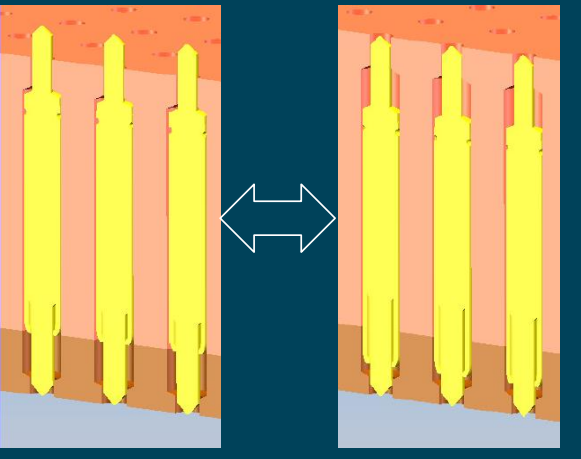
Socket body

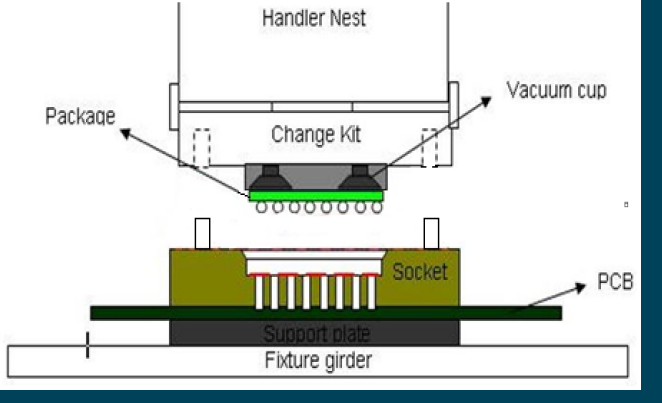
- **Spring probe preload force**
  - *BC state: static force, vary from high(outer edge) to low(center)*
  - *Testing state: no force*

**Cyclic force while testing*

- **Impact loading**
  - *No Docking plate setup:*

**Cyclic impact force*





Key Considerations in Material Selection

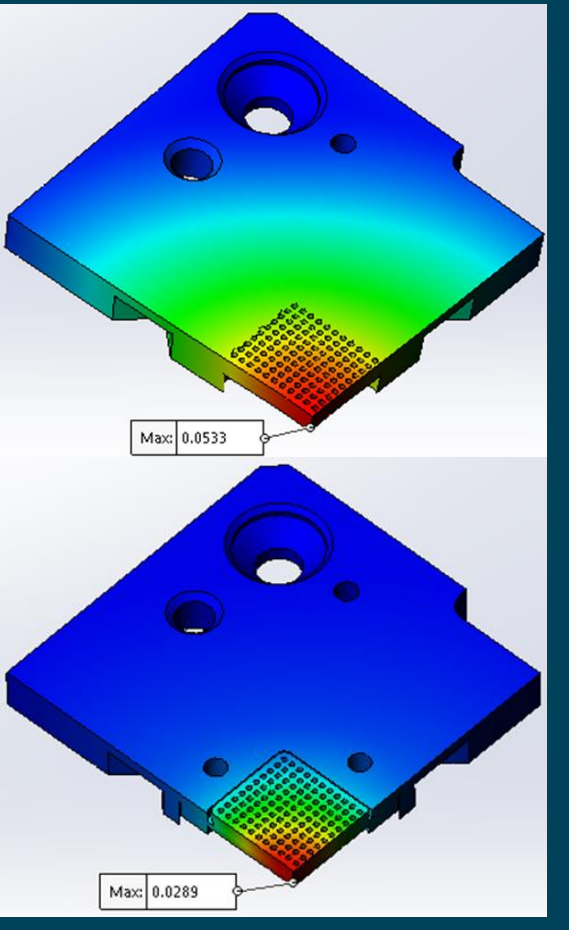
Material Strength

Relative material properties:

- **Flexural strength and modulus**
  - *Keep enough preload*
  - *Temp. raise, modulus decrease*
  - *Part structure*

**Metal Frame to improve strength*

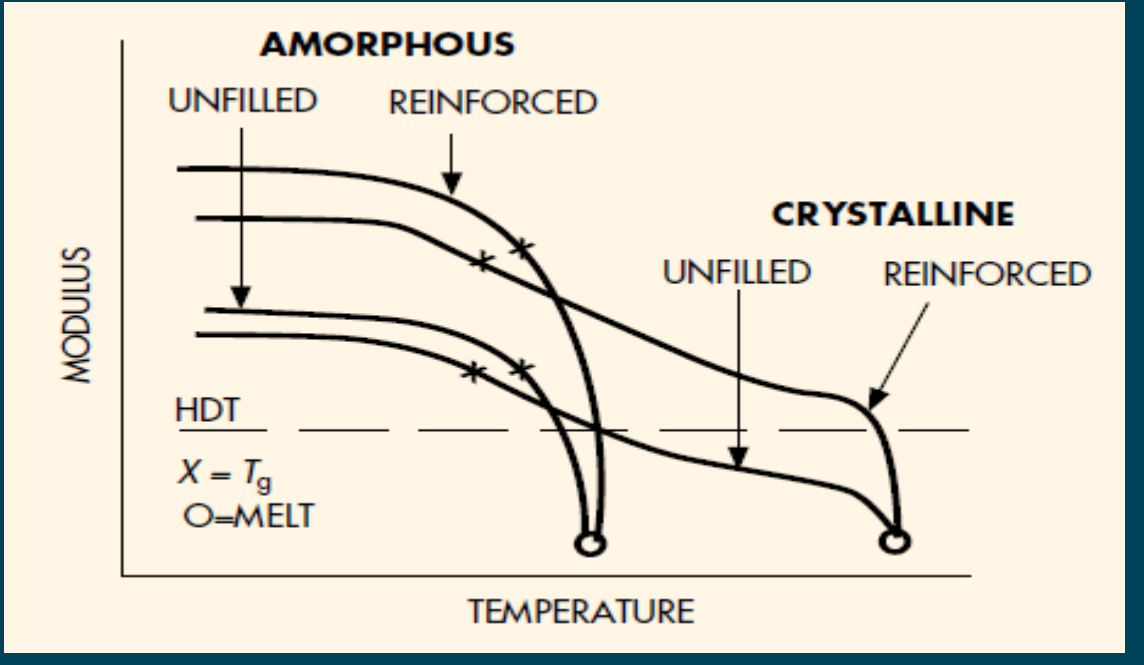
- **Fatigue (ATE testing)**
  - *Mechanical deterioration*
- **Impact strength /Toughness**
  - *Izod impact*
  - *Part shape, size and thickness*



Key Considerations in Material Selection

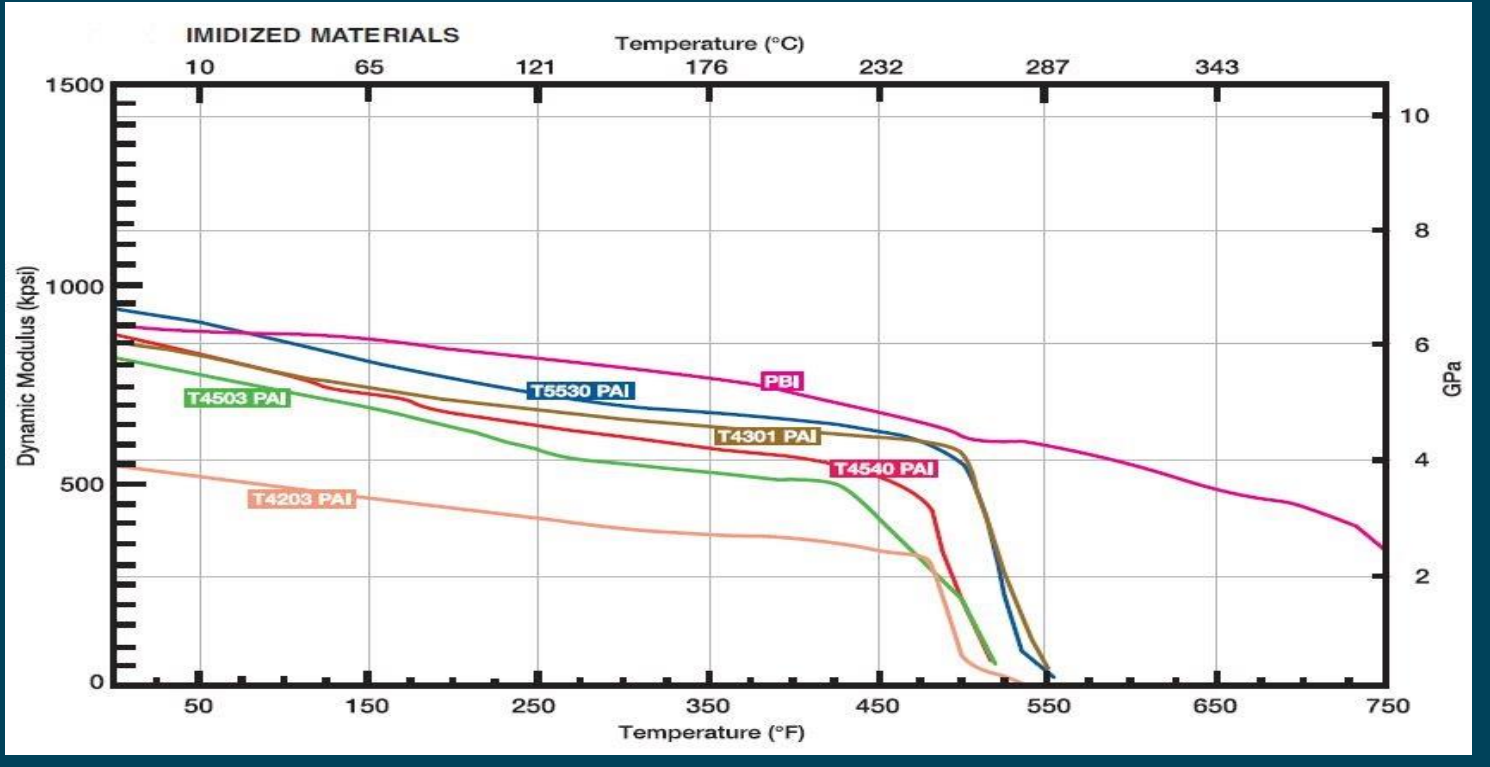
Material Strength

- **Modulus behavior Vs Temp.**
  - *Temp. increase to Tg, modulus gradually drop*
  - *Reinforced fiber improve the modulus of crystalline significantly*



Key Considerations in Material Selection

Material Strength



Dynamic modulus curve for Imidized materials PAI;

- *Use the modulus based on end-user's temperature*

Key Considerations in Material Selection

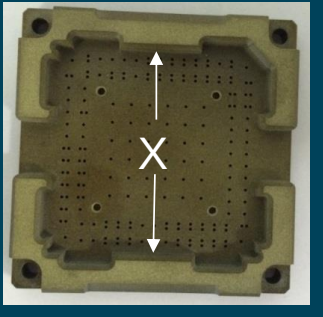
Dimensional Stability

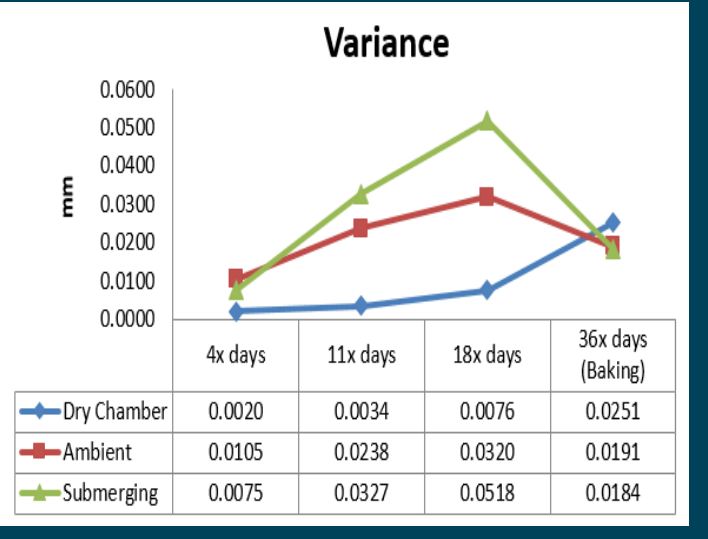
Fine pitch, multi-sites socket and Tri-temp. testing

Relative material properties:

- **Water/moisture absorption**
  - *Lower, the better*
  - *Pocket size*

Verification test:





	4x days	11x days	18x days	36x days (Baking)
Dry Chamber	0.0020	0.0034	0.0076	0.0251
Ambient	0.0105	0.0238	0.0320	0.0191
Submerging	0.0075	0.0327	0.0518	0.0184

- **Coefficient of Linear Thermal Expansion**
  - *Lower, the better*
  - *CLTE match / close*

Key Considerations in Material Selection

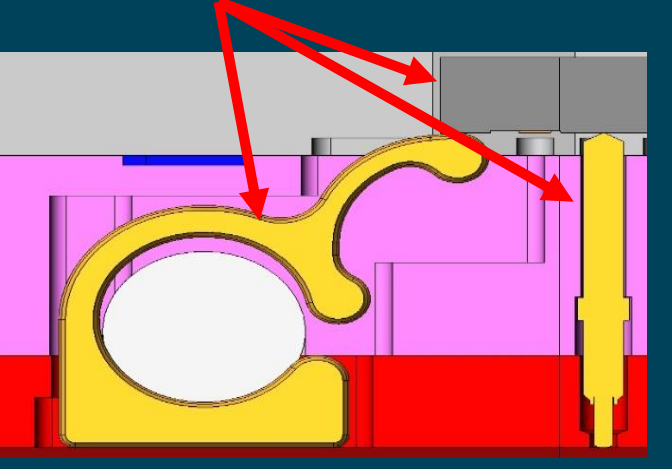
Wear Resistance

$$\text{“k”} = \frac{\text{wear}}{\text{PVT}} \times 10^{10}$$

Identifying the component most likely to encounter wear

- **Alignment plate or Floating base**
  - *PKG substrate VS guiding wall*

Relative motion points



- **Pin housing**
  - *Spring probe VS cavity hole*
  - *Stamping pin VS slot cavity*

**Celsius Socket*

The comparison of wear resistance testing provides information critical in material selection.

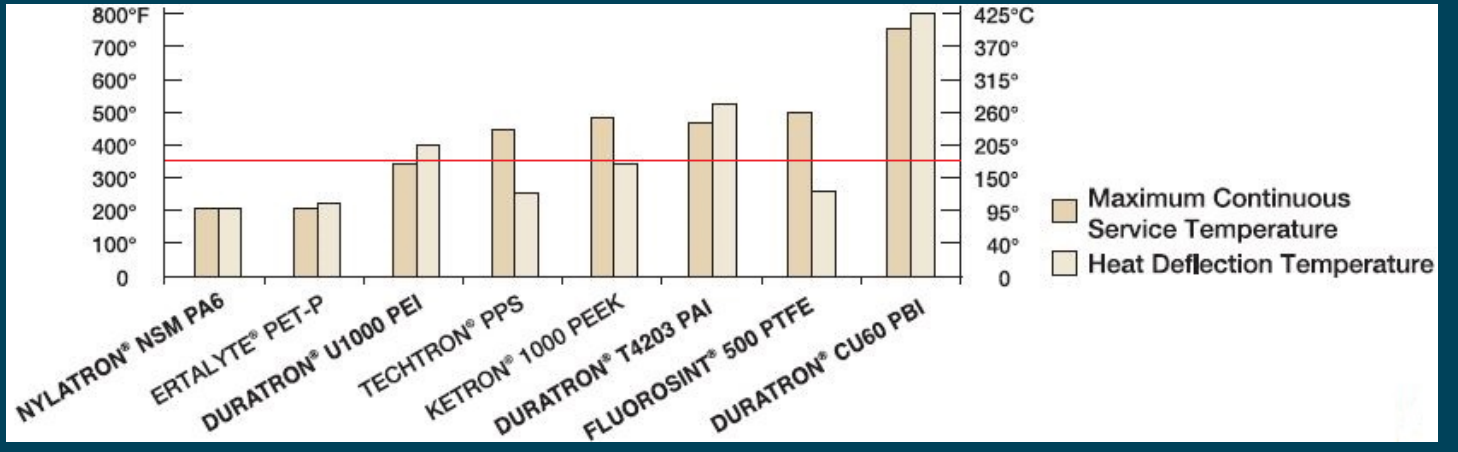
Key Considerations in Material Selection

Thermal Properties

Consider extreme operating temp. and duration

-55°C to +175°C ITRS2007 & AEC-Q100 specified

- **HDT, Heat Deflection Temperature**
- **Continuous Service Temperature**



- **Tg, Glass transition Temp.**

Key Considerations in Material Selection

RF Performance

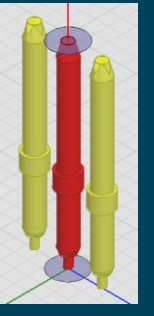
Dielectric Constant / RF Comparison

No significant variance for common plastics, Dk3 to 4

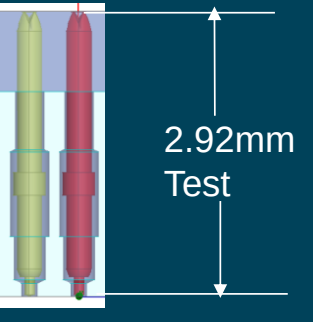
- **Test configuration**

Top: Target

Btm: PCB



2A



- **Dielectric constant comparison**

Parameter	PEEK Ceramic	Vespel SCP5000	MDS-100	PEEK Rigid
Dk	4.19	2.98	3.37	3.594
TanD	0.011	0.011	0.007	0.014

Key Considerations in Material Selection

RF Performance

- **Characteristic Summary (by using ADS software optimization)**

Socket Material	Pitch **(mm)**	Single -End Test Case	Loop Inductance L (nH)*	Capacitance to Ground C (pF)*	Characteristic Impedance Zo (ohms)**	Time Delay Td (ps)**	Insertion Loss -1dB Bandwidth (GHz)	Return Loss 10dB Bandwidth (GHz)
Peek Ceramic	0.4	2A	1.0	0.4	53.5	18.8	26.5	23.0
Vespel SCP-5000	0.4	2A	0.9	0.4	53.1	17.8	29.2	28.9
MDS-100	0.4	2A	0.9	0.3	53.7	17.7	30.0	29.0
Peek Rigid	0.4	2A	1.0	0.4	54.4	18.2	28.8	23.4

Notes:
* Inductance and Capacitance values valid from 10 MHz to 3 GHz
** Impedance and Time Delay values valid form 10 MHz to 10 GHz

Key Considerations in Material Selection

Manufacturing Capability, Efficiency & Cost

Manufacturing Capability, Efficiency

- **Ease of fabrication: Tg, Tensile elongation & fillers**
  - *Higher Tg and lower Tensile elongation: easier*
  - *Unfilled plastics: Softer, more difficult*
  - *Filled plastics: Tendency to machine more cleanly; Dulls drill bits faster; More heat during drilling*
- **For large quantity, near neat shape/injection molding**

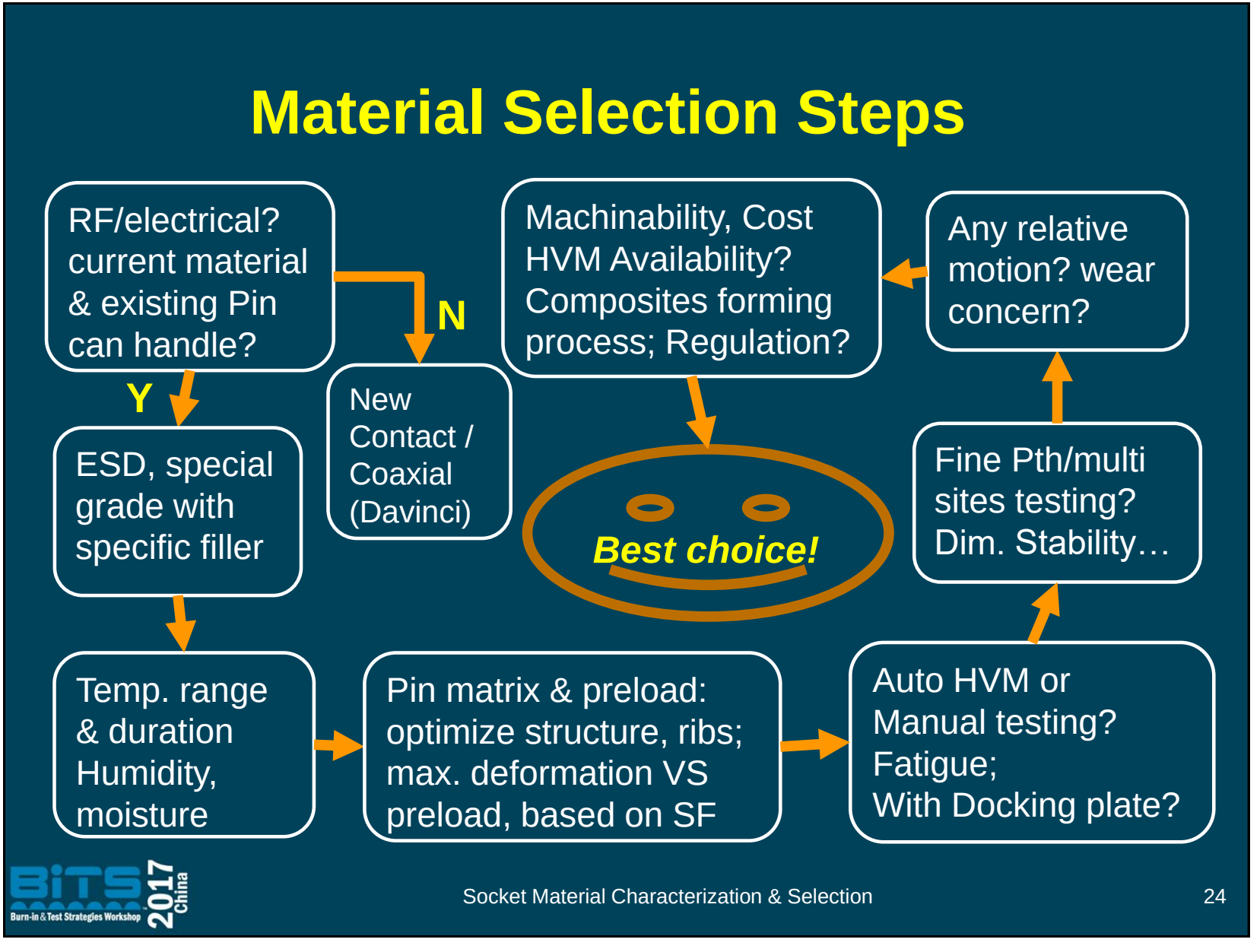
Cost

- **Material unit cost: cost per cubic inch or cm**
- **Longevity: Creep & Stress relaxation, Aging**
- **HVM availability: supply vendors, delivery lead time**

Socket Materials Comparison

Common Socket Material			EPM-2204U-W	Peek Rigid	MDS -100	Ultem 2300	Torlon 5530	SCP-5000	Photoveel II-S
Property		ASTM							
Strength	Flexural Modulus (Kpsi, 73°F)	D790	650	1965	1420	850	800	836	18854
	Izod Impact, Notched ft-lbs/in, 73°F	D256	1	NA	0.73	1	0.61	2.39	NA
Dimension stability	Water Absorption(24 hrs (%), 73°F)	D570	0.06	0.02	0.1	0.18	0.3	0.08	0
	CLTE, x10-5 in/in/°F	D696	2	1.4	1.1	1.1	2.6	2.6	2.6
Wear Resistance (Ranking)			5	3	4	NA	1	2	6
Tensile Elongation at Break (%)		D638	3.52	1.3	1.5	3	3	8	NA
Thermal	Heat Deflection Temp.@ 264psi, °F (°C)	D648	>500 (>260) (66psi)	NA	410 (210)	410 (210)	520 (271)	NA	NA
	Tg, amorphous, °F (°C)	D3418	290	313	350	410	527	752	NA
Electrical	Dielectric constant 1MHz, 50% RH	D150	4.71 (3.5 1K)	3.59	3.3	3.7 (1K)	6.3	3.3 (1GHz)	9 (1GHz)
Material stability factor *			3.3	14.0	12.9	7.7	3.1	3.2	72.5
Machine-ability factor *			2.6	0.8	3.5	1.0	1.3	7.4	NA
Relative Cost			$$$	14x $	15x $	$	7x $	18x $	58x $

*2009 BiTS Workshop, The Evolution & Evaluation of Plastics Materials in Burn-in & Test Applications


Material Selection Steps
RF/electrical? current material & existing Pin can handle?
N
Y
New Contact / Coaxial (Davinci)
ESD, special grade with specific filler
Machinability, Cost HVM Availability? Composites forming process; Regulation?
Best choice!
Any relative motion? wear concern?
Fine Pth/multi sites testing? Dim. Stability…
Temp. range & duration Humidity, moisture
Pin matrix & preload: optimize structure, ribs; max. deformation VS preload, based on SF
Auto HVM or Manual testing? Fatigue; With Docking plate?
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Socket Material Characterization & Selection
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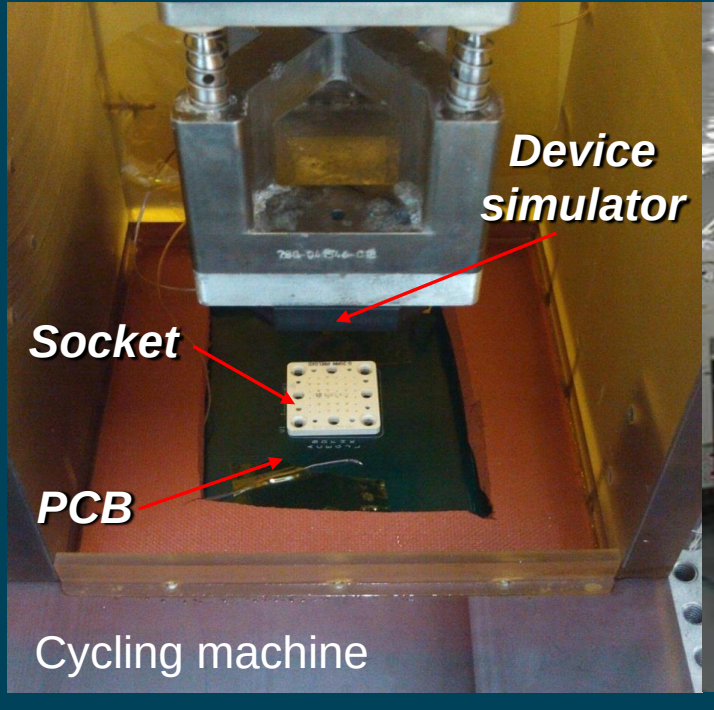
Material Verification

- Lab test / measurement
- Customer experimental / application results



Accumulate experience for future!

Summary

- Material choice should be based on the best combination of properties, not only one property; best choice usually represents a trade-off among satisfactory properties, ease of processing, and cost; No "perfect" material exists for using in all socket types.
- Metal frame can be designed to increase the strength of socket Body.
- Spring probe loading to Socket is not static while testing.
- No big electrical property difference for current common Polymers and Composites for high speed testing.

Understanding material characterizations well, and know the test application's environment & requirements well, then make a best choice!