BiTS 2009 Session 7

ARCHIVE 2009

ADVANCEMENTS & INNOVATIONS IN SOCKET MATERIALS

New Performance-Enhanced Cu-Be Strip Products for Burn-in Test Socket Applications

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The Evolution & Evaluation of Plastics Materials in Burn-in & Test Applications

Dana Scott, Scott Williams—Quadrant EPP

New Performance-Enhanced Cu-Be Strip Products for Burn-in Test Socket Applications

John C. Harkness FASM
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2009 BiTS Workshop
March 8 - 11, 2009

Outline

- Introduction: BiTS materials requirements
- Performance-enhanced C17200 strip for BiTS applications
  - High Conductivity Alloy 25*
  - Burn-in Quality Alloy 25*
    - » * *Offical product trade names not yet established*
- Conclusions

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Paper #1

Performance Requirements for BiTS Strip

- Miniaturization
  - High strength
  - High electrical conductivity (T-rise)
- Stamping & age hardening
  - Co-planarity
  - Predictable aging distortion
    - Goal = consistent electrical contact over large grid arrays

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Performance-Enhanced C17200 Strip for BiTS

- High Conductivity Alloy 25
  - Mill hardened (pre-heat treated) tempers ONLY
    - Heat treatable version not currently available
  - 30% IACS minimum
- Burn-in Quality Alloy 25
  - Heat treatable tempers ONLY
  - Controlled residual stress distribution
  - Monitored by Wire-EDM Finger Test (co-planarity)

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High Conductivity Alloy 25

- **Patent applied for**
- Conventional C17200 Cu-Co-Be composition
- Mill hardened tempers ONLY available at this time
- Proprietary processing provides at least **30 %IACS** at strengths in the Alloy 190 1/2HM-XHMS range (95-180 ksi YS), with comparable bend formability

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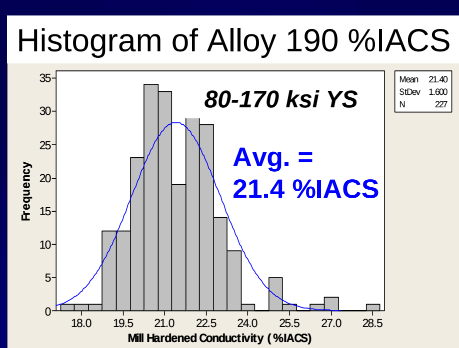
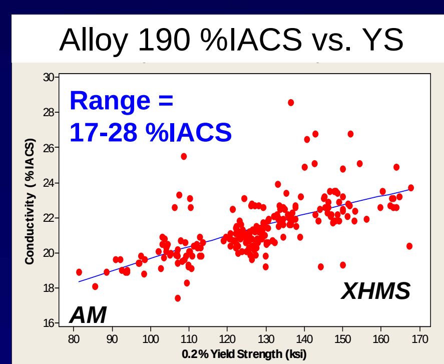
High Conductivity Alloy 25

[Standard Alloy 190 Conductivity vs. Strength]





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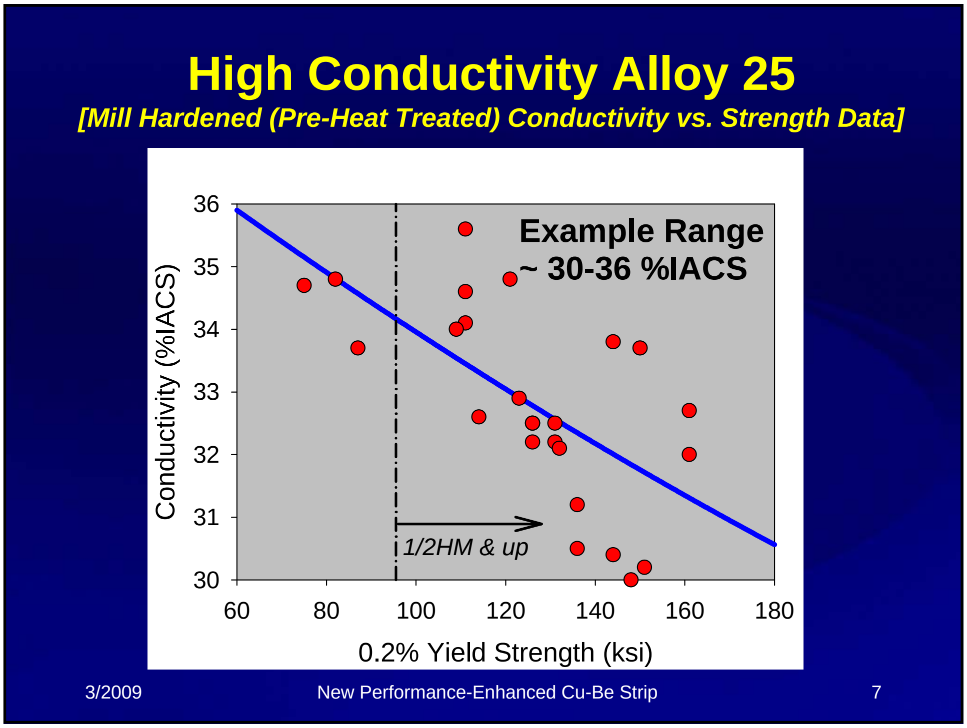
High Conductivity Alloy 25
[Mill Hardened (Pre-Heat Treated) Conductivity vs. Strength Data]
Example Range
~ 30-36 %IACS
1/2HM & up
Conductivity (%IACS)
0.2% Yield Strength (ksi)
36
35
34
33
32
31
30
60
80
100
120
140
160
180
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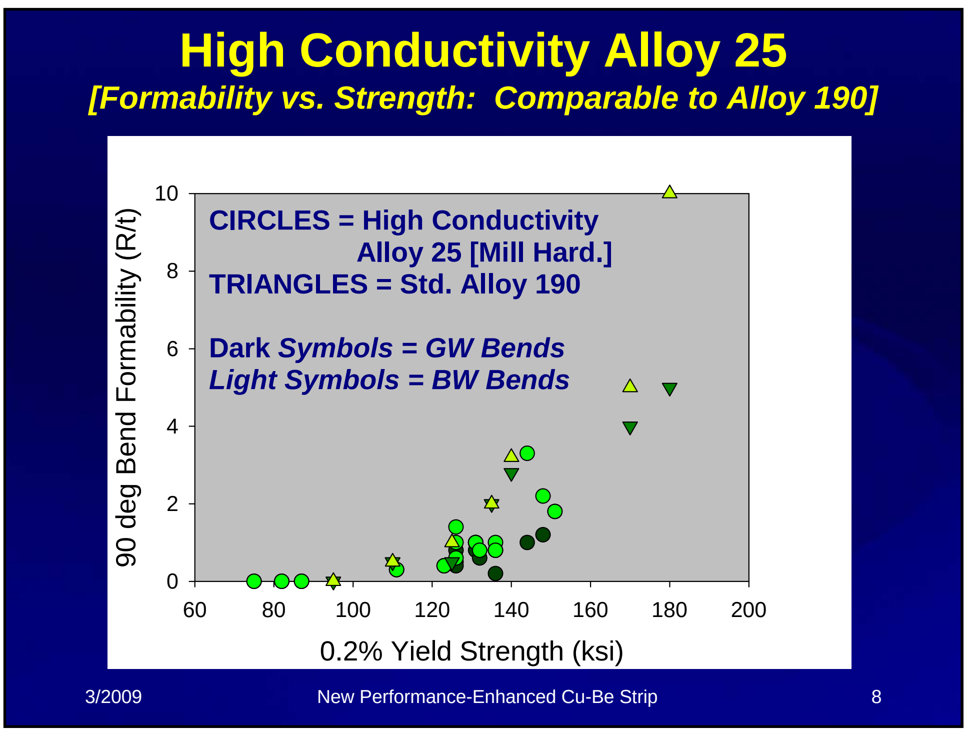
High Conductivity Alloy 25
[Formability vs. Strength: Comparable to Alloy 190]
CIRCLES = High Conductivity Alloy 25 [Mill Hard.]
TRIANGLES = Std. Alloy 190
Dark Symbols = GW Bends
Light Symbols = BW Bends
90 deg Bend Formability (R/t)
0.2% Yield Strength (ksi)
10
8
6
4
2
0
60
80
100
120
140
160
180
200
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High Conductivity Alloy 25

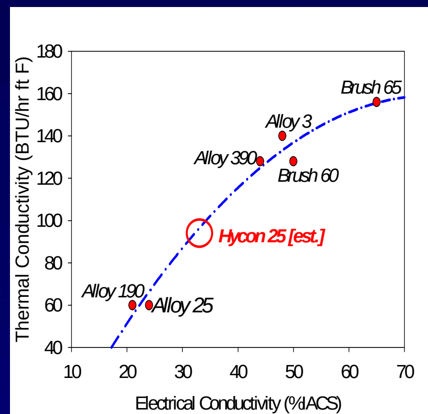
[Benefit of Higher Conductivity: Lower T-Rise]

- ***Ignoring convective heat transfer & assuming single contact:***
- T-rise (F) =

$$\frac{J^2 \times L^2}{\%IACS \times \text{Therm Cond} \times w^2 \times t^2 \times 358.68}$$

J = Current
L = Length
w = Width
t = thickness

- **T-rise of Hi. Cond. 25 ~ 59% LESS than Alloy 190 at same current & contact dimensions**
  - **~ 1/(conductivity product)**
  - **Convection model would predict somewhat lower Hi. Cond. 25 advantage over Alloy 190**



Therm. Cond. ~ %IACS

(non-linear approximation)

Burn-in Quality Alloy 25

[Basis for Concept]

- High/non-uniform residual stresses presumed to cause dimensional variation as-stamped & after aging
- Japanese references:
  - Claim appreciable Mechanical Stress Relief strains render a “zero” residual stress profile in Cu-alloys
    - “Zero” stress profile = no distortion in Etch-to-1/2 Thickness Test of as-shipped strip
    - STRETCH BEND LEVELING preferred (maximum bending strain)
  - Hold-over specification from Lead Frame Alloys = Wire-EDM Finger Test
    - “Low stress” strip has negligible out-of-plane finger displacement (< +/- 1 strip thickness)

Burn-in Quality Alloy 25
[Development Approach]

- Alloy 25 heat treatable strip ONLY
- Proprietary Mechanical Stress Relief (wide range of strains over 3 mill trials)
- Document residual stress distribution vs. processing
  - **X-Ray Diffraction (quantitative)**
  - **Etch-to-1/2 Thickness Test (qualitative)**
  - **Wire-EDM Finger Test (qualitative)**
- Customer stamping/aging trials of apparent lowest residual stress profile strip
  - Default to **Wire-EDM Finger Test** for selection
    - Wide Asian acceptance of test outcome
    - Low cost & rapid

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Burn-in Quality Alloy 25
[Outline of Stamping/Aging Trials]

- **1st Trial**
  - MODERATE Mechanical Stress Relief Strains
  - Stamped/formed BiTS contacts
  - Dimensional variation, as-stamped & aged
- **2nd Trial**
  - HIGHER Mechanical Stress Relief Strains
  - Lab-formed 90 deg bend test coupons
  - Included angle variation, as-bent & aged
- **3rd Trial**
  - HIGHEST Mechanical Stress Relief Strains
  - Stamped/formed BiTS contacts
  - Dimensional variation, as-stamped & aged

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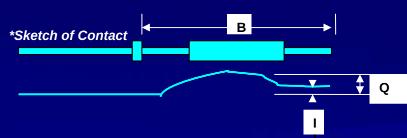
Burn-in Quality Alloy 25

[1st BiTS Stamp/Age Trial]

Process	Alloy 25 H, AS-ROLLED (Individual data omitted, n = 5)						Alloy 25 H, MODERATE MECH. STRESS RELIEF (Individual data omitted, n = 5)					
Position	Start of Coil (In)			End of Coil (Out)			Start of Coil (in)			End of Coil (Out)		
Dim.*	Q	I	B	Q	I	B	Q	I	B	Q	I	B
Condition	Unage	Unage	Unage	Unage	Unage	Unage	Unage	Unage	Unage	Unage	Unage	Unage
Avg.	2.2364	1.3234	8.1938	2.2396	1.3816	8.1772	2.2376	1.3530	8.1894	2.2402	1.3776	8.1766
Std. Dev.	0.004	0.009	0.008	0.010	0.025	0.033	0.007	0.017	0.011	0.008	0.020	0.014
Condition	Aged	Aged	Aged	Aged	Aged	Aged	Aged	Aged	Aged	Aged	Aged	Aged
Avg.	2.2556	1.3156	8.1364	2.2384	1.2740	8.1370	2.2710	1.3414	8.1230	2.2594	1.3028	8.1390
Std. Dev.	0.009	0.014	0.008	0.005	0.012	0.005	0.004	0.005	0.008	0.012	0.007	0.006



***Moderate* Mech. Stress Rel. = NO effect on stamped dim.; but aging LOWERED variation**

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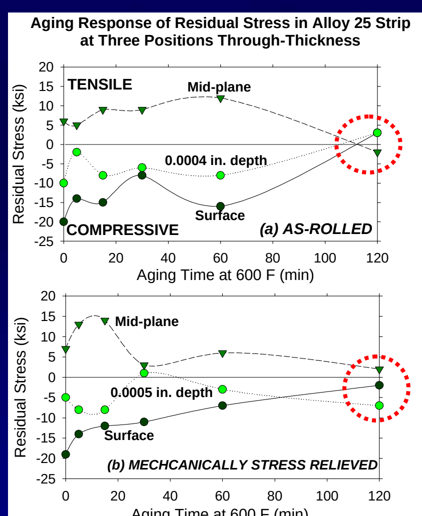
Burn-in Quality Alloy 25

[Effect of Aging on Residual Stress Profile]



- "Peak" age hardening at 600 F **REDUCES** residual stress profile to **near "zero"** as aging time approaches 2 hr, whether As-Rolled or Mechanically Stress Relieved.
- Source of lowered dimension variation after aging in 1st trial?

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Burn-in Quality Alloy 25

[2nd BiTS Trial -- Bend Test Angle Variation]

Temper & Stretch Bend Leveling Setting	LONGITUDINAL BENDS (Individual data omitted, n = 8)			TRANSVERSE BENDS (Individual data omitted, n = 8)		
	Unaged Included Angle (deg)	Aged Included Angle (deg)	Angle CHANGE (deg)	Unaged Included Angle (deg)	Aged Included Angle (deg)	Angle CHANGE (deg)
AS-ROLLED (untreated) Average	81.5	81.9	+0.4	85.3	83.4	-1.9
Std. Dev.	1.011	ND	0.988	0.978	ND	0.960
Treatment A Average	80.3	82.1	+1.8	84.8	84.0	-0.8
Std. Dev.	1.351	ND	1.215	0.917	ND	0.757
Treatment B [Strain > Treatment A] Average	87.9	86.6	-1.3	88.9	85.4	-3.5
Std. Dev.	1.731	ND	2.451	1.414	ND	1.142

90 deg Bend Test: ***HIGHER*** Mech. Stress Relief strain INCREASED as-formed bend angle variation & aged angular change variation

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Burn-in Quality Alloy 25

[3rd BiTS Stamp/Age Trial]

Coil #	Mechanical Stress Relief Treatment	Tensile Properties		
		0.2%YS (ksi)	UTS (ksi)	Elong. (%)
1	A'	117.0	123.1	1.0
2	B'	111.0	123.3	1.0
3	C'	109.5	122.3	1.0
4	D'	120.4	123.6	1.0
5	E'	113.5	123.6	1.0
6	F'	114.7	123.7	1.0
7	G'	112.2	116.9	2.0
8	H'	100.7	119.3	1.0
9	I'	119.8	124.0	1.5
10	J'	116.1-118.4	123.8-124.2	2.5-3.5
11	K'	120.4	123.7	2.5
12	As-Rolled	119.0	122.8	0.5
Spec.	Alloy 25 H	90-115	100-120	2-18

HIGHEST Mech. Str. Rlf. Strains Alter Tensile Properties (some >, some < vs. As-Rolled)

[Over YS spec ?]

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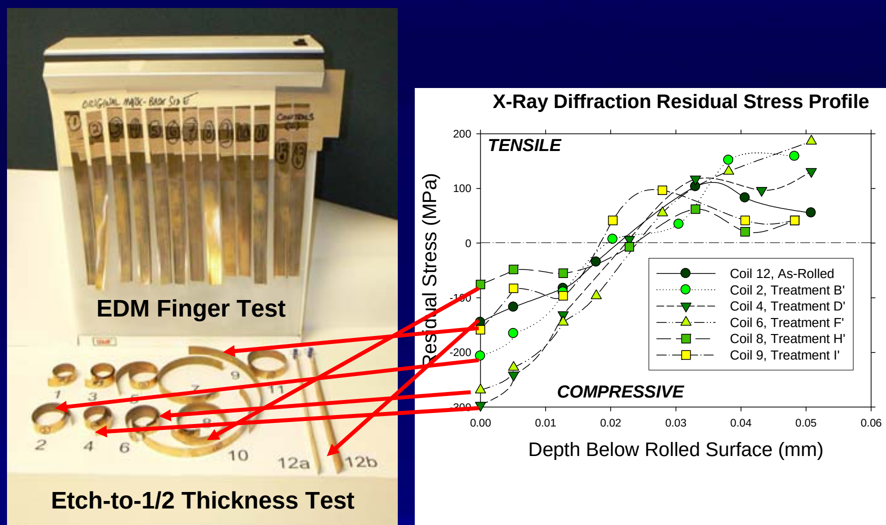
Burn-in Quality Alloy 25

[3rd BiTS Stamp/Age Trial – Residual Stress Tests]



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Alloy 25 BiQ

[3rd Stamp/Age Trial]

- **Observations**
  - NO treatment = "zero" stress profile
  - Lowest Etch Test & Finger Test distortion in As-Rolled (untreated) strip … seen in lower strain trials also
  - Lowest (flattest) XRD stress profile was NOT flattest in Etch Test nor least deflection in Finger Test
  - Coil #9 or #10 supplied for 3rd BiTS Stamping/Aging Trial (vs. As-Rolled #12)
    - 2nd flattest XRD stress profile & 2nd lowest Etch & Finger Test distortion **(i.e., "best" of Mechanically Stress Relieved coils)**
  - 3rd Trial results **NOT AVAILABLE** at manuscript submission date
    - Economic conditions have delayed Asian stamping trial
    - Will report results if available by 2009 Workshop date

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Conclusions (I)

- Two new enhanced performance C17200 strip products are introduced for BiTS applications.
- **High Conductivity Alloy 25** (patent applied for) provides 30 %IACS minimum in MILL HARDENED tempers with YS in the 95-180 ksi range. Heat treatable tempers are not currently available.
- **High Conductivity Alloy 25** bend formability is comparable to Alloy 190 of like temper/YS.
- **High Conductivity Alloy 25**, at ~34 %IACS has Thermal Conductivity ~ 95 BTU/hr ft F
- **High Conductivity Alloy 25**, for like current & contact dimensions, has temperature rise up to 59% LESS than Alloy 190 (ignore convection).

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Conclusions (II)

- **Burn-in Quality Alloy 25** is heat treatable strip, with proprietary Mechanical Stress Relief applied for reduced residual stress.
- Residual stress tests for strip included:
  - X-Ray Diffraction (quantitative)
  - Etch-to-1/2 Thickness Test (qualitative)
  - Wire-EDM Finger Test (qualitative)
- **Burn-in Quality Alloy 25** residual stress is monitored by Wire-EDM Finger Test.
  - Cost-effective, adapted from lead-frame strip

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Conclusions (III)

- **Burn-in Quality Alloy 25** stamping/aging trials
  - **1st trial:** NO benefit of **moderate** Mechanical Stress Relief on stamped dimensions; aging REDUCED variation.
  - **2nd trial:** **greater** Mechanical Stress Relief INCREASED both as-formed & aged included angle variation in bend specimens.
  - **3rd trial** (**highest** Mechanical Stress Relief) = **pending**.
    - **Tensile properties altered vs. As-Rolled**
    - **NO treatment = "zero" residual stress.**
    - **As-rolled strip flattest in Wire-EDM & Etch-to-1/2 Thickness Tests, but NOT the lowest XRD residual stress profile.**
    - **Flattest XRD stress profile NOT lowest Finger or Etch Test distortion.**
    - **Lowest Finger Test distortion treatment being compared to As-Rolled condition.**

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The Evolution & Evaluation of Plastics Materials in Burn-in & Test Applications

Dana Scott, Scott Williams
Quadrant Engineering Plastic Products

2009 BiTS Workshop
March 8 - 11, 2009

The Overall Objective of this Paper

- Introduce a methodology for analyzing & comparing plastic materials with respect to their ability to meet the increasingly challenging requirements of the market
- To look at the history of the market to understand how to solve the issues that will confront us in the future
- To provide a comparison of current market available materials based on the proposed methodology
- Propose a roadmap for next generation socket material selection based on projections for increasingly aggressive requirements

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Content

I. A Look Back at Test Sockets

II. The Changing Environment

III. Methodology to Compare Materials for Next Generation Tests Sockets

- Polymeric Stability
- Machine-ability

IV. Solution for Next Generation Sockets

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Evolution of Consumer Products Driving Miniaturization

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Evolution of Test Sockets as a result of Miniaturization of Consumer Electronics

Year	Pitch	Thru Hole	Wall Size	I/O Count	Typ Materials
1980-1998	2.54mm-1.27mm	1mm - .75mm	.75mm	200	Ultem PEEK
1998-2002	1mm-.6mm	.4mm - .65mm	.2mm-.35mm	200-1000	Ultem PEEK Torlon Polyimide
2002-Present	.6mm-.4mm	.3mm - .4mm	.1mm-.2mm	Up to 2500	PEEK TORLON Polyimide
2009-2012	**.4mm-.25mm**	**.2mm - .3mm**	**.05mm-.01mm**	**????????**	**????????**

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Content

I. A Look Back at Test Sockets

II. The Changing Environment

III. Methodology to Compare Materials for Next Generation Tests Sockets

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IV. Solution for Next Generation Sockets

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The Changing Environment

- Driven by market requirements, the BiTS industry is pushing material science to the brink of polymeric capability
  - higher I/O count
  - reduction in pitch
  - thinner cross sections
  - higher power
- The traditional remedy for increasing the stiffness & stability of a polymer works against the requirements for a more machine-able polymer
  - To increase stiffness you add fillers to the material
  - Filled material means decreased machine-ability especially in increasing hole & decreasing pitch sizes

How do we evaluate & compare materials for test applications

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Methodology To Compare Materials

Statement: Since we are focused on the increasing I/O count and reduction in pitch size we conclude that the machine-ability of the polymer & the stability of the polymer are key components to achieving next generation socket designs

Broad Definitions

- Machine-ability – the ability to successfully machine a given hole pattern
- Polymeric Stability – The ability of the polymer to maintain shape during the machining process and throughout the useful life of the socket

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Polymeric Stability

- Polymeric stability in Test Socket applications relates specifically to the polymer substrates ability to withstand minimal dimensional change during the machining phase and testing phase
- The polymers ability to withstand dimensional change is characterized by two factors:
  - *Stiffness of the polymer*
  - *Expansion of the polymer over useful temperature range*
- Two accepted methods for measuring stiffness & expansion
  - *Flexural Modulus @ 73°F (D790) – a measure of the ability of the polymer to withstand bending under a given load*
  - *CLTE (-40°F - 400°F, E-831) – measure of the dimensional change over a wide temperature range*

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Measuring Polymeric Stability

Formula: $$\frac{\text{Flexural Modulus @ 73°F} \,/\, 100{,}000}{\text{CLTE @ (-40°F to 300°F)} \,/\, 10^{-5}}$$

- Higher numerator / higher stiffness - desired
- Lower denominator / less expansion - desired
- thus… higher overall polymeric stability factor desired

Formula applied to Semitron® MDS-100

Sample Calculation: $$\frac{1{,}420{,}000 \,/\, 100{,}000}{1.1 \times 10^{-5} \,/\, 1 \times 10^{-5}} = 12.91$$

12.91 Polymeric Stability Factor

Comparison of Common Test Polymers for Stability using the Formula

Higher is better

Resin	CLTE (E-831) (-40 - 300F) X10-5	Flex Modulus D-790	Polymeric Stability Factor
Polyimide	3.05	450,000	1.48
PEEK	2.60	500,000	1.92
Ultem 1000 (PEI)	2.60	600,000	2.31
Ceramic Filled PEEK	2.00	650,000	3.25
30% GF PAI	2.60	900,000	3.46
Unfilled PAI	1.70	600,000	3.53
MDS-100	1.10	1,420,000	12.91

Machine-ability

For the purpose of Back End Test applications **machine-ability** is defined as the polymers capacity to successfully machine decreasing cross-sections defined by decreasing wall thickness between holes *(larger holes, decreasing pitch, higher I/O count)* and decreasing overall part thickness

Factors Affecting Machine-ability

- **Heat sensitivity at point of drill contact**
- **Ability of the polymer to resist movement & remain rigid during machining - *ductility***
- **The Homogeneous nature of the polymer**

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Measuring Machine-ability

- **Tg or Glass Transition (D3148) – the temperature at which an amorphous materials softens**
  - ***Higher temp resistance means cleaner holes***
- **Tensile Elongation (D638) – a measure of the the elastomeric properties of a material. For machining fine features, increased rigidity is desired**
- **Fillers – fillers used to increase the physical properties of the polymer have an adverse affect on the machine-ability of small features**
  - ***Fibers have greater negative impact***
  - ***Particulate have less impact on performance***

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Measuring Machine-ability

Formula: Tg (°F) — Tensile Elongation (%) = Machine Ability Factor

Filler Factor: Machine Ability Factor X 0.25 for fiber fillers / 0.85 for particulate fillers

Formula applied to Torlon 5530 30% GF PAI

Sample Calculation: (527° - 3) (.25) = 131 / 100

1.31
Machine Ability Factor

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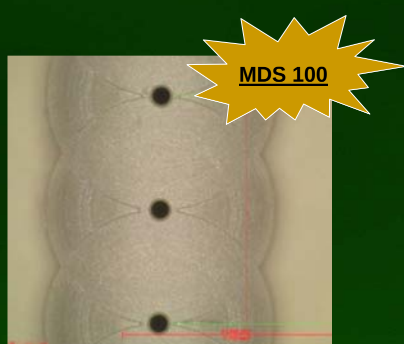
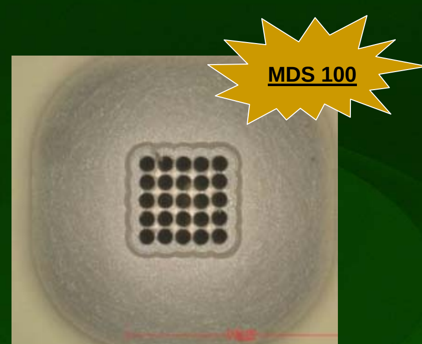
Examples of Machine-ability

Example of machining small holes is shown in the pictures below. .





Example-1

Diameter of hole	0.08mm
Pitch	0.5mm

Example-2

Diameter of hole	0.08mm
Pitch	0.1mm
Wall thickness	0.02mm

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Comparison of Common Test Polymers for Machine-ability using the Formula

Higher is better

Polymer	Tg	Tensile Elogation	Filler Factor	Machine-ability Factor
Polyimide	752	7.5	O	7.4
Torlon 4203 (PAI)	527	10	O	5.2
Semitron MDS-100	350	1.5	O	3.5
Ultem 1000 (PEI)	410	80	O	3.3
GP PEEK	290	40	O	2.5
CF PEEK	290	10	(0.90)	2.5
Torlon 5530 (PAI+30%GF)	527	3	(0.25)	1.3

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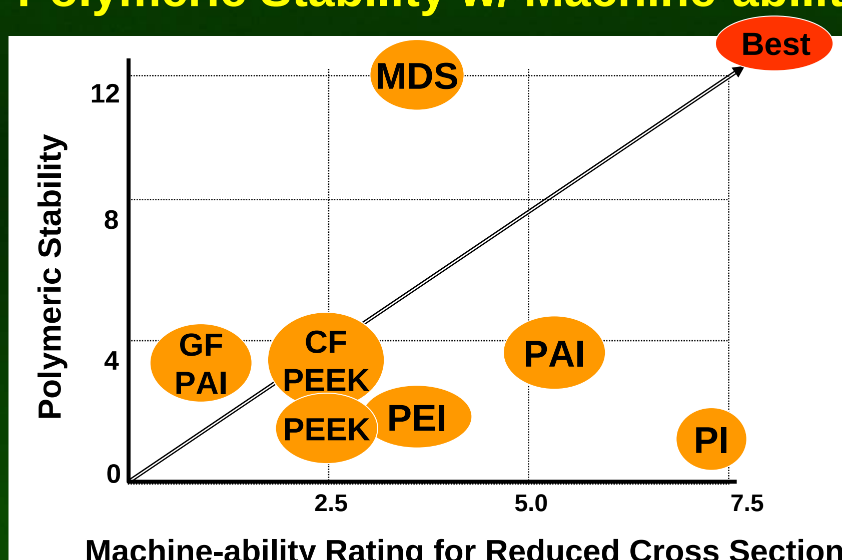
Polymer Comparison Grid Combining Polymeric Stability w/ Machine-ability



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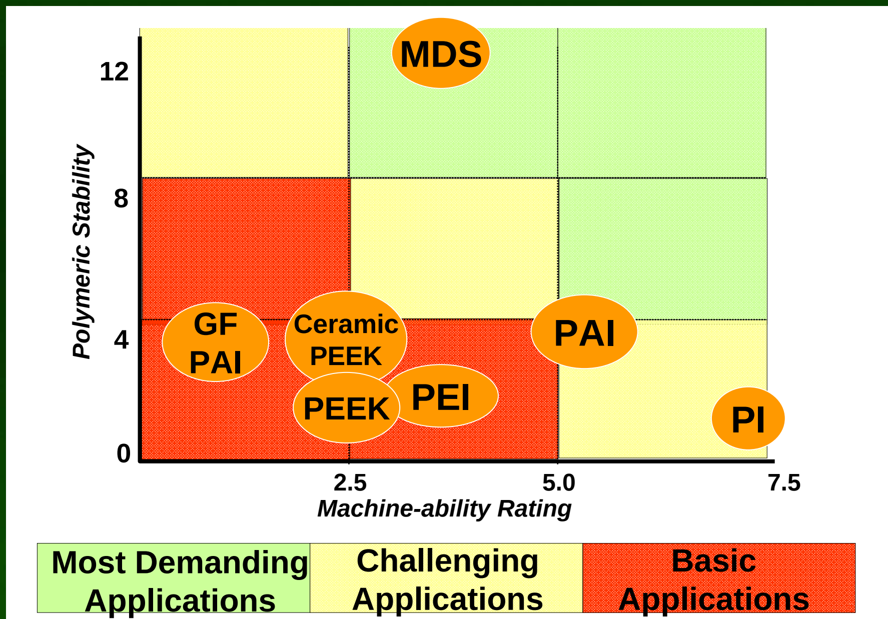
What this means…



Key Points

- There is no universal material that meets all of the requirements of the entire market rather materials need to be chosen based on the unique needs of the actual socket
- Other factors such as cost of material, antistatic requirements … also play into the decision process
- Water absorption was not included in the product stability rating since it can be controlled by limiting exposure to humidity in handling, but should be considered if conditions are not controllable

Content

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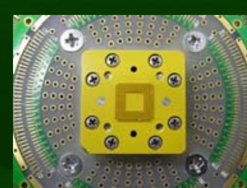
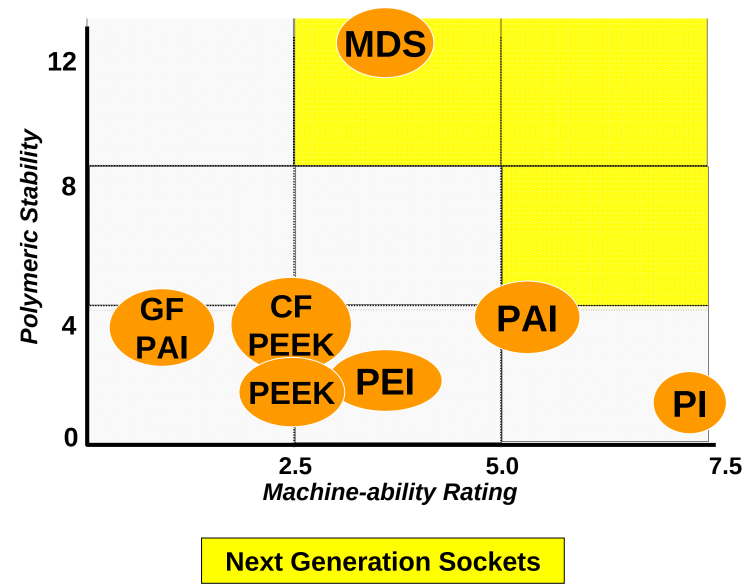
Test Sockets in 2009 - 2012



Pitch	0.4mm – 0.25mm…
Thru Hole	0.2 mm – 0.3mm
Wall Size	0.05mm – 0.1mm
I / O count	+++
Materials	???

If you use the grid to select …



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Conclusion for Next Generation Socket

- Over the next few years, Industry changes will push traditional materials beyond their performance limits.
- Increased I/O counts. Smaller I/O pitches, thinner cross sections, increased loads per sq/in, smaller diameter holes, are issues we see today and will be at the forefront of issues leading into the next decade
- Using the Polymeric Stability along with the Machine-ability index will guide Engineers to right material from the start
- Semitron MDS 100 will allow Engineers to work around design limitations associated with traditional materials.
- Semitron MDS 100 is the future…the Future is now

	Pitch	Thru Hole	Wall Size	I/O Count	Typ Materials
2009-2012	.4mm-.25mm	.2mm - .3mm	.05mm-.01mm	????????	Semitron MDS - 100

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