Session 3

Tuesday 3/11/14 8:00am

SHOW THEM WHAT WE'RE MADE OF

Microelectronics continually tests the limits and ingenuity of test and burn-in strategies. So, more and more, the onus falls on materials solutions for sockets. This session kicks off with an examination of available socket materials to foster a better understanding of their relative merits for various applications, plus there's a sneak preview of coming material trends. The continuing trend of tighter pitches, higher temperatures and higher density contacts places heavy demands on test probes and equipment, particularly the materials used to manufacture them. As these materials continuously evolve, finite element modeling can help designers demonstrate the effects of material properties and performance as you'll learn in the second paper. The third presentation focuses on high temperature burn-in for automotive applications, emphasizing advancements in contact pin plating and surface finishing technologies to address the thermal challenges being faced. Wrapping up this session is a case study comparing three types of palladium alloys for spring pin contactors to determine what the best material is for test.

The Stuff We're Made Of
An Examination of the State of the Art in Socket Materials

Jon Diller—Smiths Connectors | IDI

This Paper

Rising to the Challenge: Material Evolution to Enable Reliable Performance at Tighter Pitches and Higher Temperature

Mike Gedeon—Materion

180 Deg. C BGA Burn-in, Is It Doable?

Kenji Ichihara, Masaru Sato, Noriyuki Matsuoka—Yamaichi Electronics Co., Ltd.
Jec Sangalang—Yamaichi Electronics USA

Palladium Alloy Hardening and Wear Away Characteristics

Takuto Yoshida, Craig Hudson—Test Tooling Solutions Group

Rising to the Challenge:
Material Evolution to Enable Reliable Performance at Tighter Pitches and Higher Temperature

Mike Gedeon
Materion

2014 BiTS Workshop
March 9 - 12, 2014

Agenda

- What is a Contact?
- Performance Requirements
- Material Requirements
- Burn-in Trends
- Future Direction

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What's Important in BiTS Design?

- What we might think about

Mechanical Engineers	Electrical Engineers	Materials Engineer
Number of Contacts	Signal Integrity	Yield strength
Contact Pitch	Contact Resistance	Elastic modulus
Contact Force	Impedance Matching	Stress Relaxation Resistance
Planarity	Parasitic Capacitance and Inductance	Electrical Conductivity
Wear Rate	Cross Talk	Thermal Conductivity
Temperature	S-Parameters	Fatigue Strength
…	…	…

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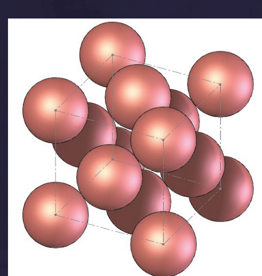
What is a Contact, Exactly

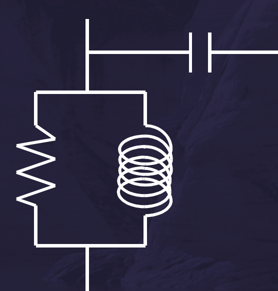
Materials Engineer

- CuBe C17200 – TH02
- FCC copper alloy



Electrical Engineer

- Set of S-Parameters
- Circuit Element



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What is a Contact, Exactly

- **Mechanical Engineer**
  - Current Carrying Spring
- **Hooke's Law**
  - $F = k \cdot X$

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Determining Spring Properties

- **Engineering Properties**

$$\text{Stress}\,(\sigma) = \frac{\text{Force}}{\text{Area}}$$

$$\text{Strain}\,(\varepsilon) = \frac{\Delta\text{Length}}{\text{Length}_0}$$

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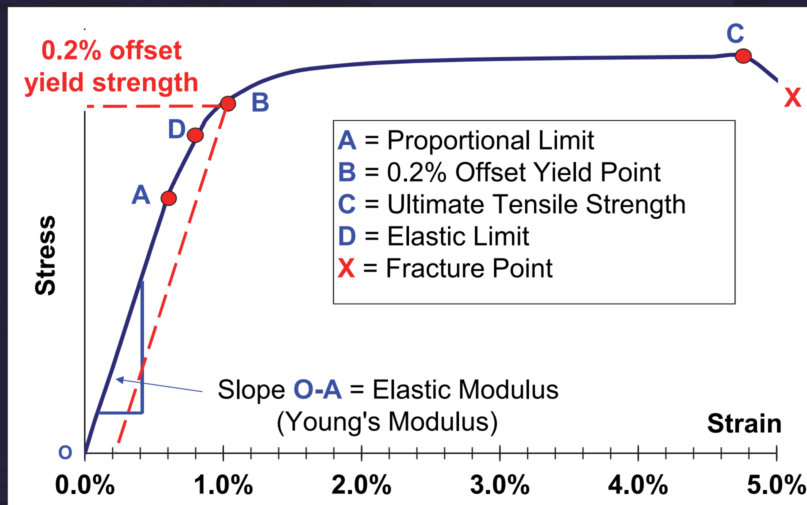
Stress-Strain Curves



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Example Contact

- Finite Element Models Run
  - Spring Force
  - Permanent Set
  - Temperature Rise
  - Coplanarity Tolerance

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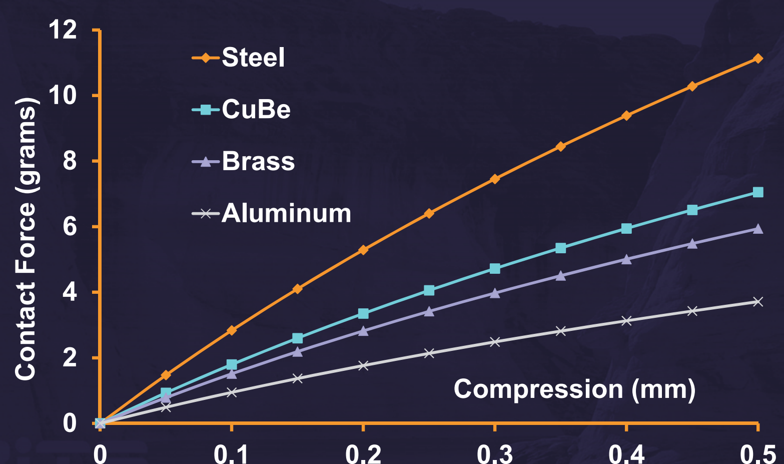
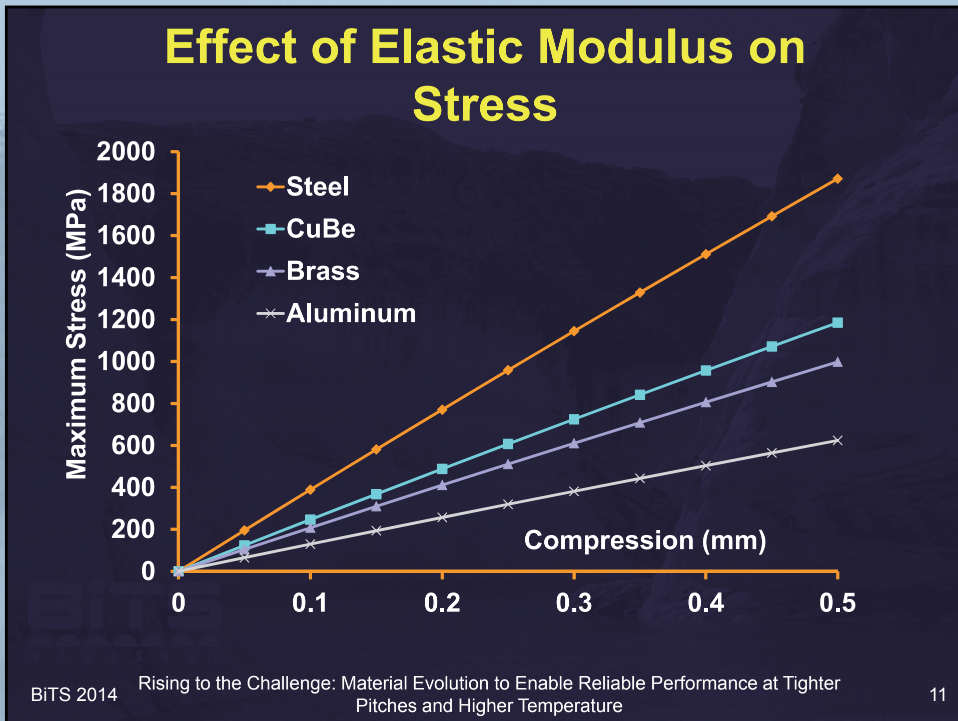
Materials Compared

- Steel
  - S41000 high strength stainless steel
- CuBe
  - C17200 TH04 copper beryllium
- Brass
  - C26000 H04 Brass
- Aluminum
  - 6061 T6 Aluminum

Effect of Elastic Modulus on Force




Effect of Elastic Modulus on Stress
Maximum Stress (MPa)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Steel
CuBe
Brass
Aluminum
Compression (mm)
0
0.1
0.2
0.3
0.4
0.5
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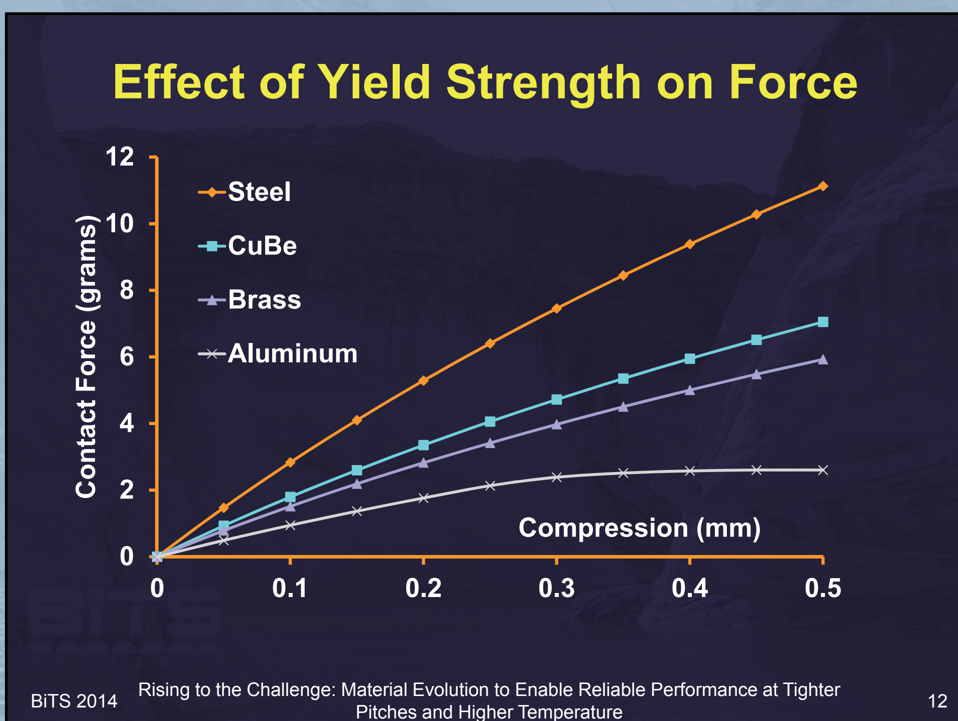
Effect of Yield Strength on Force
Contact Force (grams)
12
10
8
6
4
2
0
Steel
CuBe
Brass
Aluminum
Compression (mm)
0
0.1
0.2
0.3
0.4
0.5
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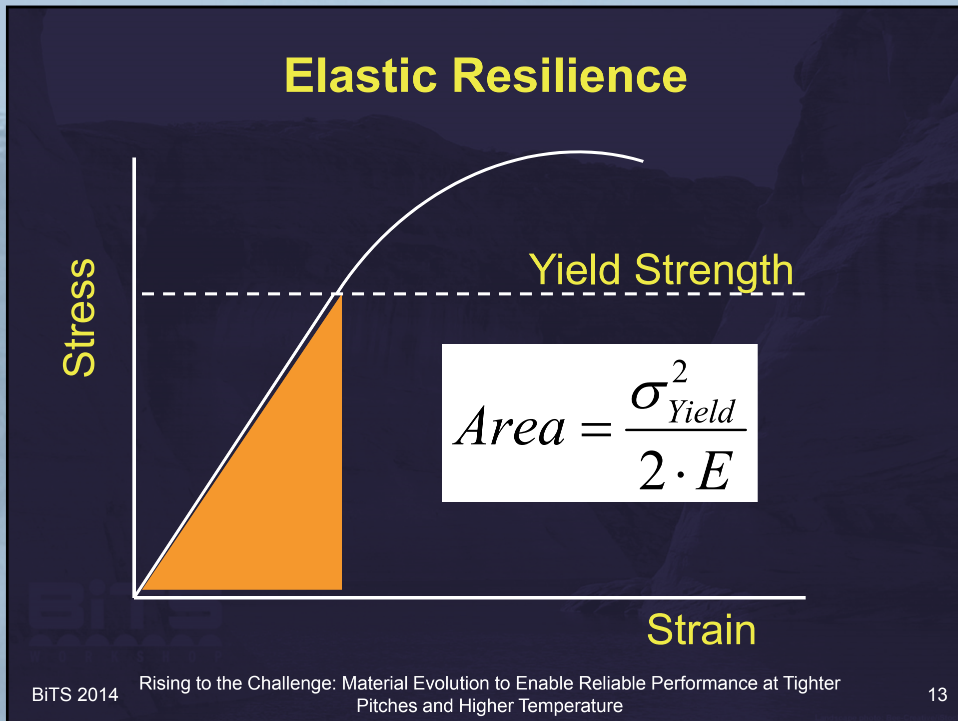
Elastic Resilience
Stress
Yield Strength
$Area = \frac{\sigma_{Yield}^2}{2 \cdot E}$
Strain
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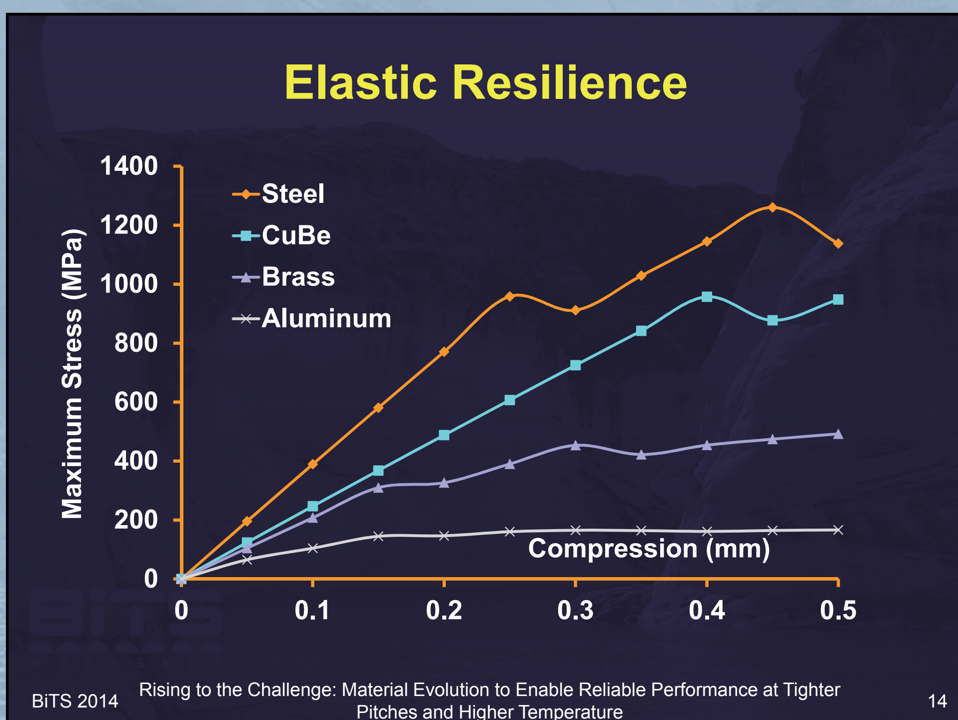
Elastic Resilience
Maximum Stress (MPa)
1400
1200
1000
800
600
400
200
0
Steel
CuBe
Brass
Aluminum
Compression (mm)
0
0.1
0.2
0.3
0.4
0.5
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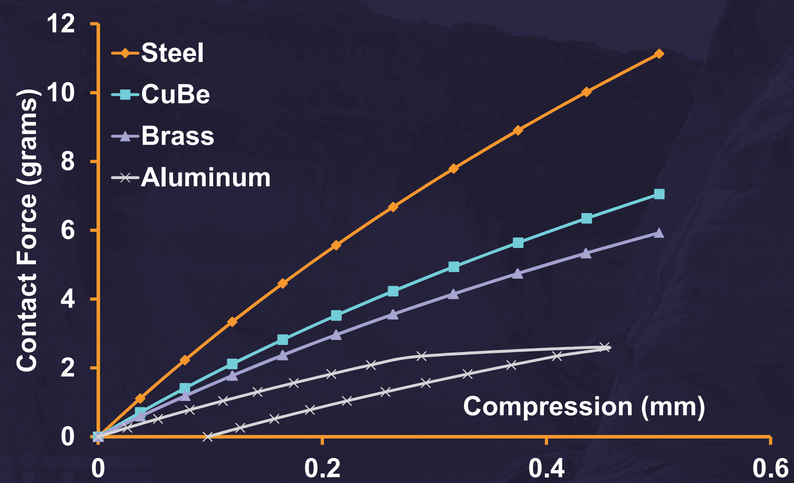
Permanent Set



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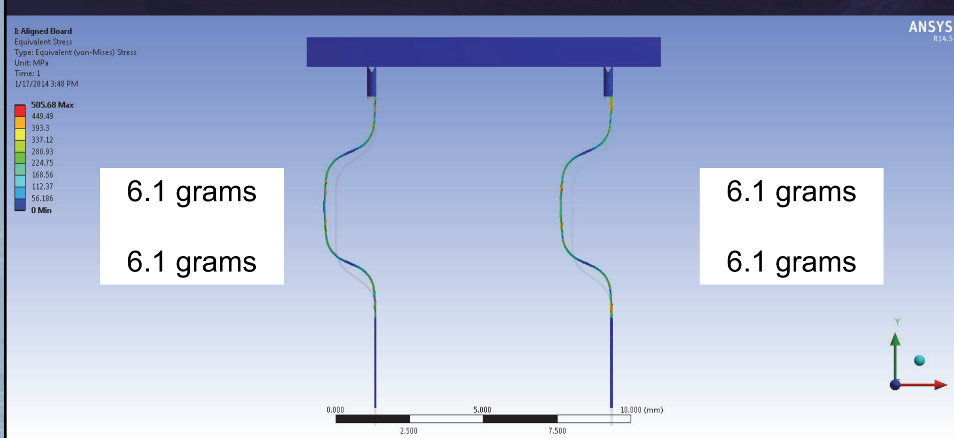
Non-Coplanarity

- Perfect Alignment



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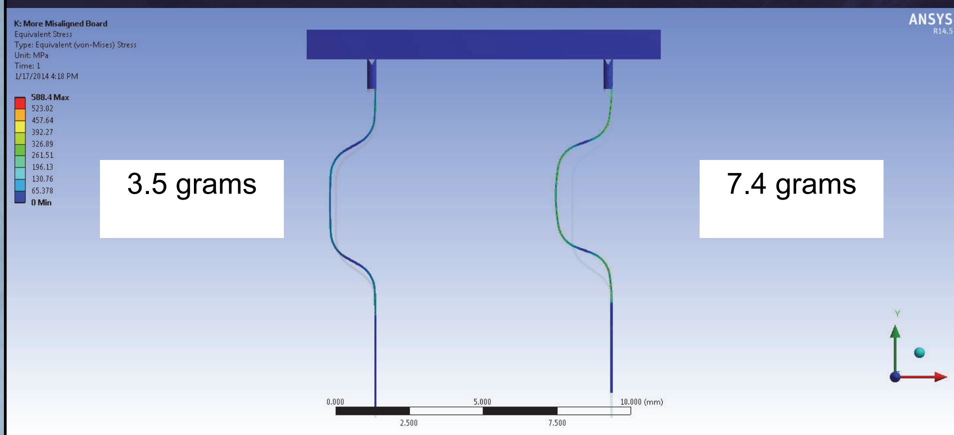
Non-Coplanarity

- **Misaligned – Cycle 1**



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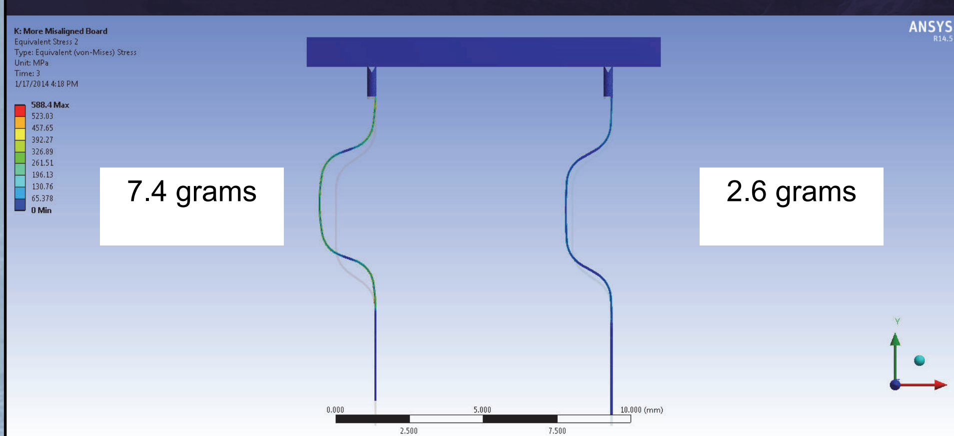
Non-Coplanarity

- **Misaligned – Cycle 2**



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Non-Coplanarity

- **Summary**

Aligned

Cycle	Left Contact Deflection	Left Contact Force	Right Contact Deflection	Right Contact Force (g)
1	0.5 mm	6.1	0.5 mm	6.1
2	0.5 mm	6.1	0.5 mm	6.1

Misaligned- Worst Case

Cycle	Left Contact Deflection	Left Contact Force	Right Contact Deflection	Right Contact Force
1	0.25 mm	3.5	0.75 mm	7.4
2	0.75 mm	7.4	0.25 mm	2.6

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Stress Relaxation

- **Stress Remaining after 1000 hours**
  - **Initial Stress 75% of Yield Strength**

	CuBe	Brass	Steel
100°C	98	41	99

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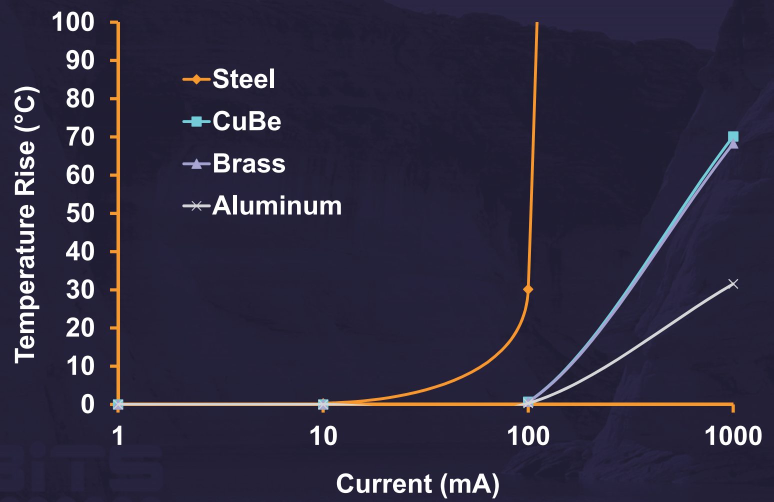
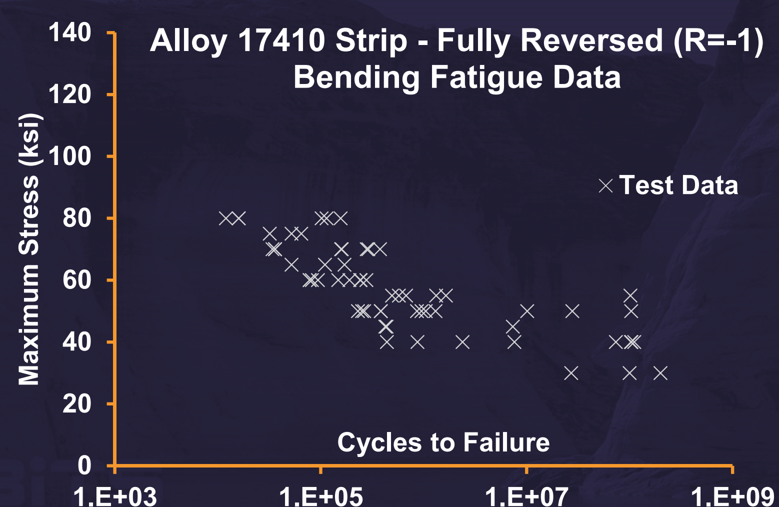
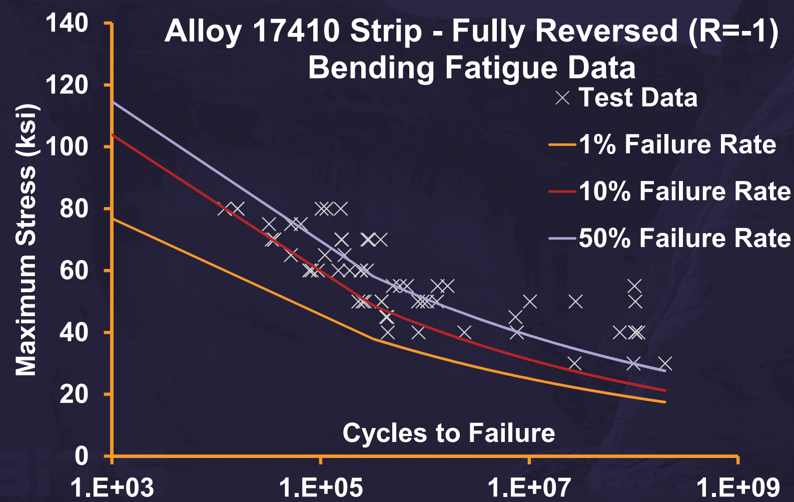
Temperature Rise FEA Results



Fatigue Strength



Importance of Statistical Analysis



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How Many Cycles will the Contact Survive?

- Use appropriate failure rate line
- Maximum 1st Principal Tensile Stress

OR

- Conduct Detailed Fatigue Simulation

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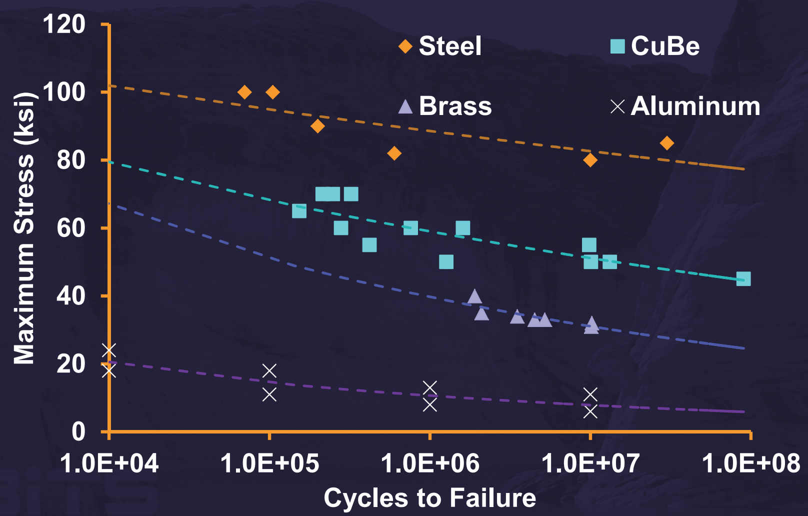
Fatigue Comparison



Burn-in Trends

- More Contacts
- Tighter Pitch
- Greater Current & Temperatures
- Higher Frequencies

More Contacts

- More contacts → higher force
  - Don't crack the DUT
  - Closure of socket
- Reduce force/contact to minimum
- Reduce contact size & Tighten pitch
  - Smaller contacts - greater resilience

Thermal Issues

- Higher Current
  - conductivity
  - stress relaxation resistance
- Higher Temperatures
  - stress relaxation resistance

Parasitic Capacitance

- Contact Spacing and area of adjacent faces
- Tighter pitches > greater capacitance
- Need shorter contacts with less area > lower force and/or higher stress

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Parasitic Inductance

- Loop area of circuit
- Tighter pitches > lower inductance
- Need shorter contacts > lower force and/or higher stress

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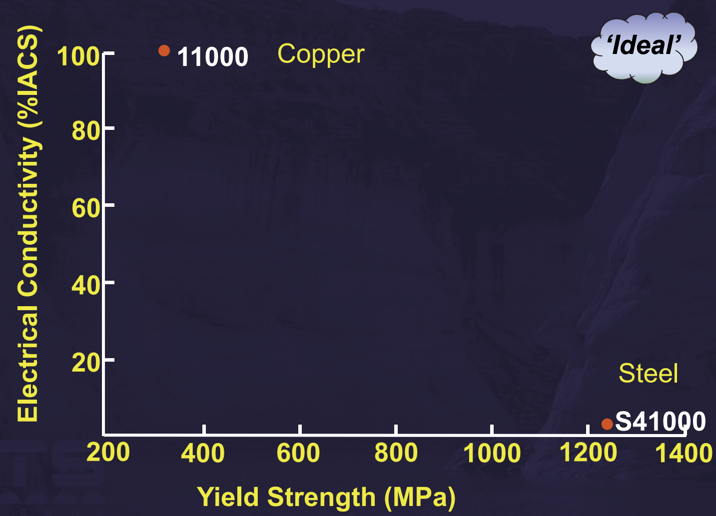
Strength – Conductivity Relationship



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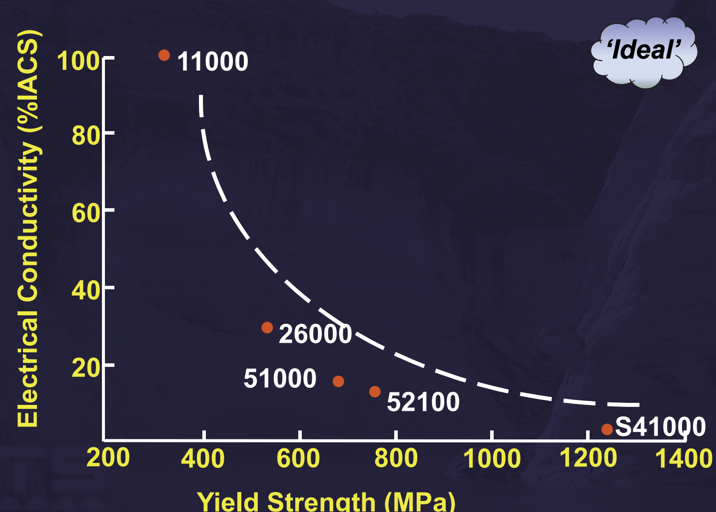
Metals of "Antiquity"



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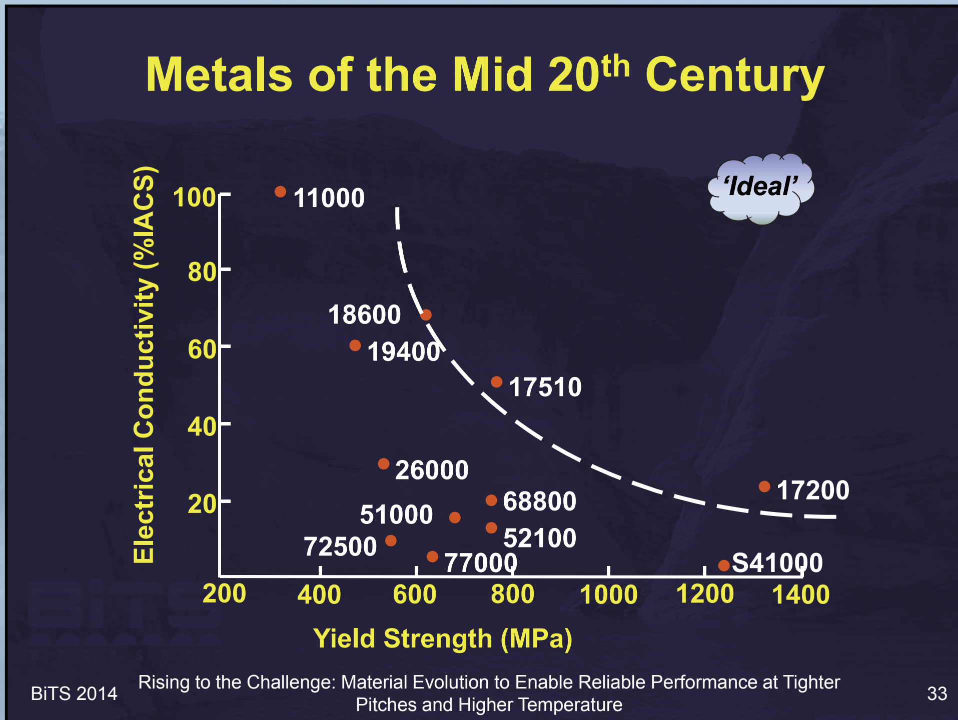
Metals of the Mid 20th Century
'Ideal'
Electrical Conductivity (%IACS)
Yield Strength (MPa)
100
80
60
40
20
200
400
600
800
1000
1200
1400
11000
18600
19400
17510
26000
17200
68800
51000
52100
72500
77000
S41000
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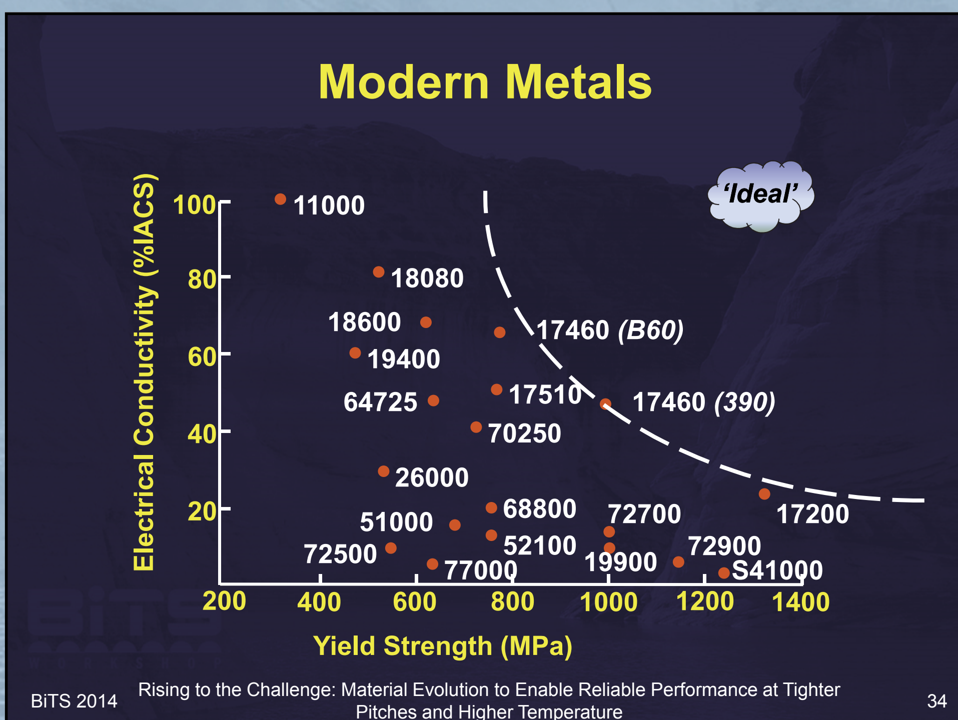
Modern Metals
'Ideal'
Electrical Conductivity (%IACS)
Yield Strength (MPa)
100
80
60
40
20
200
400
600
800
1000
1200
1400
11000
18080
18600
17460 (B60)
19400
64725
17510
17460 (390)
70250
26000
68800
72700
17200
51000
52100
72900
72500
19900
77000
S41000
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Summary

- Strength and conductivity are inversely related
- Strength and conductivity are both increasingly important to ensuring reliability
- Don't forget stress relaxation or fatigue
- New advances in materials science bring us ever closer to unobtanium