PRODUCT AND MATERIAL MÉLANGE

This final session focuses on new products and materials in the test and burn-in market. The first presentation looks at high-temperature burn-in readiness, discussing a burn-in socket solution designed to address cost, design and performance challenges of high temperature burn-in. Next on the agenda is a description of new technologies developed to produce high reliability stamped parts and elastomer contacts for a finer pitch and high performance applications. The final presentation covers a new and innovative ESD control molding compound for encapsulation, developed to reduce the ESD issues in the test process.

This Paper

High Temperature Burn-in (Up to 200º C): Are We Ready Yet?

Noriyuki Matsuoka, Kazumi Uratsuji —Yamaichi Electronics Co., Ltd.
Jec Sangalang—Yamaichi Electronics USA
Ryota Takeuchi—NGK Insulators, Ltd.

Development of High Performance Spring Probe Pin and Elastomer Contact by Stamping

Samuel Pak, A.J. Park—IWIN Co. Ltd.

ESD Safe Materials for Test Socket and Encapsulation

Tatsuya Kawasaki—Krefine Co., Ltd.

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2013 BiTS Workshop
March 3 - 6, 2013

Contents

- Background & Previous BiTS Work
- Present Socket's Performance at 200°C
- Key Considerations in Creating a 200°C Capable Burn-in Socket
- Examination of Contact and Mold materials in the market
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- Socket Evaluation at 200°C
- Compare 150°C and 200°C evaluation data
- Conclusions & Next Steps

Background

We've heard customer's demand to raise burn-in temperature several times over the last 30 years

To shorten burn-in time and reduce cost

The push to raise burn-in temperature is being heard from customers, once again

For Higher Reliability, especially for automotive

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Previous BiTS Work

Research Driving Forces

	...ature	Metric	2003	2005	2007	2009	2014	2019	Barrier
	...s	Types	SO, LGA, BGA, mBGA, QFN, DFN, CSP, etc.						
	...Matl.	Alloy	Cu Alloy [brass, BeCu]					Same/New	None
	...ontacts	#	1,000	1,000	2,000	3,000	5,000	10,000	10,000
	...avities	#	1	1	2	4	8	16	64
	...h	mm	0.65	0.4	0.3	0.3	0.25	0.2	100µm
	Max. Edge Rate	GHz	3	6	12	24	40	≥ 10Gbps	20Gbps
	Inductance	nH	1	1	0.4	0.3	0.2	0.1	0.1
Burn-In Sockets	Contact Matl.	Alloy	Cu Alloy [BeCu]					Same/New	None
	Max # Contacts	#	1,000	5,000	10,000	10,000	10,000	10,000	Pkg Size
	Max. # Cavities	#	16	32	32	64	64	64	64
	Min. Pitch	mm	1	0.8	0.65	0.5	0.3	≤0.3mm	0.2
	Max. Temp.	°C	150	150	150	175	250	250	250
	Housing	Material	Thermoplastic					250°C	250

Source: Bishop & Associates Inc., Post Recession Outlook Electronics Industry and Connector Road Map 2009-2019

3/2012 Using Clad Alloys to Make High Temperature Burn-in and Test Sockets 4

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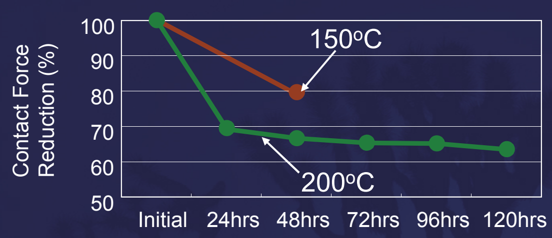
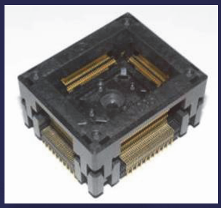
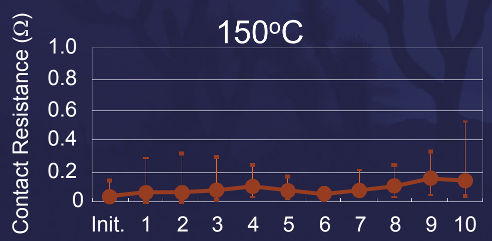
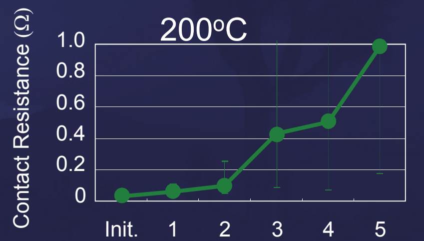
Present Socket's Performance at 200^{o}C







1 cycle : 150^{o}C 12hrs + 2k times actuation



1 cycle : 200^{o}C 24hrs + 4k times actuation

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Key Considerations in Creating a 200^{o}C Capable Burn-in Socket

- **Performance**

  Electrical : Stable contact resistance

  Mechanical : Minimal contact force reduction, Mechanical life

- **Socket outline**

  As small as possible but meeting performance expectation

  At least the same size as the current socket

- **Price**

  As low as possible

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Examination of Contact material

Key factors for contact material

Young's Modulus, Yield Strength and Cost

- **Contact Force : $P = \delta \times 3EI/Z_1$**
  - **δ : Displacement**
  - **E : Young's Modulus**
  - **I : Moment of inertia of area (Fixed by contact shape)**
  - **Z_1 : Fixed by contact shape**
- **Contact Stress : $\sigma = 6PZ_2$**
  - **Z_2 : Fixed by contact shape**
  - **Contact stress should be less than Yield Strength.**

Balance of Young's Modulus and Yield Strength is important.

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Examination of Contact material (Available materials in the market)

Contact Material

Present : BeCu
Considered : TiCu, NiBe

	BeCu	TiCu	NiBe
Young's Modulus (GPa)	127	127	195-210 BeCu x 1.6
Tensile Strength (MPa)	1328	885-1080	1584
Yield Strength (MPa)	1140	800-900 BeCu x 0.8	1380 BeCu x 1.2
Electrical Conductivity (%IACS)	22	10 to 13	4 to 6
Cost Comparison	100	120	650

No suitable contact material in the market for 200°C BI

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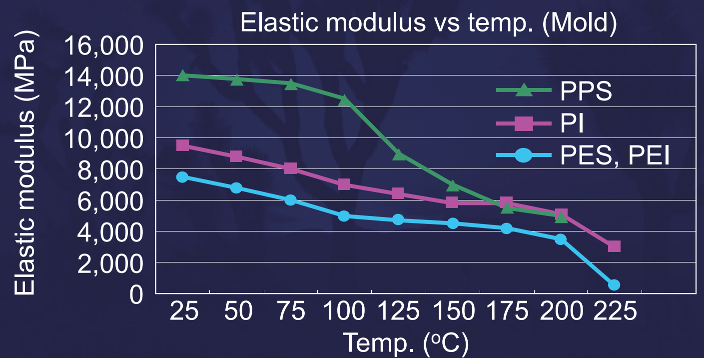
Examination of Mold material (Available materials in the market)

Mold Material

Present : PES, PEI

Considered : PPS, PI

	PES	PEI	PPS	PI
Deflection Temp.(°C)	216	209	270	245
Cost Comparison	100	120	70	650



Present mold material can be used

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To achieve the same features and price level of current socket . . .

•High performance, but costly material cannot be utilized

➢ Improve present BeCu as contact material
- Minimize contact force reduction at 200°C
- Keep good balance of Young's modulus and Yield strength
- Consider 600MPa stress at 200°C

➢ Re-consider contact force
- Special contact surface treatment cannot be applied
- Increase contact force per unit area with smaller contact area

➢ Utilize present PES as mold material

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Newly Developed BeCu

Succeeded in improving the present BeCu.

Result : Maintained Young's Modulus and
Electrical Conductivity
but Improved Yield Strength

Item	Unit	New BeCu	Present BeCu	Material spec of present BeCu
Young's Modulus	Gpa	127	127	---
Tensile Strength	MPa	1374	1328	1240 to 1440
Yield Strength	MPa	1270	1186	more than 1100
Electrical Conductivity	%IACS	24.1	25.0	More than 22

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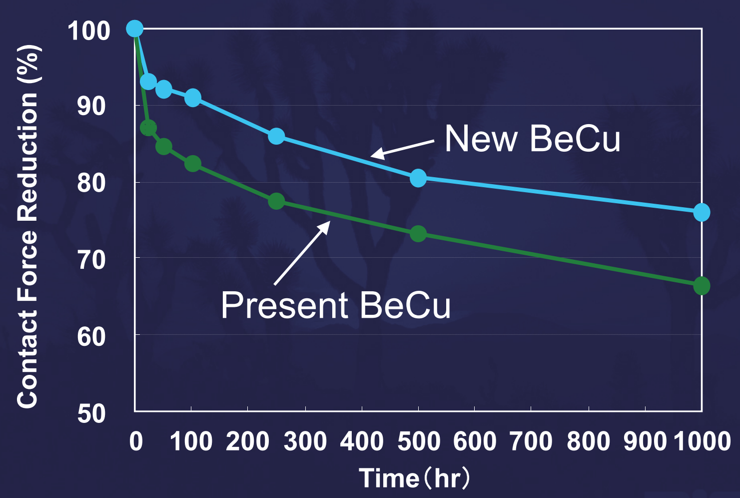
Newly Developed BeCu

Stress Relaxation

Temperature : 200°C
Surface Stress : 600 MPa



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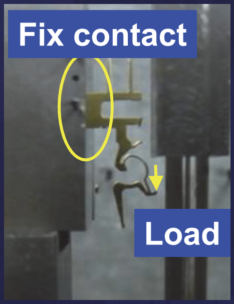
Stress Relaxation of actual contact

Comparison of New BeCu and Present BeCu

<u>Test Description</u>

1. Fix the base part of contact to the jig.
2. Load 0.22mm at contact point.
3. Heat soak at 200°C for 500hrs.
4. Measure Contact force and Contact deformation
5. Test sample : 3 contacts each

Test Jig



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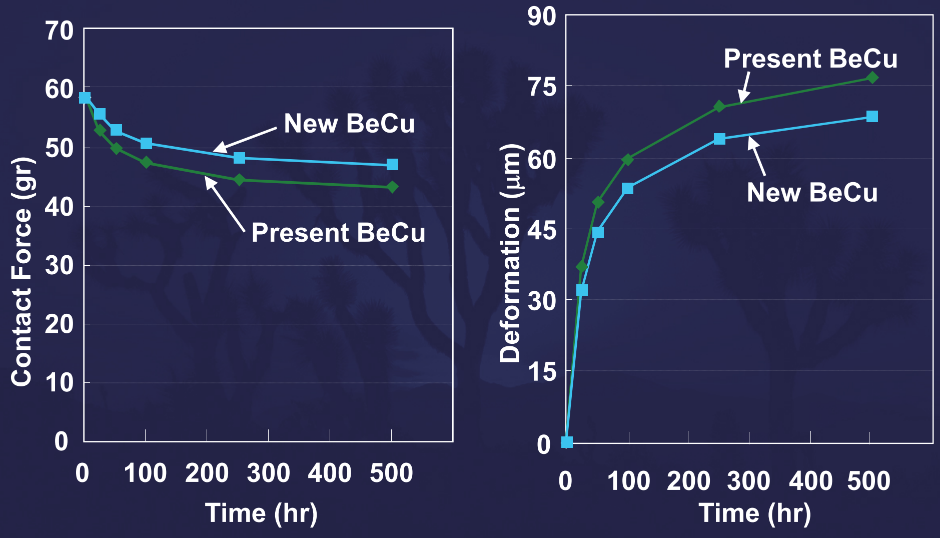
Stress Relaxation of actual contact



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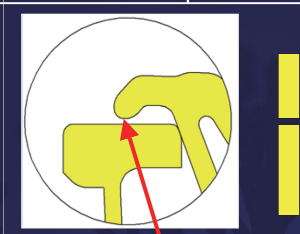
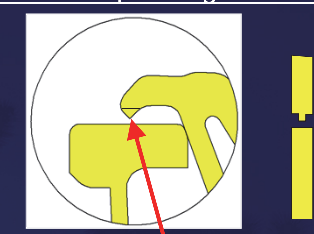
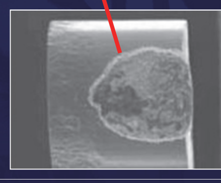
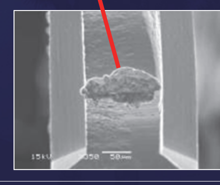
Contact force per unit area

	Present Shape - Round	New Shape - Edge + Coining
Contact Tip Shape		
Solder Transfer (Upper Contact)		
Contact Area mm^2	0.026	0.006
Ratio of Contact force per unit area	1	4.3

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Socket Evaluation at 200°C

Heat and Mechanical Stress test-1

<u>Test Description</u>

1. Check the contact force reduction and contact resistance under the test condition below;
2. Set "heat soak at 200°C for 24hrs and 4k times actuation" as 1 cycle.
3. Repeat up to 5 cycles
4. Measure Contact force and Contact resistance at "initial" and every cycle.
5. Contact resistance : for 2 contacts
6. IC device lead plating : Sn-Bi
7. Test sample : 1 each (details on the next page)

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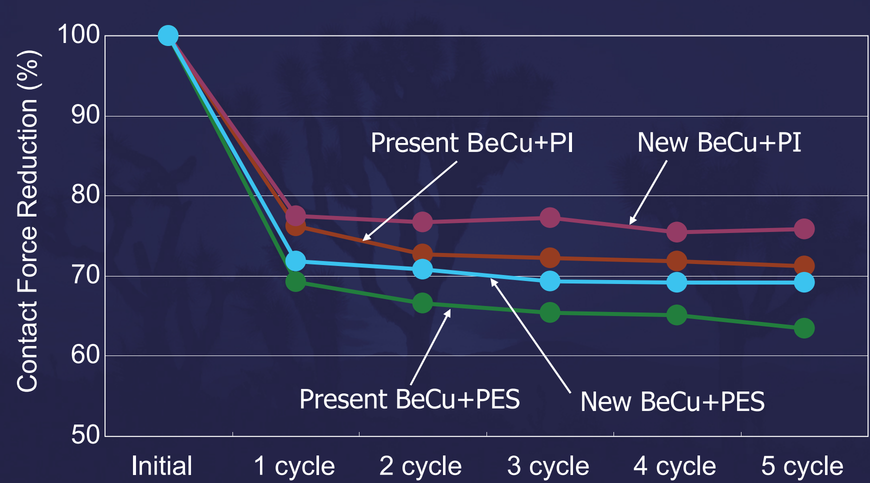
Socket Evaluation at 200°C

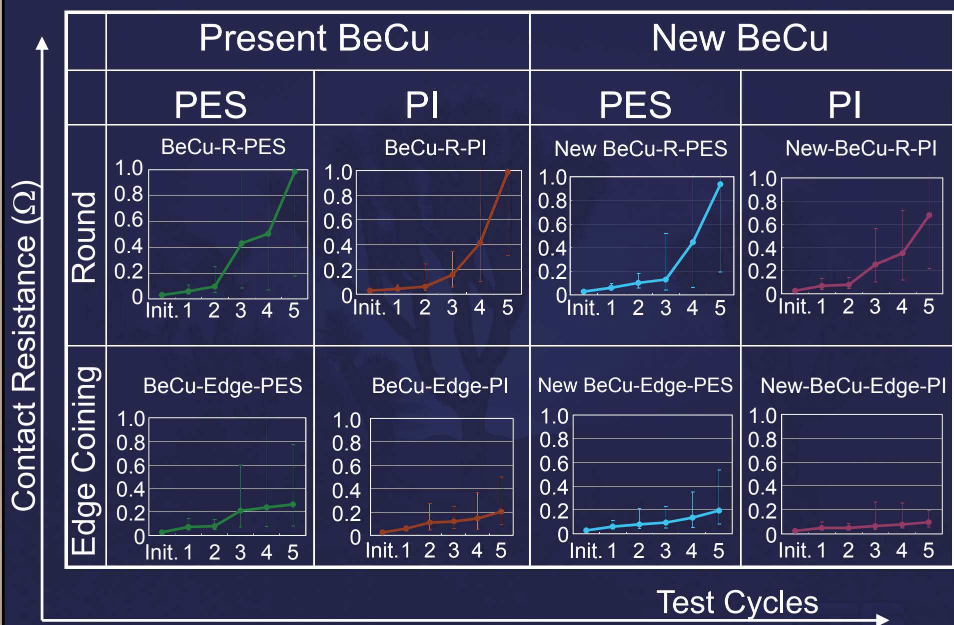
Test sample : 1 each

Contact Material	Contact Tip Shape	Mold Material	Contact Force	Contact Resistance
Present BeCu	Round	PES	✓	✓
		PI	✓	✓
	Edge + Coining	PES	---	✓
		PI	---	✓
New BeCu	Round	PES	✓	✓
		PI	✓	✓
	Edge + Coining	PES	---	✓
		PI	---	✓

Contact Force Reduction



Contact Resistance



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Heat and Mechanical Stress test-2

Test Description

1. Check the contact resistance and observe IC lead and contact tip under the test condition below
2. Set "heat soak at 200°C for 12hrs and 2k times actuation" as 1 cycle.
3. Repeat up to 10 cycles.
4. Measure Contact resistance at "initial" and every cycle.
5. Contact resistance : for 2 contacts
6. Observe contact mark on IC lead
7. Observe contact tip after 10 cycles
8. IC device lead plating : Sn-Bi
9. Test sample : 2 (New BeCu + Edge with coining + PES)

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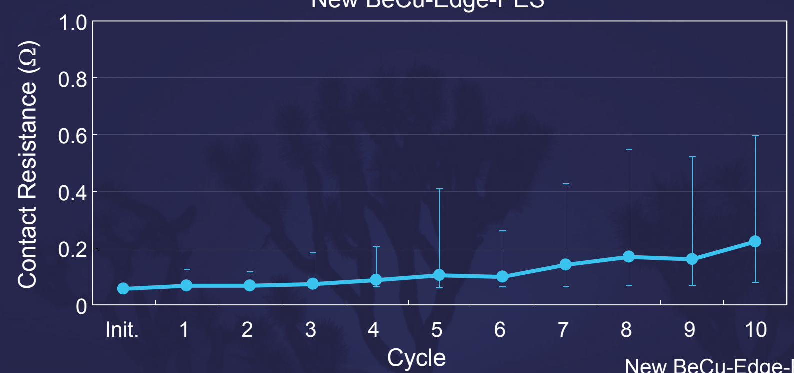
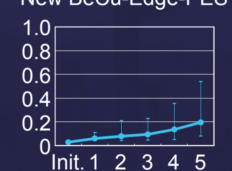
Contact Resistance



Almost the same result with test-1

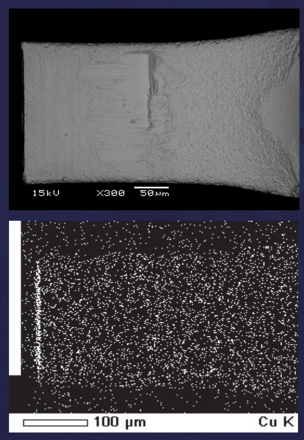


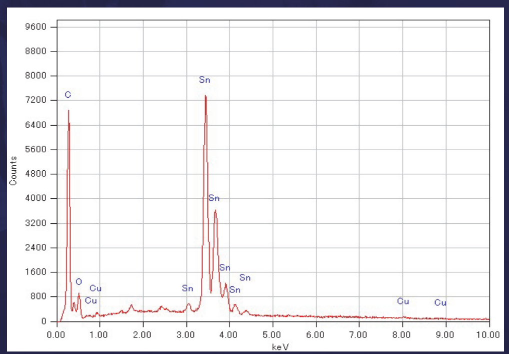
Reference : Result of test-1

Observation of contact mark on IC lead

New device lead after 10 cycles

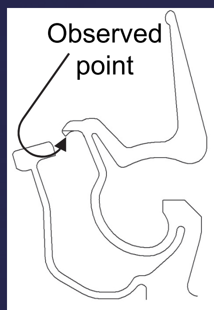
IC lead's base material did not get exposed



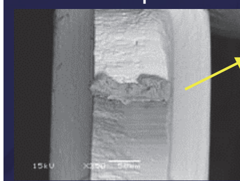


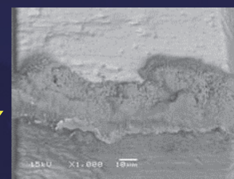
Observation of contact tip

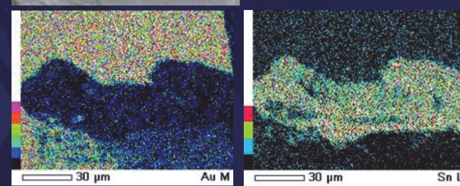
After 10 cycles



SEM picture

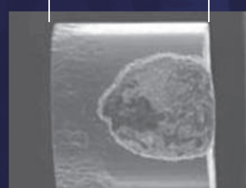






Same Contact Width

Round Shape Contact



Solder Transfer is observed.
Solder transferred area is small.

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Mechanical stress test

Actuate the contact pins until one of them is broken.

Room Temperature

Test Sample : 1 each

Assembled in socket

Test Result

Present BeCu : 23k (Broke in 24k)

New BeCu : 23k (Broke in 24k)

No difference between new BeCu and Present BeCu in terms of mechanical durability

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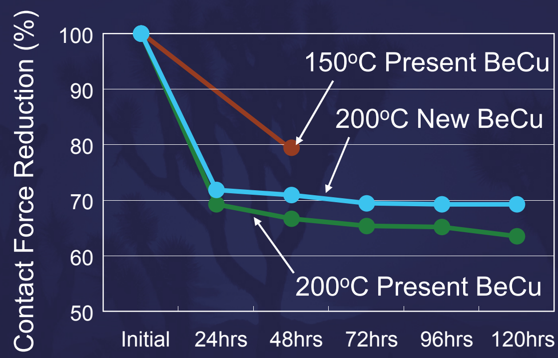
Compare 150°C and 200°C evaluation data

Contact force reduction



Contact Force Reduction of New BeCu at 200°C is larger than Present BeCu at 150°C but smaller than Present BeCu at 200°C

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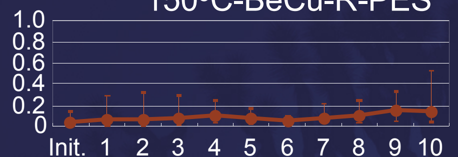
Compare 150°C and 200°C evaluation data

Contact Resistance

Contact Resistance (Ω)

150°C-BeCu-R-PES

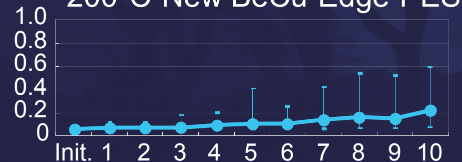


1 cycle : 150°C 12hrs + 2k times actuation

200°C-BeCu-R-PES

1 cycle : 200°C 24hrs + 4k times actuation

200°C-New BeCu-Edge-PES



1 cycle : 200°C 12hrs + 2k times actuation

Contact Resistance of New BeCu + Edge shape contact at 200°C is almost the same as the Present BeCu at 150°C

Test Cycles

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Conclusions

QFP Open Top Socket with combination of Newly Developed BeCu, Edged Contact Tip and Present Mold can be used for 200°C Burn-in.

The same level of

Contact Resistance,
Contact Mechanical Life,
Contact Electrical Conductivity,
Socket Outline,
Operation Force

as 150°C Burn-in can be achieved.

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Next Steps

- More Field trials with customers.
- Try with BGA Tweezers style contact Open Top Socket.
- Try to improve mold material for better stability.

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