New Evolution of Copper Wire

“Convergence”
Gold price per Ounce during the last decade

Sources: Kitco
In Global Electronics the most emphasized precious metal is Gold.
Question is how to cut the cost while using Gold (Au) metal?

1. Reduce the thickness of Au plating on the substrate

2. Use alternative metals instead of Au wire

Reduce the material cost of PKG

Target is to optimize the combination between the Surface finish material and Wire bond material
Industry Market Acceptance for Cu Wire Adoption

Main Issues/Concerns that would Prevent the Use of Copper Wire

- Process Yield
- In-Service Reliability
- Incremental Process Costs
- Unproven Historical Performance
- Customer Specification
- Other
- None

Top 3-concerns carry over to 2011 & 2012?

- Biggest obstacle? Market Acceptance
  - Not wanting to be first to change from known Au wire performance and acceptance criteria to lesser known Cu wire performance
  - Adoption rate for multiple markets increasing dramatically
Concerns Listed (iNemi January 2011)

**Question:**
What are the major concerns with Cu wire bonding?
- In-service reliability
- Process yield
- Throughput
- JEDEC reliability spec
- Unproven historical performance
- Manufacturing Statistical Process Control
- Equipment and assembly process parameters

**Survey Result:**
- Reliability and historical performance are major concerns for the OEM community.
- Suppliers have concerns in these areas as well but to a lesser degree.
- Suppliers have additional concerns on throughput and yield.

When “In-service Reliability” is selected, the major reason is lack of use history (80%), then follow with “unknown or poor correlation of JEDEC testing with in-field performance” (20%).

Note difference between Suppliers and Customers
Industry Analysis Copper Wire Growth

Industry Projection Summary

- **Prismark Copper Wire Use**
  - 2013 ~ 1.65 Billion Meters

- **Semi Copper Wire Use**
  - 2013 ~ 4.6 Billion Meters

Source: Semi

Source: Prismark

CAGR Estimate 2007 – 2013

- Total BW CAGR ~ 6%
- Cu wire CAGR ~ 67%

CAGR = compounded annual growth rate

Source: Semi
World Wide Copper Wire Market Adoption

**WW Au, Cu and PCC wire shipped**

Source: Tech Search

**Gold vs. Copper Wire: Copper is ~11% of the market**

Annual Gold and Copper Wire Consumption

Source: SEMI
Tanaka Copper Wire Business & Forecast

Tanaka Projections
- Copper Wire Ramp Started 2009
- Copper Wire Shipments
  - 2011 Over 11% Cu Wire Shipments
  - 2013 Over 40% Cu Wire Shipments

Source: Tanaka
Copper Wire End Markets

- Different end markets implementing at different rates, but all are moving forward

<table>
<thead>
<tr>
<th>Market</th>
<th>Current Adoption</th>
<th>Activity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer/Computer</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Mobile Handset</td>
<td>Mid</td>
<td>High</td>
</tr>
<tr>
<td>Networking/Server</td>
<td>Mid</td>
<td>Mid</td>
</tr>
<tr>
<td>Automotive</td>
<td>Low</td>
<td>Initial</td>
</tr>
</tbody>
</table>

Applications
- Consumer – HDTV, DVD, Digital Frame, Digital Camera
- Communication – Cell Phone, Blue Tooth, Wireless
- Computer – USB Controller, Power Manage, MPG Encoder
- Network – ADSL, Switch, PWM, Video Decoder

Electronics Network Revolution
Are you ready?

The Future is Precious.
Product Distribution

➢ Semiconductor Application Revenue

2009

- Communication: 27%
- Automotive: 7%
- Consumer: 17%
- Data processing: 40%
- Industrial: 8%
- Military/civil aerospace: 1%

2014

- Communication: 24%
- Automotive: 7%
- Consumer: 18%
- Data processing: 43%
- Industrial: 7%
- Military/civil aerospace: 1%

Source: Gartner (2010)

➢ Market of Mobile phone & Advanced Portable Systems

2009

- WB-CSP: 10%
- FCCSP: 12%
- FBGA: 63%

2014

- WB-CSP: 19%
- FBGA: 30%
- FCCSP: 51%

Source: Gartner
Majority of IC interconnects are wire bond ~75%-80%
# Copper Wirebond Silicon Node Roadmap

<table>
<thead>
<tr>
<th>Technology Items</th>
<th>HVM (Production) few years now</th>
<th>Qualified &amp; HVM</th>
<th>2011 (NPI)</th>
<th>2011/2012</th>
<th>2012/2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer Technology</td>
<td>CMOS</td>
<td>Low-K</td>
<td>ULK / ELK</td>
<td>ULK / ELK</td>
<td>ULK / ELK</td>
</tr>
<tr>
<td></td>
<td>0.13 um and higher nodes</td>
<td>90/ 65 nm</td>
<td>45/ 40 nm</td>
<td>28 nm</td>
<td>22 nm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology Items</th>
<th>HVM few years</th>
<th>Qualified &amp; HVM</th>
<th>2011 (NPI &amp; HVM)</th>
<th>2011/2012</th>
<th>2012/2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Wire (Pd_Cu/bare Cu)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bond Pad Pitch (um)</td>
<td>65</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Bond Pad Open (um)</td>
<td>58</td>
<td>40</td>
<td>40</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Wire Diameter (mil)</td>
<td>0.9</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Line up of TANAKA Cu-Bonding wires

New
- CFB-1 [Bare-Cu]
  Stitch bond is excellent

New
- CLR-1A [Coating-Cu]
  Long Capillary Life

- CLR-1 [Coating-Cu]
  Coating 4N-Cu wire

- TCA1 [4N-Bare Cu]
  99.99% Standard wire

- TCB1 [4N-Bare Cu]
  Stitch bond is good

- TPCW [4Nup-Bare Cu]
  High purity wire

- TOCW [3N-Bare Cu]
  Squashed ball shape is good
Copper Technical Challenges
Copper Wire versus Gold Wire

Advantages

- Low Material Cost (Approx 30-50% lower than Au)
- Better Conductivity (Approx 20% better than Au)
- Higher Fusing Current (Approx 30% higher than Au)
- Low Reaction Rates (Cu/Al IMC @ 150-300C 10x slower Au/Al)

Disadvantages

- Need N2 or Forming Gas (Gas necessary for Copper wb)
- Higher Mechanical Strength (FAB hardness, Work Hardening)
- Narrow parameter window at 1st & 2nd bonding process
- Require halogen free resin
- Need additional investments (Cu bonder, Forming gas piping)
Cu Wire Bonding Process Window Comparison

- Copper wire is harder than Gold wire

Diagram:
- Bonding Parameters
  - High
  - Low
- Parameter Range
  - Low Parameters: Wide Range
  - High Parameters: Narrow Range
  - Cu Wire Parameters: Narrow Range
  - Std Parameters: Wide Range

First Bond:
- High Parameters
- Narrow Range

Second Bond:
- Cu Wire Parameters
- Narrow Range

Images:
- First Bond Image
- Second Bond Image
Existing Common problem in Cu bonding

- Lifted Metal occurs at lower side of optimum parameters

Aluminum splashing shorting to adjacent pad

Lifted Metal
Existing Common problem in Cu bonding

Short tail / No tail issue

Parameter Range

Low Parameters

High Parameters

Optimum Parameters

Cu
How to achieve Process Window closer to Au for Fine Pitch Bonding???

Parameter Range

- **PdCu closer to Au wire wb performance**

<table>
<thead>
<tr>
<th>Gases</th>
<th>USG 9</th>
<th>PreBleed</th>
<th>USG 20</th>
<th>PreBleed</th>
</tr>
</thead>
<tbody>
<tr>
<td>N2H2</td>
<td></td>
<td>20</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td>9</td>
<td></td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>N2</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The Future is Precious.
Palladium Coated Copper
Palladium Coated Copper Wire

- Atomic # 46 (Member of the Platinum Group)
  - ½ worlds supply goes into catalytic converters
  - Palladium is used as an oxidation catalyst
  - Palladium is 10% harder than platinum
    - Pt is harder than Au
    - Pd softer than Cu (good adhesion to Cu wire)
- 3N Copper FAB is 30% harder than Au FAB
- PdCu alloy FAB harder than bare Cu FAB
- Oxidation Free (longer storage/shelf & bonder life)
- Copper and Gold tensile strengths are comparable
  - Copper has higher elongation than Gold which means Copper can withstand plastic deformation longer
- Palladium Copper bonded products are ‘one-to-one’ pin compatible with Au bonded products.
  - No form, fit or function change
- SMT and System level customers do not need to do anything different in receipt and use of the Palladium Copper products
## (Gen I) Palladium Coated Wire: CLR-1

**Copper bonding wire, Long life & Robust stitch bond**

### Comparison with Bare Copper wire

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longer Spool Lengths (1km – 5km/spool)</td>
<td>Price is higher than bare copper</td>
</tr>
<tr>
<td>Wider 2(^{nd}) bond window/Higher 2(^{nd}) bond pull</td>
<td>(Au relative value 1.0, bare Cu 0.2, PdCu 0.4 in HVM)</td>
</tr>
<tr>
<td>Chemical Stability</td>
<td>FAB is harder (possible pad damage)</td>
</tr>
<tr>
<td>Better HAST (BGA)</td>
<td>Capillary Life</td>
</tr>
<tr>
<td>Longer shelf life; 6 months after manufacturing date, 1 month after opening package (bare Cu 1-week after opening)</td>
<td></td>
</tr>
</tbody>
</table>

4N Bare Cu wire

Thin Coated layer

CLR-1 \( \phi 20\)um

![Image of 4N Bare Cu wire with thin coated layer and CLR-1 wire]
Manufacturing Process Comparison Copper Wire

**Bare Cu wire**
- Melting Casting → Drawing → Annealing → Winding

**Coated Cu wire**
- Melting Casting → Drawing → Coating → Drawing → Annealing → Winding
Next Generation
...Bonding Wire
## (Gen II) Palladium Coated wire: CLR-1A

**Diagram:**
- CLR-1 (Gen I)
- 4N Bare Cu wire
- Pd Coated layer
- Thin Au layer

### Compare with CLR-1 (Gen I)

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wider 2(^{\text{nd}}) bond window/Higher 2(^{\text{nd}}) bond pull</td>
<td>New Qualification</td>
</tr>
<tr>
<td>Slightly softer FAB</td>
<td>PCN</td>
</tr>
<tr>
<td>Reduce capillary drag</td>
<td></td>
</tr>
<tr>
<td>Fine pitch applications</td>
<td></td>
</tr>
<tr>
<td>SSB bonding</td>
<td></td>
</tr>
<tr>
<td><strong>Same Cost as CLR-1 (Gen I)</strong></td>
<td></td>
</tr>
</tbody>
</table>
Capillary drag force set up

【Measurement condition】
・Wire drag speed: 10(mm/sec)
・Wire drag angle (deg)
  ①55, ②60, ③65, ④70, ⑤75, ⑥80
・Measurement length: 100(mm)
・Capillary: SPT
・Capillary condition
  ①New,
・Wire type
  ①CLR-1A φ 18um,
  ②CLR-1 φ 18um
  ③Competitor φ 18um

【Measurement result】
・Summarized by from four directions data averaged
<table>
<thead>
<tr>
<th>Angle(°)</th>
<th>AVG</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CLR-1</td>
<td>CLR-1A</td>
<td>Competitor n=1</td>
<td>Competitor n=2</td>
</tr>
<tr>
<td>55</td>
<td>0.06</td>
<td>0.01</td>
<td>0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>60</td>
<td>0.14</td>
<td>0.04</td>
<td>0.48</td>
<td>0.23</td>
</tr>
<tr>
<td>65</td>
<td>0.19</td>
<td>0.09</td>
<td>0.65</td>
<td>0.40</td>
</tr>
<tr>
<td>70</td>
<td>0.28</td>
<td>0.15</td>
<td>0.81</td>
<td>0.69</td>
</tr>
<tr>
<td>75</td>
<td>0.41</td>
<td>0.25</td>
<td>0.94</td>
<td>1.08</td>
</tr>
<tr>
<td>80</td>
<td>0.59</td>
<td>0.34</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Au/Cu/PdCu Hardness & Compression Comparisons

Cross section Hv hardness of FAB

Compression stress of FAB is squashed side direction

[FAB Making condition]
- Wire: \( \phi 20 \mu m \)
- FAB: 40 \( \mu m \)
- Bonder: Maxum plus
- Gas: \( \text{N}_2-5\%\text{H}_2 \)

[Measurement Equipment]
- Hardness Tester: MVK-3 (AKASHI)

[Measurement condition]
- Force: 2 gf
- Press Speed: 3 \( \mu \text{m/sec} \)
- Hold time: 10 sec
- Measurement count \( n=5 \) each

[FAB Making condition]
- Wire: \( \phi 20 \mu m \)
- FAB: \( \phi 40 \mu m \)
- Bonder: Shinkawa UTC-1000
- Gas: \( \text{N}_2-5\%\text{H}_2 \)

[Measurement Equipment]
- Compression Tester: MCT-W500 (SHIMADZU)

[Measurement Conditions]
- Compression speed: 100 mN/sec
- Maximum Load: 1000 mN

![Graphs showing hardness and compression stress comparison between 4N-Au, Bare Cu, and CLR-1.]
FAB Hv hardness Comparisons

FAB make
- Wire: TCA1, CLR-1, Competitor φ 20um
- FAB: φ 38um
- Bonder: UTC-3000
- EFO: 80mA, 0.12-0.14ms
- Gas: N₂+5%H₂, 0.5L/min
- Measurement count n=3-5

Hv hardness
【Measurement Equipment】
- Hardness Tester : MVK-3 (AKASHI)
【Measurement condition】
- Force : 2gf
- Press Speed : 3 μm/sec
- Hold time : 10sec
- Measurement count n=5 each

Molded by epoxy resin
Polish and buff
Ion milling
Hv hardness

Molded by epoxy resin
Polish and buff
Ion milling
Hv hardness

FAB Hv hardness: Competitor1 > Competitor2 > CLR-1A > TCA1
FAB Compression Test (Gen I/Gen II vs. Competitor)

Compression stress and deformation plot of FAB.

<table>
<thead>
<tr>
<th>Compression Stress (MPa)</th>
<th>CLR-1A</th>
<th>CLR-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVE</td>
<td>Lot A</td>
<td>Lot B</td>
</tr>
<tr>
<td>Std</td>
<td>6.0</td>
<td>4.2</td>
</tr>
<tr>
<td>1</td>
<td>85.3</td>
<td>90.5</td>
</tr>
<tr>
<td>2</td>
<td>83.5</td>
<td>90.9</td>
</tr>
<tr>
<td>3</td>
<td>84.5</td>
<td>96.5</td>
</tr>
<tr>
<td>4</td>
<td>83.9</td>
<td>88.8</td>
</tr>
<tr>
<td>5</td>
<td>87.0</td>
<td>92.3</td>
</tr>
<tr>
<td>6</td>
<td>96.6</td>
<td>83.2</td>
</tr>
<tr>
<td>7</td>
<td>92.8</td>
<td>85.6</td>
</tr>
<tr>
<td>8</td>
<td>79.5</td>
<td>84.4</td>
</tr>
<tr>
<td>9</td>
<td>95.9</td>
<td>93.6</td>
</tr>
</tbody>
</table>

Compliance Test: "CLR-1A" is equal to "CLR-1"
### 2nd Bond Process Window PPF QFN

#### 2nd-Bond parameter window

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CLR-1A</strong></td>
<td>NSOL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SHTL</td>
</tr>
<tr>
<td><strong>Competitor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Bonding condition

- **Bonder:** UTC-3000
- **Wire dia.:** 20um
- **Capillary:** SU-25080-385F-ZU34TP
- **Gas:** N2-5%H2 0.5l/min
- **Frame:** PPF Flat
- **Bond Temp.:** 240degC
- **160wires**

#### Frame structure

- Pd
- Ni
- Cu

#### Machine Stop

- **Non stop**
- **1 stop**
- **2 stops up**

The parameter window of CLR-1A spreads in the low condition side in comparison with Competitor wire.
2nd Bond stitch pull PPF QFN Data Comparison

Evaluation of wire pull load

![Graph showing 2nd Pull Load vs. Bond parameter]

- **Bonder:** UTC-3000
- **Wire dia.:** 20um
- **Capillary:** SU-25080-385F-ZU34TP
- **Gas:** N2-5%H2 0.5l/min
- **Frame:** PPF Flat
- **Bond Temp.:** 240degC

Pull condition:
- **Pull:** 1000um
- **250um**
Comparisons (Gen I vs. Gen II) CLR-1 & CLR-1A

Mechanical Property: "CLR-1A" is equal to "CLR-1". Wedge pull strength and Ball shear response is equal.
CLR-1A (Gen II) SSB bonding

Evaluation

Sample CLR-1A, CLR-1 (Diameter: 0.8 mil)
Flame: QFP200pin Ag-plated (42 alloy) 4 positions
Chip: RENESAS DG001  Al-0.5%Cu-1%Si (t=0.8um) / SiO2 (t=0.6um) / Si
Bonder: KnS ICONN
Capillary: H9 (23um), CD12 (30um), T28 (70um)

Bonding Layout

USG Direction
CLR-1A (Gen II) SSB bonding Comparison Data

Test position

N=20, \( \phi \) 0.8mils

- CLR-1A
- Ref.
- CLR-1

Center Pull Strength (gf)

- CLR-1A
- Ref.
- CLR-1

SBB Pull Strength (gf)

- CLR-1A
- Ref.
- CLR-1

The Future is Precious.
Reliability
HAST of CLR-1 bonded BGA and molded halogen-free resin is better than bare copper.

**UHAST Halogen Free MC: "CLR-1" is better than bare Copper**
UHAST Comparisons (Gen I vs. Gen II)

HAST, 130degC, 85%rh, BGA, Halogen-resin, WD20um

Bonder: Shinkawa UTC-1000
Forming Gas : N2-5%H2, 0.5l/min
Die-Pad : Al-0.5%Cu (t=0.8um)
(Hitachi 6mm□ Al-Cu0.5%)
Capillary : SPT SI-25130-385E-ZS36
(H:25, T:130, CD:38, FA:8, OR:30)
Wire Dia. : 20um
FAB Dia.: 40um
Squashed Ball Dia. : 50um

UHAST w/Halogen MC: "CLR-1A" is equal to "CLR-1"
UHAST Comparisons (Gen I vs. Gen II)

HAST 130deg C 85%rh, QFP, Green resin

UHAST Halogen Free MC: "CLR-1A" is equal to "CLR-1"
HTS Comparisons (Gen I/Gen II vs. Competitor)

HTS 220deg C, QFP, Non green resin

Bonder: K&S Maxum Plus
Forming Gas : N2-5%H2, 0.5l/min
Die-Pad : Al-0.5%Cu (t=0.8um)
(Hitachi 6mm □ Al-Cu0.5%)
Capillary : SPT SI-25130-385E-ZS36
(H:25, T:130, CD:38, FA:8, OR:30)
Wire Dia. : 20um
FAB Dia. : 40um
Squashed Ball Dia. : 50um

HTS: "CLR-1A" is better than both CLR-1 & Competitor
Mechanism of HAST-BGA failures with Copper Wire

- Cu/Al boundary was attacked by moisture on HAST test of BGA.
- The BGA substrate is bent more easily by heat & Assy handling compared with lead frames. Water can seep into boundary of Al splash and Cu 1st bond.
- It is presumed that the possibility of preventing moisture attack is HIGH if Pd exists on the copper surface.
Mechanism of HTS LF failures with Copper Wire

- Cu/Al boundary was attacked by halogen contained in resin on HTS test.
  - Even halogen free resin, halogens of less than 0.09wt%. *JPCA standard can exist (JPCA-ES-01-1999)
- Cu/Al IMC change to aluminum bromide by priority.

\[
Cu/Al + Br^- \rightarrow Al_2Br_3 + Cu
\]
*Aluminum bromide MP. 97.5 deg C
*Water-soluble
Fine Pitch PdCu
Ultra Fine Pitch Capability - 45um BPP with 0.7mil Pd Copper wire

Platform:
Device: BGA substrate with 1.4um Al metallization
Wire type: Tanaka Pd coated copper 0.7mil
Wire bonder: ASM Eagle 60AP
Capillary: SU-20058-233E-ZU36TP-200

Ball size 29um
Ball size + Al splash = 32-33um
<table>
<thead>
<tr>
<th></th>
<th>Wire Pull</th>
<th>Ball Shear</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ave</strong></td>
<td>7.344</td>
<td>8.9562</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>7.862</td>
<td>9.619</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>6.74</td>
<td>8.402</td>
</tr>
<tr>
<td><strong>std. dev</strong></td>
<td>0.272</td>
<td>0.326</td>
</tr>
</tbody>
</table>

after ball shear– Al shear
Lead Frame Plating Tested

【Electro Ag plating】
- Ra=0.236um
- Rz=4.867um
- Ag
- Cu
- 42Alloy
- 2.5um Min
- 0.005um Frame

【Electro Au plating】
- Ra=0.137um
- Rz=1.289um
- Cu
- Ni
- Au
- 0.2um
- 1um
- 1um
- 0.8um
- Frame

【Pd-PPF】
- Ra=0.078um
- Rz=1.206um
- Cu
- Ni
- Pd
- 0.03um
- 0.006um
- Frame

42Alloy Frame

Ag = 2.5um Min
Cu = 0.005um
Ni = 1um
Au = 0.2um
Pd = 0.03um
Cu = 1um
Frame
### Parameter window of 2nd bond

Wire diameter: 20um

<table>
<thead>
<tr>
<th>Ag plating</th>
<th>US</th>
<th>Force (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Ag plating</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Ag plating</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Ag plating</td>
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<td>50</td>
</tr>
<tr>
<td>Ag plating</td>
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<td>43</td>
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</tbody>
</table>

- Bare Cu 4N wire –
  (TCA1)

<table>
<thead>
<tr>
<th>Au plating</th>
<th>US</th>
<th>Force (g)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Au plating</td>
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<td>50</td>
</tr>
<tr>
<td>Au plating</td>
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</tr>
<tr>
<td>Au plating</td>
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</tr>
<tr>
<td>Au plating</td>
<td>70</td>
<td>10</td>
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</table>

- Pd coated Cu wire –
  (CL1-A)

<table>
<thead>
<tr>
<th>Pd plating</th>
<th>US</th>
<th>Force (g)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Pd plating</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Pd plating</td>
<td>50</td>
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<td>50</td>
</tr>
<tr>
<td>Pd plating</td>
<td>70</td>
<td>4</td>
</tr>
</tbody>
</table>

NSOL wire count in 50 wires

- Bare Cu 4N wire –
  (TCA1)

- Pd coated Cu wire –
  (CL1-A)
Various Wire Process Windows
PCB Plating

Wire bond material

- Electroless Plating process -

Surface finish material on PCB

【ENEPIG】

- Au = 0.05-0.10um
- Pd = 0.05um
- Ni = 5-7um
- Cu PCB

【ENIG】

- Au = 0.1-0.2um
- Ni = 5-7um
- Cu PCB

- Ag wire (SEA)
- Bare Cu wire (TCA1)
- Pd coated Cu wire (CLR1)
- Pd coated Cu wire (CLR1A)
### Parameter window of 2nd bond (ENIG vs ENEPIG)

#### ENIG process (Electroless Ni/Au)

**Au wire (GFC)**

<table>
<thead>
<tr>
<th>Process</th>
<th>Ultrasonic energy (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
</tbody>
</table>

**Ag wire (SEA)**

<table>
<thead>
<tr>
<th>Process</th>
<th>Ultrasonic energy (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>25</td>
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<td>40</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
</tbody>
</table>

#### ENEPIG process (Electroless Ni/Pd/Au)

**Au wire (GFC)**

<table>
<thead>
<tr>
<th>Process</th>
<th>Ultrasonic energy (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
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<tr>
<td>40</td>
<td>0</td>
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<tr>
<td>50</td>
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<tr>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
</tbody>
</table>

**Ag wire (SEA)**

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<td>60</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
</tbody>
</table>
### Parameter window of 2nd bond (ENIG vs ENEPIG)

**ENIG process (Electroless Ni/Au)**

<table>
<thead>
<tr>
<th>Bare Cu wire (TCA1)</th>
<th>Pd coated Cu wire (CLR1)</th>
<th>Pd coated Cu wire (CLR1A)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process</strong></td>
<td><strong>Ultrasonic energy (mA)</strong></td>
<td><strong>Process</strong></td>
</tr>
<tr>
<td>20</td>
<td>20 25 30 35 40 45 50 55 60 65 70 75</td>
<td>20 25 30 35 40 45 50 55 60 65 70 75</td>
</tr>
<tr>
<td>Au:0.1um</td>
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<td></td>
</tr>
<tr>
<td>Force (g)</td>
<td>40 20 20 20 20 13 10 5 3 2 0 0 0</td>
<td>40 20 20 11 7 3 0 0 0 0 0 0</td>
</tr>
<tr>
<td></td>
<td>50 20 20 16 13 6 3 1 0 0 0 0 0</td>
<td>50 20 20 8 2 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td></td>
<td>60 20 10 6 2 0 0 0 0 0 0 0 0 0</td>
<td>60 20 6 3 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td></td>
<td>70 20 12 0 0 0 0 0 0 0 0 0 0 0</td>
<td>70 20 3 0 0 0 0 0 0 0 0 0 0</td>
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<tr>
<td>Au:0.2um</td>
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<tr>
<td>Force (g)</td>
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<td>40 15 10 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td></td>
<td>50 20 20 20 12 6 2 0 0 0 0 0 0 0</td>
<td>50 10 7 0 0 0 0 0 0 0 0 0 0</td>
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<td></td>
<td>60 20 18 4 0 0 0 0 0 0 0 0 0 0 0</td>
<td>60 5 2 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td></td>
<td>70 20 12 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>70 1 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

**ENEPIG process (Electroless Ni/Pd/Au)**

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<td><strong>Process</strong></td>
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<td>20 25 30 35 40 45 50 55 60 65 70 75</td>
<td>20 25 30 35 40 45 50 55 60 65 70 75</td>
</tr>
<tr>
<td>Pd:0.05um Au:0.05um</td>
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<tr>
<td>Force (g)</td>
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<td>40 20 13 9 5 3 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td></td>
<td>50 20 20 8 4 2 0 0 0 0 0 0 0 0 0 0</td>
<td>50 16 9 6 4 1 0 0 0 0 0 0 0 0 0 0</td>
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<tr>
<td></td>
<td>60 20 18 1 2 1 0 0 0 0 0 0 0 0 0 0 0</td>
<td>60 14 7 3 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
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<td>70 20 12 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>70 11 4 1 0 0 0 0 0 0 0 0 0 0 0 0</td>
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<td>Pd:0.05um Au:0.10um</td>
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<tr>
<td>Force (g)</td>
<td>40 20 20 13 5 3 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>40 16 5 4 2 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td></td>
<td>50 20 20 14 4 2 0 0 0 0 0 0 0 0 0 0 0</td>
<td>50 12 7 2 0 0 0 0 0 0 0 0 0 0 0 0</td>
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<tr>
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<td>60 8 5 1 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
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<td></td>
<td>70 11 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>70 4 2 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>
We are the world's largest provider of bonding wires, delivering optimum quality wires suitable for PKG.

**The kind of TD wires**
- Gold bonding wire
- Gold alloy bonding wire
- Silver alloy bonding wire
- Copper bonding wire
- Aluminum bonding wire for Power Device
- Aluminum bonding ribbon
- AlSi alloy bonding wire

New release!!

**SEA (Silver Alloy Wire)**
*Please contact us for more information*
The World No.1 Share Products

- Bonding Wires
- Fuel Cell Catalysts
- Cadmium-free Rivet Contacts

How much 1g gold stretched to?

- Pure Gold 1g (Purity: Over 99.9%)

- Rolled to Gold Foil (T=0.0001mm)
  → 0.62mm²

- Drawn to Gold Wire (φ 0.005mm)
  → 3,000 m

1g gold is sandwiched with paper and hammer stretched.

- Bathing Suit in Pure Gold
  ¥10,000,000  Pure Gold 500g
  Complete Ensemble
  About USD 1mil.

- Pure – Platinum Mobile Suit
  Gundam Figure  $250,000

The Future is Precious.
Mission Statement
To satisfy our Customers by delivering products of the highest quality, reasonably priced, in the shortest possible time, through activities based on mutual trust.

Thank you for your attention!