Cu Alloy Wire

TANAKA Cu Alloy Wire

Introduction

May 2019

TANAKA DENSHI KOGYO K.K.

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Contents

- Benefit of Cu alloy wire
- Excellent characteristic of Cu alloy
    - > 2nd Bondability
    - > 1st Bondability
    - > Reliability
- Summary of Cu alloy bonding wire

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Benefit of Cu alloy wire

◆For customer using **bare Cu** wire

1. Better 2nd Bondability
   - ➢Wider 2nd bond process window.
   - ➢Higher stitch pull strength.
2. Higher reliability
   - ➢ Longer HTS life.

◆For customer using **Pd coated Cu** wire

1. Cost
   - ➢Lower cost
2. 1st Bondability
   - ➢ Less Al splash

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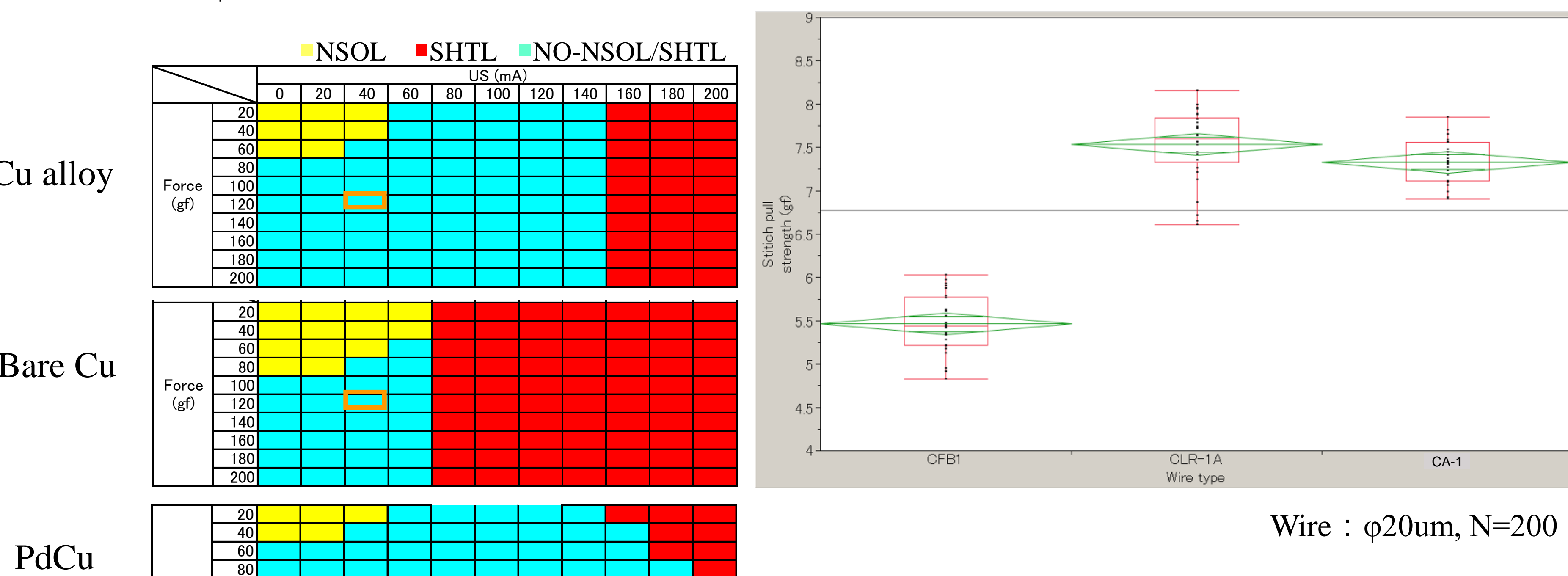
Excellent characteristic of Cu alloy 【2nd Bondability】

◆Bonding parameter window

Wire：φ20um, N=200

◆Stitch pull strength

(Force 120gf, US 40mA)



Bonder:KnS Maxum Plus (Cu kit)
Capillary :SPT SU-25080-385F-ZU34TP
Sub: Dummy substrate ,Ag electro plating
Bonding Temp:220°C

□⇒Stitch pull Test (Right Graph)

2nd Bonding window of Cu alloy is wider than bare Cu (Almost same as PdCu)

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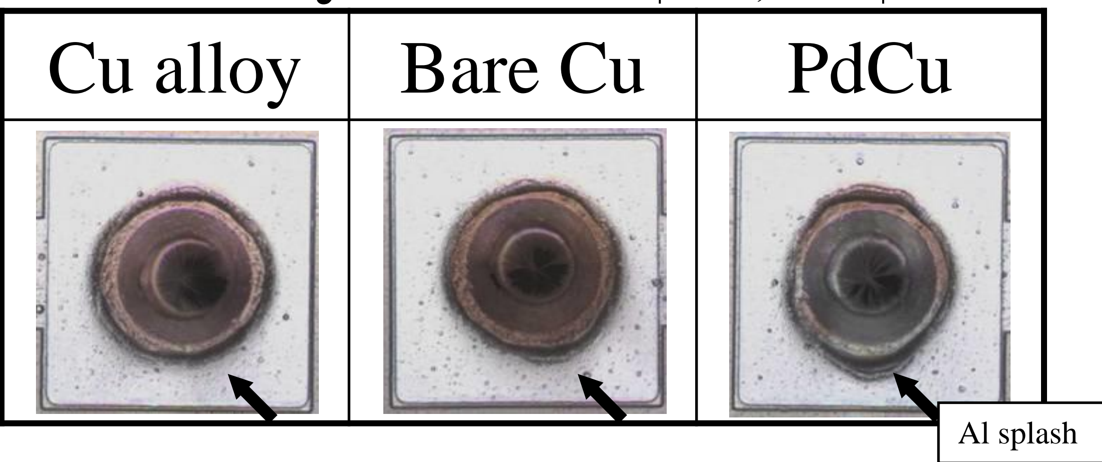
Excellent characteristic of Cu alloy

【1st Bondability】

Wire：φ20um,FAB：φ38um



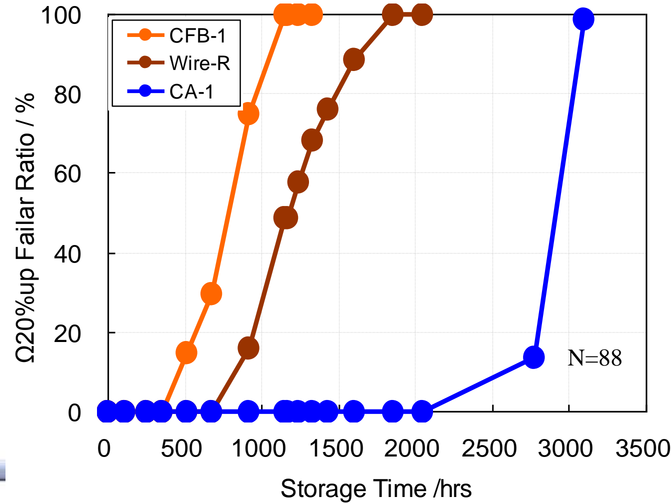
Al splash

The state of Al splash of Cu alloy is almost same as bare Cu.

【Reliability】

HTS 175℃, QFP, Non-Green resin

◆ Failure Ratio



Cu alloy shows excellent reliability.

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Details of Technical Data

➢Evaluation wire

Type : Cu alloy, 4N bare Cu, PdCu, Wire-R (Competitor Cu-Alloy)

Wire Diameter : φ20um

➢Evaluation Data

1. Mechanical properties (BL, El)
2. Compression test of FAB
3. Resistivity
4. FAB Formation
5. 1st Bondability
6. 2nd Bondabitity
7. Reliability
8. Summary (Details of Technical Data)

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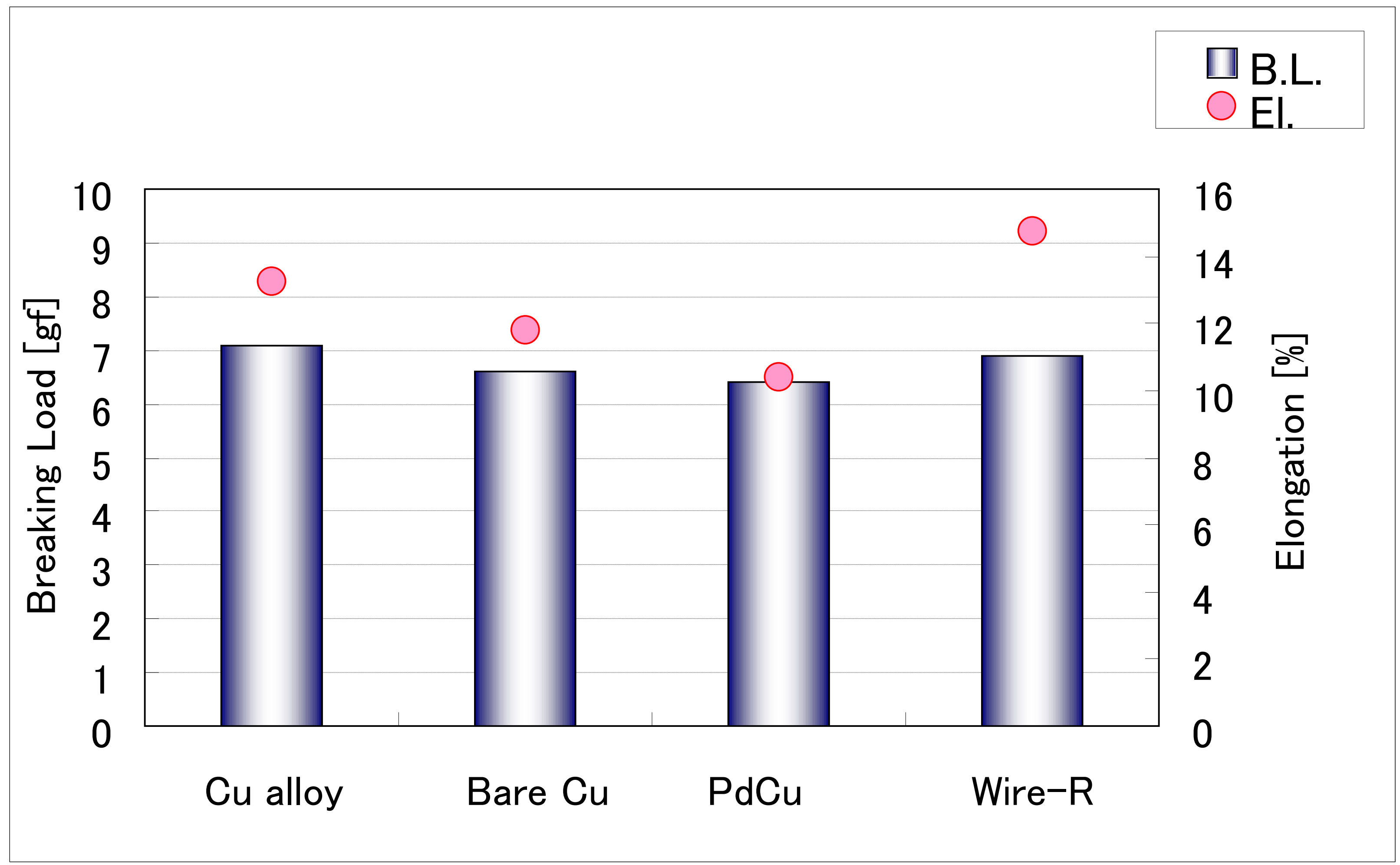
Mechanical Property Wire Comparisons (BL,El)



Breaking load and elongation of Cu alloy is higher than bare Cu and PdCu

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Compression test of FAB

Compression stress at 20% deformation from initial / MPa

110
100
90
80
70
60
50

n=1
n=2
n=3
n=4
n=5
n=6
n=7
n=8
n=9
n=10
AVE
MAX
MIN

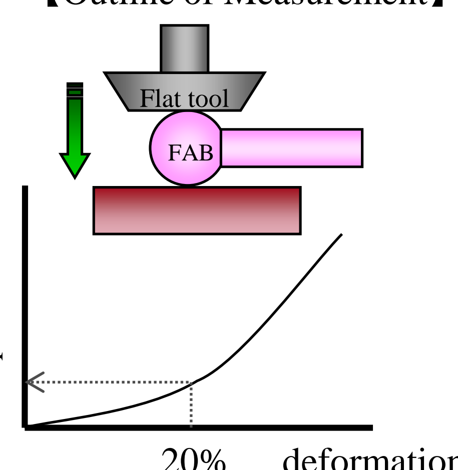
Cu alloy | Bare Cu | PdCu | Wire-R

【FAB Making condition】
Wire ：φ20um
FAB ：38um(Target)
Bonder ：K&S Iconn
Gas ：N_2-5%H_2, 0.5l/min
Loop mode：Free Air Ball mode
EFO Time ：160us
EFO Current ：70mA

【Measurement Equipment】
Compression Tester ：MCT-√500
(SHIMADZU)

【Measurement Conditions】
Compression speed：100mN/sec
Maximum Load：1000mN

【Outline of Measurement】



Compression stress of FAB of Cu alloy is almost same as bare Cu.

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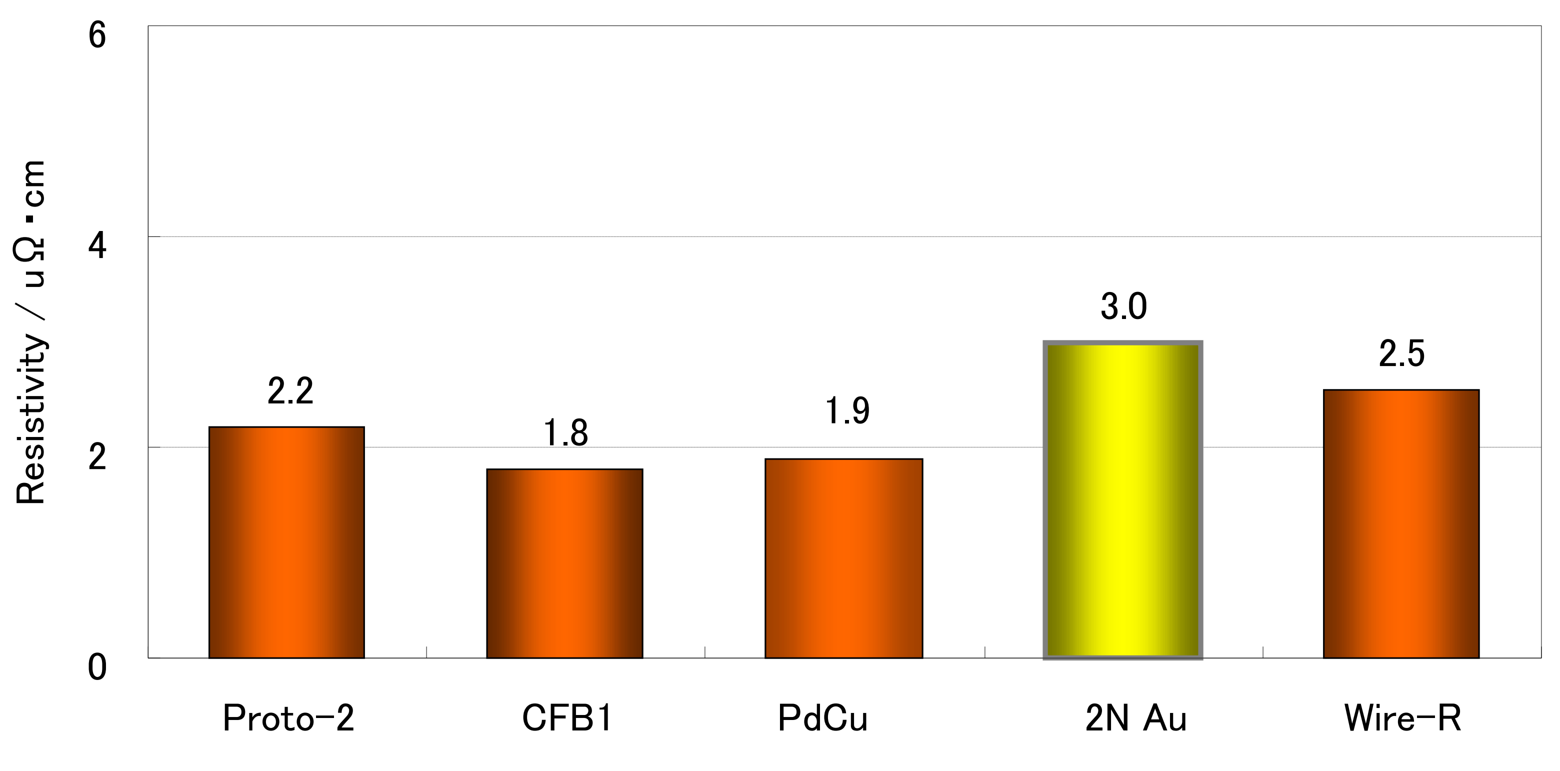
Resistivity



Constant Current Regulator : TORISHA TYPE CCR 110-1

Digital Multimeter : Agilent 34401A

Tester : sanwa PC520　Number : n=3

Temperature : 25℃

Resistivity of Cu alloy is lower than 2N-Au and Wire-R.

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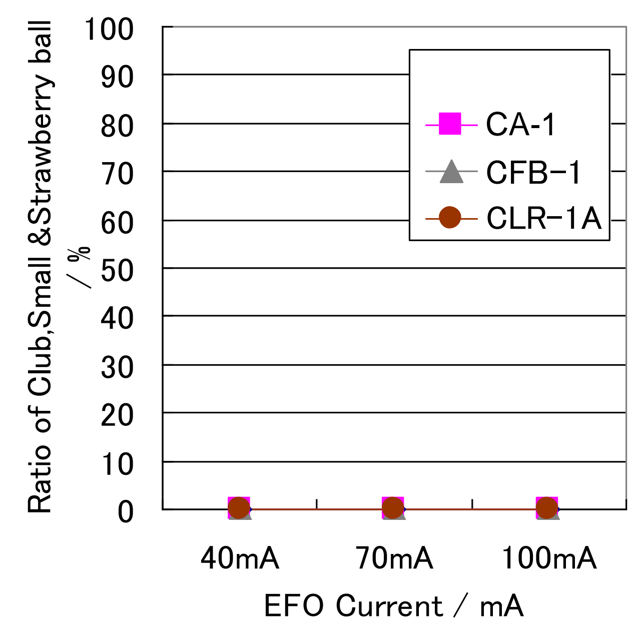
FAB formation

Observation of FAB

EFO Current [mA]	40	70	100
EFO Time [usec]	331	161	101
Cu alloy			
Bare Cu			
PdCu			

Ratio of Club, Small &Strawberry Ball



Cu alloy has same FAB formation window as bare Cu and PdCu .

○Wire Information
- Wire Dia :φ20um
- FAB Size Target :35um

○Bonding Condition
- Bonder : KnS Maxum plus (Cu Kit)
- Capillary : SPT SU-25080-385F-ZU34TP
- Loop Parameters FREE-AIR-BALLS
- Ball Parameter
  Wire Dia:0.79mil
  Tail extension:15mil
  EFO GAP:40mil
  Flow Gas: N2+5%H2 ,0.5L/min
- Bond 2 Parameters
  Tip:5mils
  C/V0.5mils/ms
  USG Current:100mA
  USG Bond Time:7ms
  Force:35gf

○Evaluation Conditions
- Observation of FAB
  Device:KEYENCE VE-9800 (SEM)
  Magnification :×2000
- Ratio of Club ball etc..
  Device:OLYMPUS Measuring Micro Scope STM6
  Object Grass:×20
  N=200

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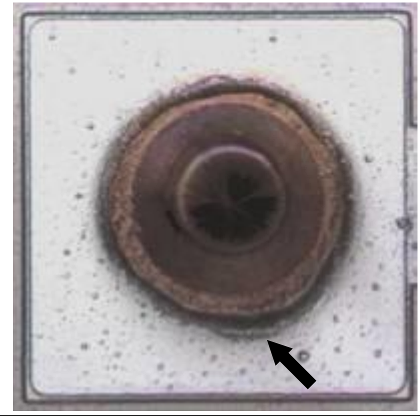
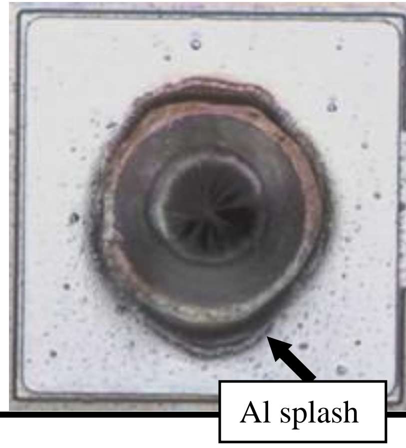
1st Bondability-1

Observation of Squashed Ball (1st bonding condition of All wires are same.)

Wire : φ20um, FAB : φ38um

Cu alloy	Bare Cu	PdCu
		

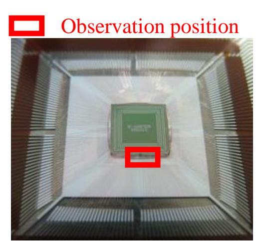
Al splash

・Bonding condition
Wire Dia : 20um
Bonder:KnS Maxum Plus (Cu kit)
Capillary :SPT SU-25080-385F-ZU34TP
Die: TANAKA TEG Al-0.5%Cu,
t=0.8um (Renesas)
Sub:QFP-200(Ag electro plating)
Bonding Temp:220℃
FAB size (Target):38um
Squasehd ball size (Target)
:X,Y=48±2um,Z=11±1um
Flow Gas : N2+5%H2, 05L/min

・Ball Parameter
Wire Diameters:0.79mill
FFO Fire Mode:Ball Size
Ball size:1.55(Proto-1,2,CFB-1),1.57(CLR1A)
EFO Current:70mA,EFO Gap:30mils
Tail extension:10mils

・Bond 1 Parameters
Tip:10mils ,C/V:0.3mils/ms, V Mode,USG Mode:Contact Current, USG Current:60mA, USG Bond Time:10ms, USG Pre-Bleed:55mA, USG Profile:Square, Force:20gf, Initial force:30gf, Initial Force Time:33%, Force Ramp Time:10%, X-Scrub:3um, Y-Scrub:0um, Scrub Cycles:1, Scrub Phase:90deg, 1st Scrub Mode:Pre-USG

Observation position



Bond Layout

The state of Al splash of Cu alloy is almost same as bare Cu.

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1st Bondability-2

Squashed Ball size & Shear strength
(1st bonding condition of All wires are same.)

Wire:φ20um, FAB:φ38um

N=20

Squashed Ball Dia & Height [um]

	SBD x	SBD y	SBH
Proto-2	48.2	46.8	11.5
CFB1	48.7	47.7	11.9
PdCu	47.8	46.4	12.2

Shear Strength [kgf/mm^2]

AVE, MAX, MIN

Proto-2 CFB1 PdCu

Shear strength of Cu alloy is same as bare Cu and PdCu.

・Bonding condition
Wire Dia：20um
Bonder:KnS Maxum Plus (Cu kit)
Capillary :SPT SU-25080-385F-ZU34TP
Die: TANAKA TEG Al-0.5%Cu, t=0.8um (Renesas)
Sub:QFP-200(Ag electro plating)
Bonding Temp:220℃
FAB size (Target):38um
Squasehd ball size (Target)
:X,Y=48±2um,Z=11±1um
Flow Gas：N2+5%H2, 05L/min

・Ball Parameter
Wire Diameters:0.79mill
FFO Fire Mode:Ball Size
Ball size:1.55(Proto-1,2,CFB-1),1.57(CLR1A)
EFO Current:70mA,EFO Gap:30mils
Tail extension:10mils

eters
:0.3mils/ms,
ode:Contact Current,
mA, USG Bond Time:10ms,
:55mA, USG Profile:Square,
ial force:30gf, Initial Force Time:33%,
ne:10%, X-Scrub:3um, Y-Scrub:0um,
Scrub Phase:90deg,
:Pre-USG

lition
size
easuring Micro Scope STM6
100

・Shear strength
Equipment: dage BT4000
Shear Speed:125um/s
Shear height:3um
N = 20

Measurement position

Bond Layout

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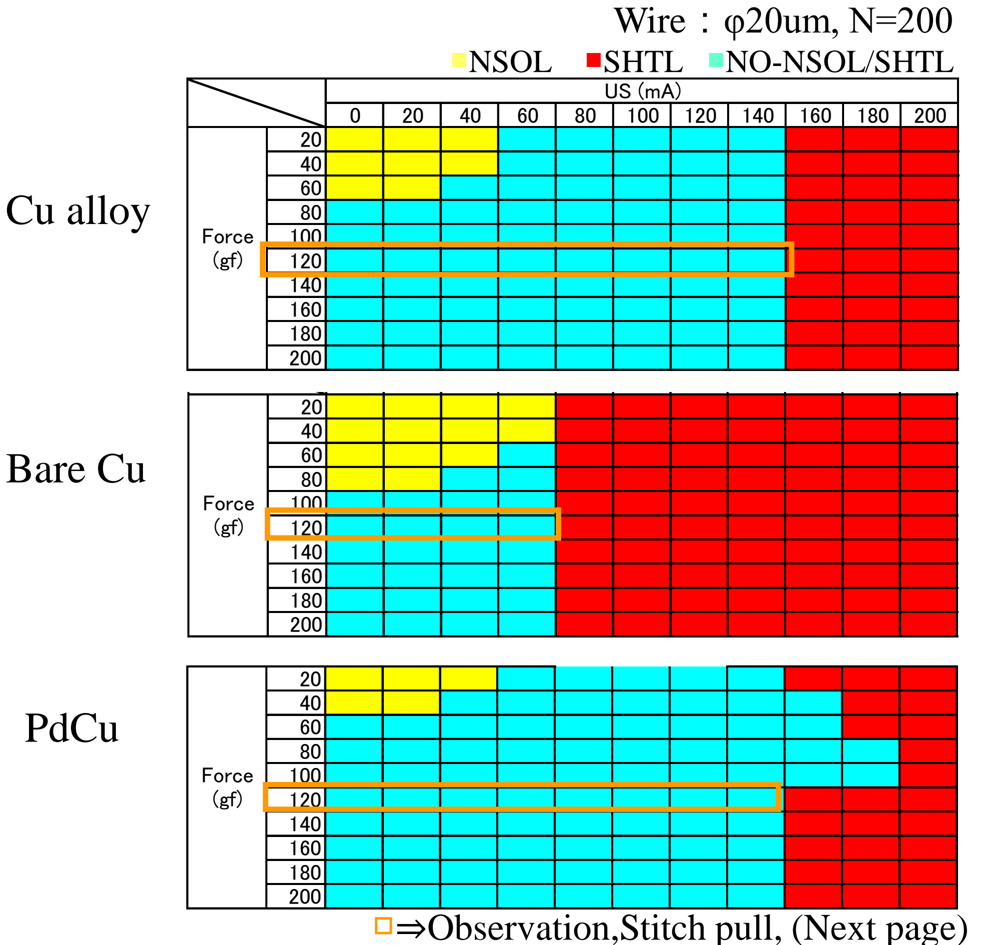
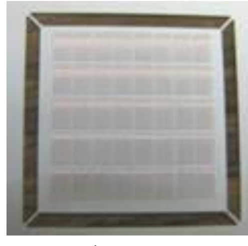
2nd Bondability-1

Bonding window (Ag electroplating / QFP Dummy)





Bond Layout

･Bonding condition
Wire Dia：20um
Bonder:KnS Maxum Plus (Cu kit)
Capillary :SPT SU-25080-385F-ZU34TP
Sub: Dummy substrate ,Ag electro plating
Bonding Temp:220℃
FAB size Target:38um
Flow Gas　：N2+5%H2, 05L/min

･Bond 2 Parameters
Tip:10mils ,C/V:0.5mils/ms,
Contact Threshold:70%, USG Bond Time:7ms
Power Equ Factor:100%, USG Pre-Bleed:0mA,
Init'l Force:50g,Init'l Force Time:33%
Tail XY Scrub:0um
Z-Tear USG:50mA, Z-Tear Speed:10%
Tail Scrub USG:0mA,

Evaluation condition
･Squashed Ball size
OLYMPUS Measuring Micro Scope STM6
Object Grass:×20
N=200

2nd Bonding window of Cu alloy is wider than bare Cu and PdCu.

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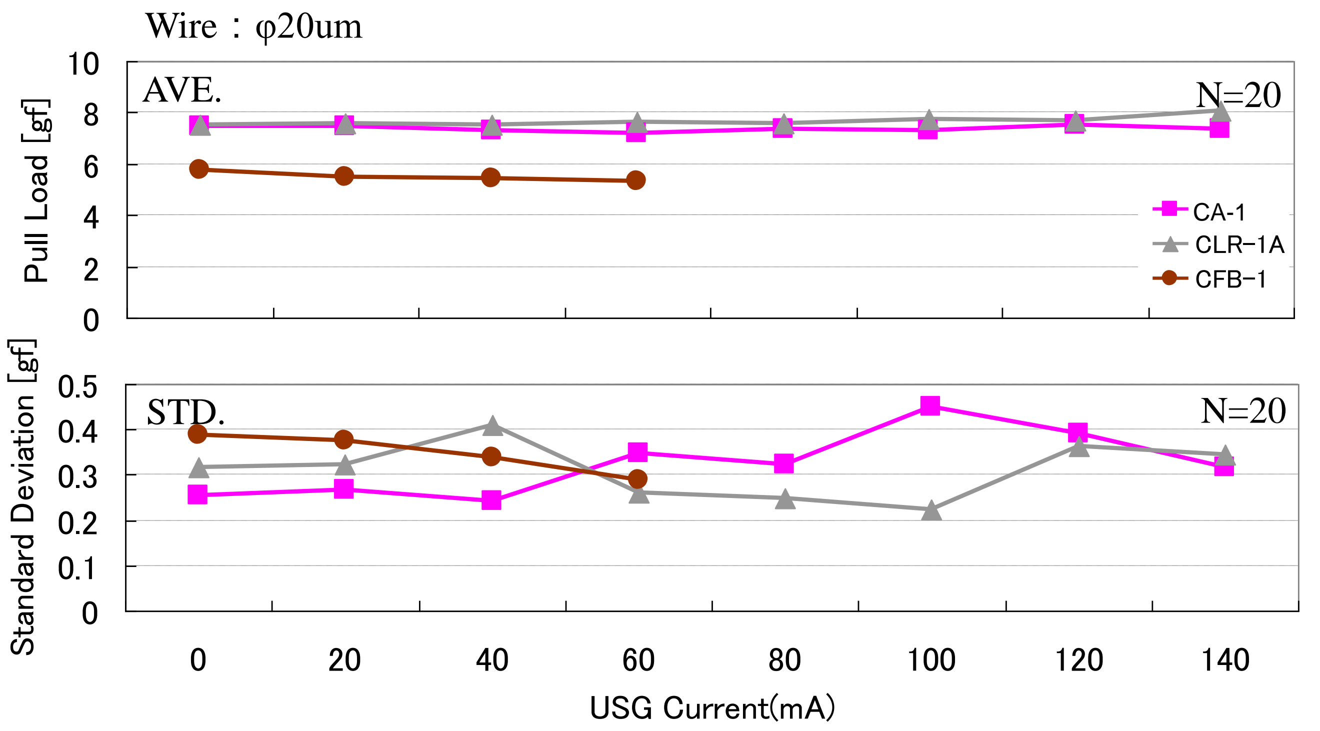
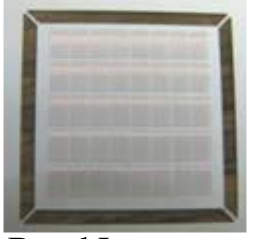
2nd bondability-2

Stich Pull Test (Ag electroplating / QFP Dummy)

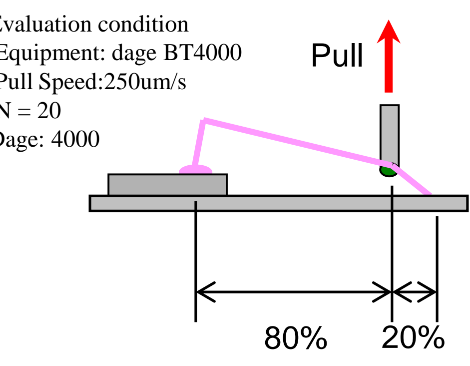


・Bonding condition
Wire Dia : 20um
Bonder:KnS Maxum Plus (Cu kit)
Capillary :SPT SU-25080-385F-ZU34TP
Sub: Dummy substrate ,Ag plating
Bonding Temp:220℃
FAB size Target:38um
Flow Gas : N2+5%H2, 05L/min



Bond Layout

Evaluation condition
Equipment: dage BT4000
Pull Speed:250um/s
N = 20
Dage: 4000



Stitch Pull strength of Cu alloy is higher than bare Cu.
(Almost same as PdCu)

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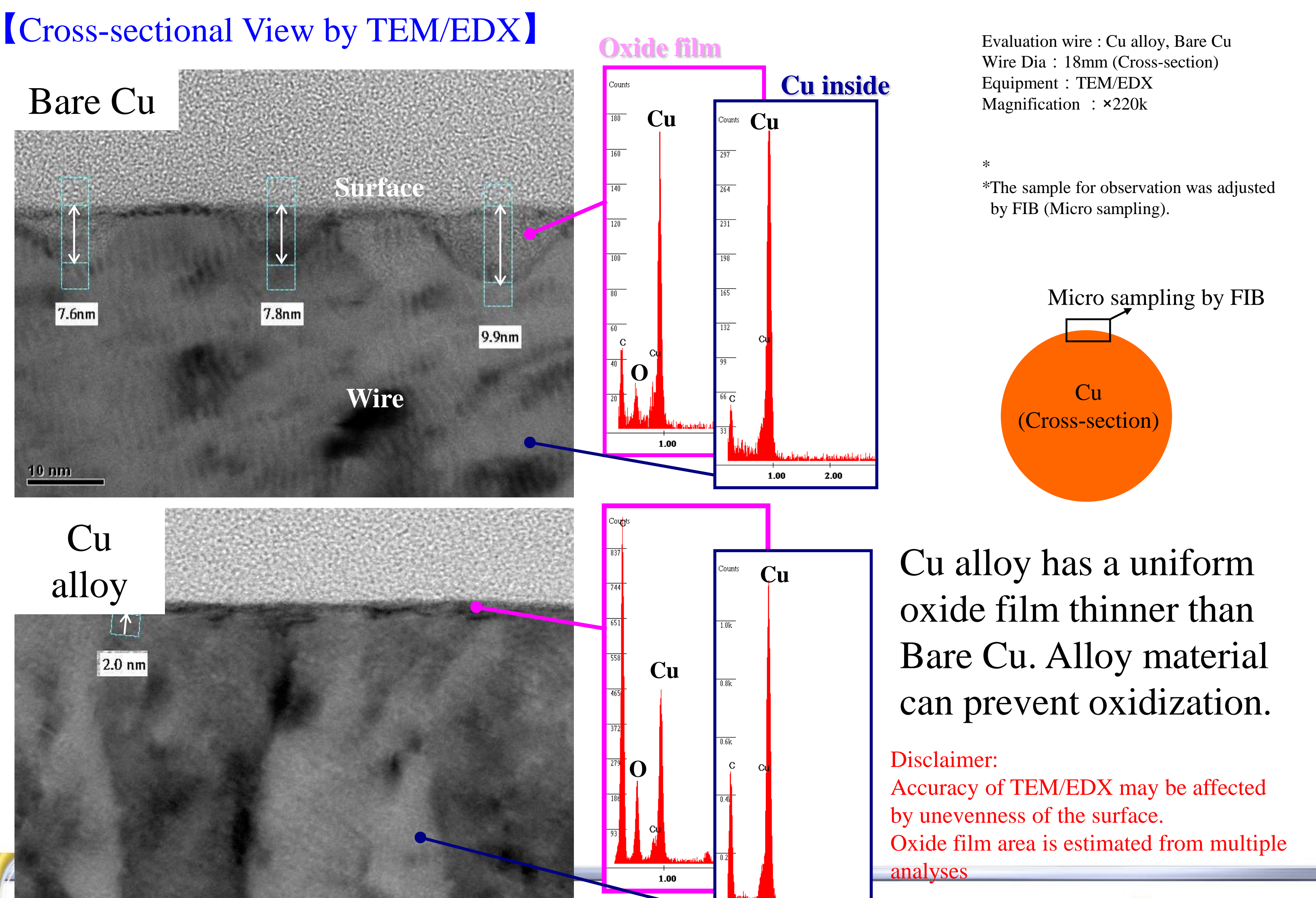
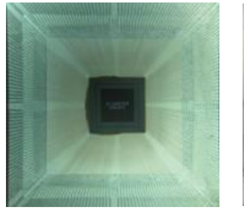
Comparison of Oxide film on wire surface



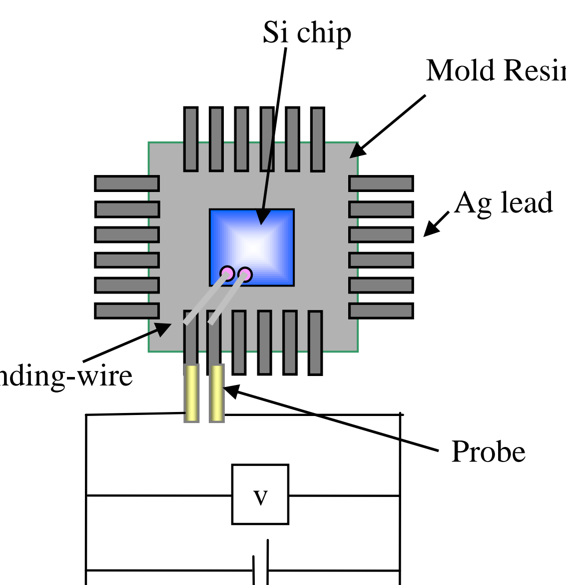
Reliability test Overview

Test Condition (HTS and HAST)

Evaluation wire: Cu alloy, 4N-Cu
Diameter: 20um
Squashed ball size: X,Y=50um,Z=10um (Up to 13kg/mm2)
Gas Flow: N2+5%H2(0.5L/min)
Flame：QFP200pin (Measurement number：88pairs), 42 alloy, Ag-plated
Substrate: FR-4 32pin, (Measurement number：64pairs), Au electro-plating
Chip: TANAKA TEG Chip Al-0.5%Cu, t=0.8um (Renesas)
Bonder: K&S Maxum Plus (Cu kit)
Capillary ：SPT SU-25080-385F-ZU34TP
Mold resin: Nitto Denko MP-8000CH, GE7470L-A
Mold temperature: 180 deg C
Cure: 175 deg C, 5hrs in the air



Mold Temp.=180℃
Post Cure=175℃×5hr



【Test condition】
1. HTS: 175℃, QFP, Non-Green resin(MP-8000CH)
2. uHAST: 130deg C 85%rh, BGA, Green resin (GE7470L-A)
*no preconditioning, no reflow

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Reliability

HTS 175℃, QFP, Non-Green resin

- Failure Ratio (Ω20%up) &Failure Analysis

Cu alloy shows no failure until 2000 hrs.

Cu alloy has no detect at cross-section of 1st Ball/Pad at 1300hrs.

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Comparison of Cu-Al inter-metallic @HTS 175℃ 1300hrs

Cu alloy

Bare Cu

Disclaimer:
Accuracy of TEM/EDX may be affected by unevenness of the surface and the others
Intermetallic area is estimated from multiple analyses

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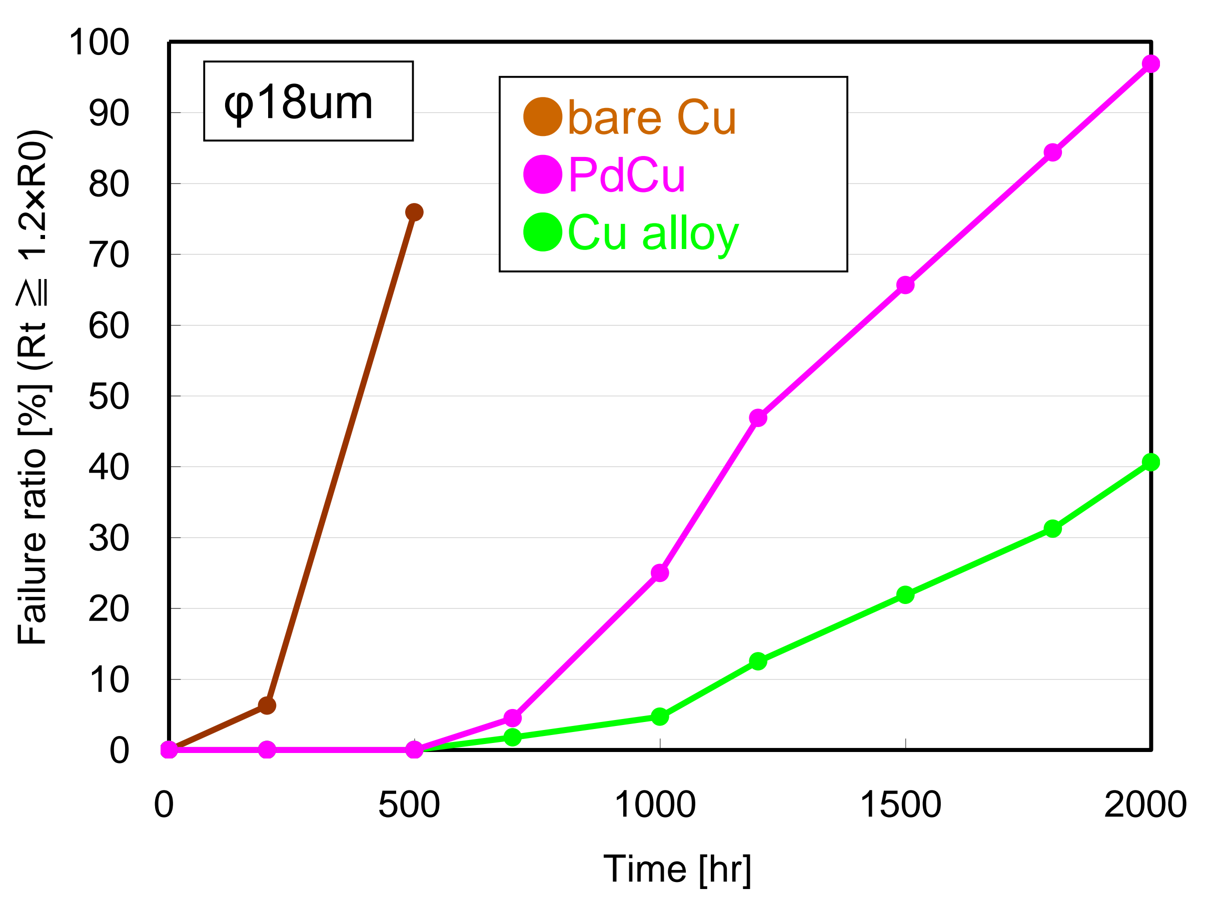
Reliability

HTSL - 200℃ , BGA , Green resin



<Bonding conditions>
Bonder: ProCu
Gas flow rate:
Forming, 0.50l/min(EFO)
EFO Current: 65mA
Wire dia.: 18um
Squashed ball dia.: 36um
Squashed ball thickness: 9um
Shear stress: over 12kgf/mm2
SPT SU-23060-283F-ZU34TP

<other conditions>
Die :WALTS MB6020-0102JY,
Pad : Al-0.5%Cu, 0.8umt
substrate:OKI PBGA32pin（HF）
256point, 128circuit
（=16circuit/IC × 4IC × 2Frame）
Initial resistance:0.8-1.0Ω

Cu alloy is better than BareCu / PCC about HTSL test.

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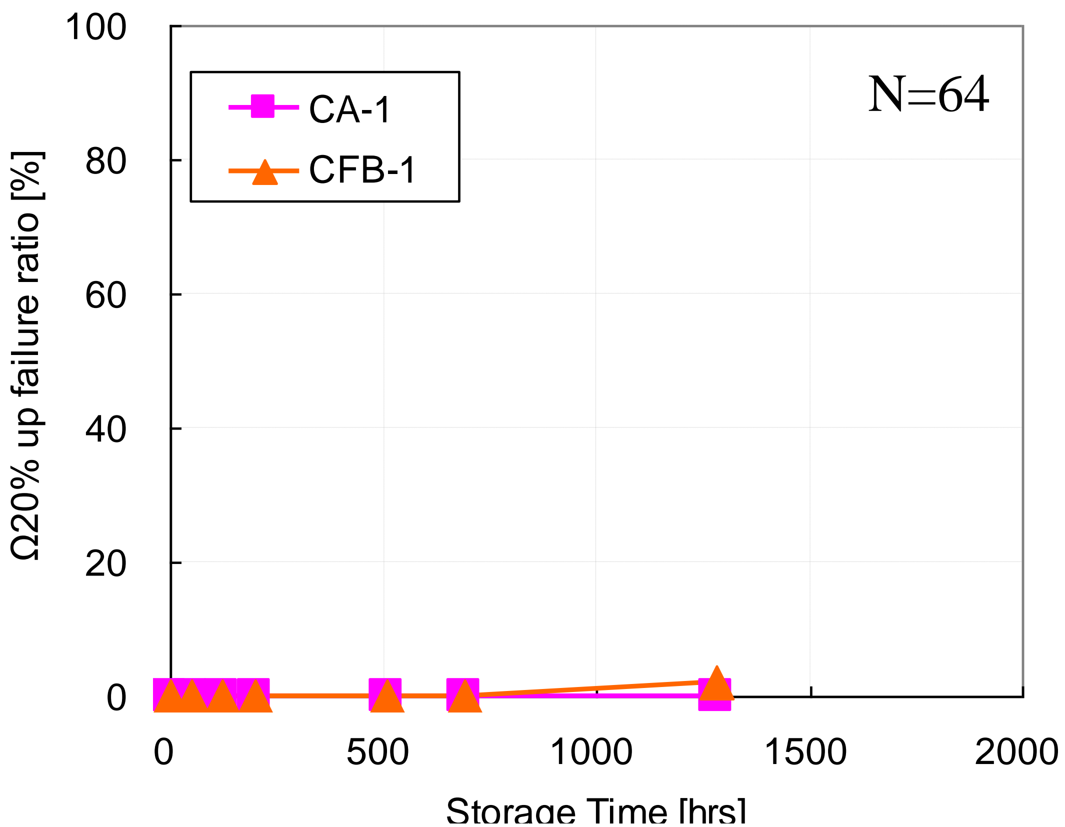
Reliability

uHAST 130deg C 85%rh, BGA, Green resin

- Failure Ratio (Ω20%up)



Cu alloy shows no resistance changes until 1200 hrs.

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Summary (Details of Technical Data)

- Cu alloy has a larger breaking load and elongation compared with bare Cu and PdCu wire.
- Cu alloy has a lower resistivity compared with 2N-Au.
- Cu alloy has same FAB formation window as bare Cu and PdCu.
- Cu alloy has same compression stress on FAB compared with bare Cu.
- Cu alloy has wider 2nd window than bare Cu.
- Cu alloy has superior reliability (HTS) performance than bare Cu.

End of Report

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Summary of Cu alloy wire evaluation

Category		Pd coated Cu	Cu alloy	bare Cu
type		CLR-1A	CA-1	CFB-1
Resistivity		★★★	★★	★★★
Reliability	HTS	★★	★★～★★★	★
	HAST	★★★	★★～★★★	★
FAB formation		★★	★★	★★
1st bondability		★	★★	★★
2nd bondability		★★★	★★	★
Price		★	★★	★★★

Cu alloy wire has no major negative point.

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Thank you !

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