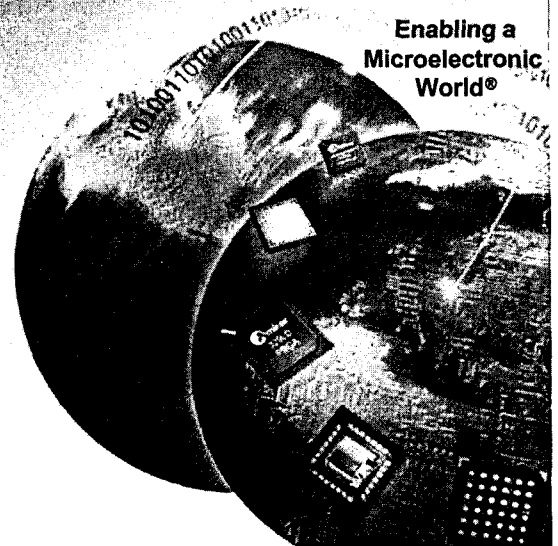


Solder Joint Integrity Study with Various Pb-free Solder Compositions

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Solder joint integrity study with various Pb free solder composition

Apr 26 '2005



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- **Factor to solder joint integrity**
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Pb-free legislation



✍ European Directives now published

1. WEEE(Waste Electrical & Electronic Equipment)
 - Recycling, recovery, re-use by product producers
 - Aug.2005 effective
2. ROHS
 - Eliminates banned substances by July 1, 2006
 - a. Pb, Hg, Cd, Cr+6, PBB and PBDE
 - b. Exemptions for high temperature Pb alloys, electronic switching, networking & certain high reliability applications

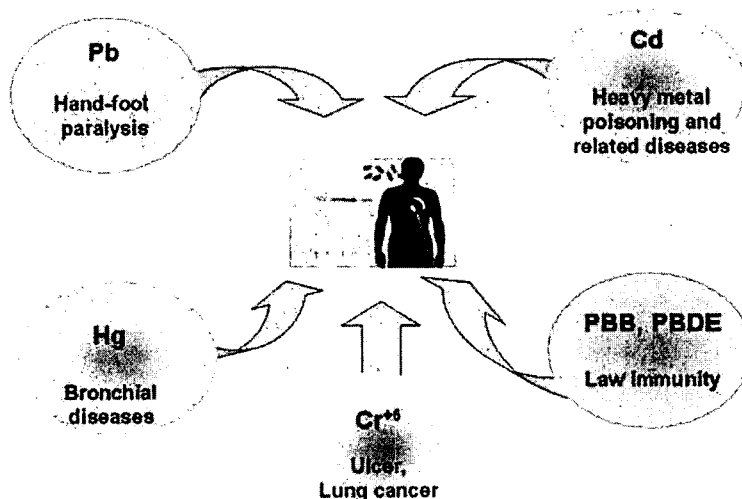


Pb-free legislation



✍ ROHS

1. Symptoms

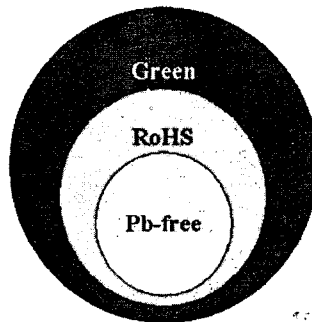


Current Amkor Pb-free status



Amkor Criteria for Pb-free & Green

1. Pb-free
 - Pb content of solder materials < 1000 ppm
2. Reflow capability
 - MSL level 3 minimum @ 260°C
3. ROHS compliant
 - Meets Pb, Hg, Cd, Cr+6, PBB and PBDE requirements as banned substances.
 - Limits under consideration by European Commission



Current Amkor Pb-free status



Pb-free Solder Plating

1. Sn-Bi alloy
 - Significant portion of Japan Pb-free market
 - a. Direct customers in Japan
 - b. US and European customers selling to Japan
 - Significant opposition in US & European market
 - Bi connection with Pb mining
2. Matte Sn
 - Popular choice for Pb-free
 - a. Non-Japan markets

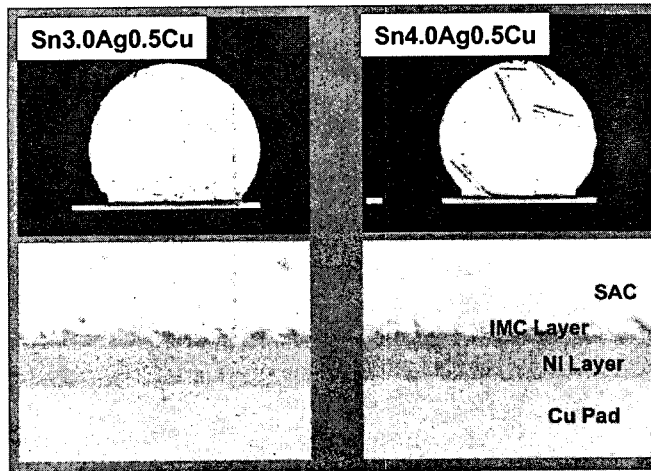


Current Amkor Pb-free status



Pb-free Solder Ball

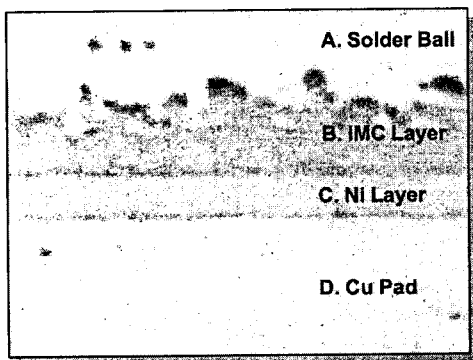
1. Sn/Ag/Cu(SAC) is the current industrial standard.
2. Composition : Sn4.0Ag0.5Cu & Sn3.0Ag0.5Cu



Factor to Solder Joint Integrity



Pb-Free Solder on Ni/Au Pad



- A**
1. Solder Composition(+ dopant)
 2. Solder Reflow Profile Condition

- B**
1. IMC Thickness by Temp/Time
 2. IMC Composition

- C**
1. Plating Thickness
 2. Plating Surface Morphology

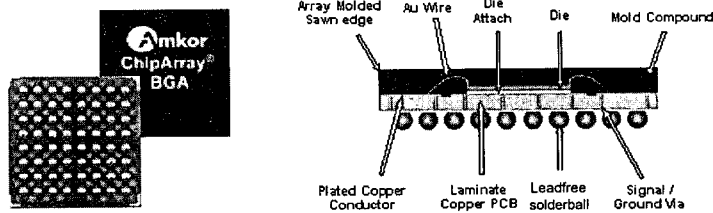
- D**
1. PCB pad design(SMD, NSMD)

Various solder composition review



Test vehicle Information

1. Package : CABGA 14x14
2. Solder Ball Diameter : 0.3mm
3. Test condition (Reading Time)
 - End of Line (EOL)
 - Precondition(30°C/60%-192hrs, 260°C reflow x3)
 - High Temperature Storage Test (HTS) at 150°C/168hrs

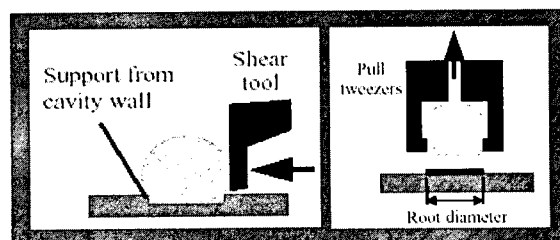


Various solder composition review



Test Methods Introduction

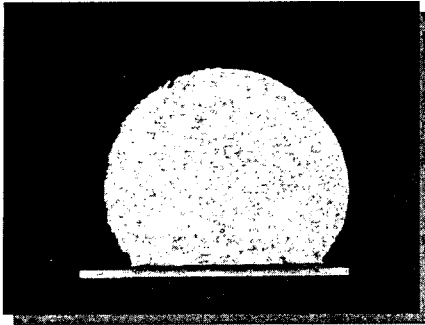
1. Ball shear test : Test speed - 300um/sec, height - 50um
2. Ball pull test : Test speed - 5000um/sec
3. Impact shear : Test speed - 60mm/sec, Tension - 1.2N
4. Zone shear test : Same condition with ball shear
5. Board level drop test : Peak Acceleration - 1500 G, Pulse duration - 0.5 millisecond



Various solder composition review



✍ Test Candidates



PCB surface

1. Ni/Au Surface
2. OSP-Cu Surface

* OSP : Organic Solderability Preservative

Solder Ball

1. Ag contents

- Sn1.0Ag0.5Cu
- Sn2.5Ag0.5Cu
- Sn3.0Ag0.5Cu
- Sn4.0Ag0.5Cu

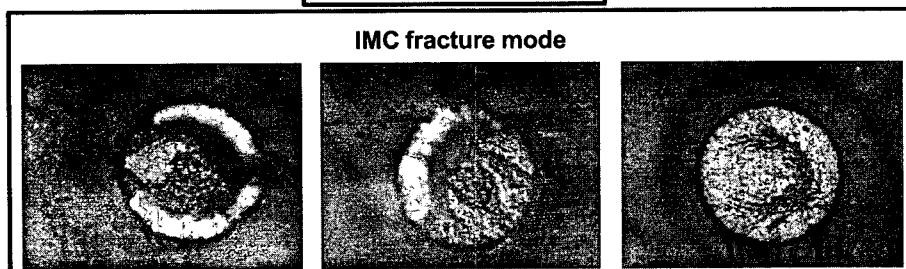
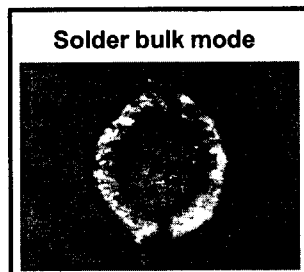
2. Dopant

- Sn2.5Ag0.5Cu0.5Ni
- Sn1.2Ag0.5Cu0.05Ni

Various solder composition review



✍ Failure mode for mechanical test

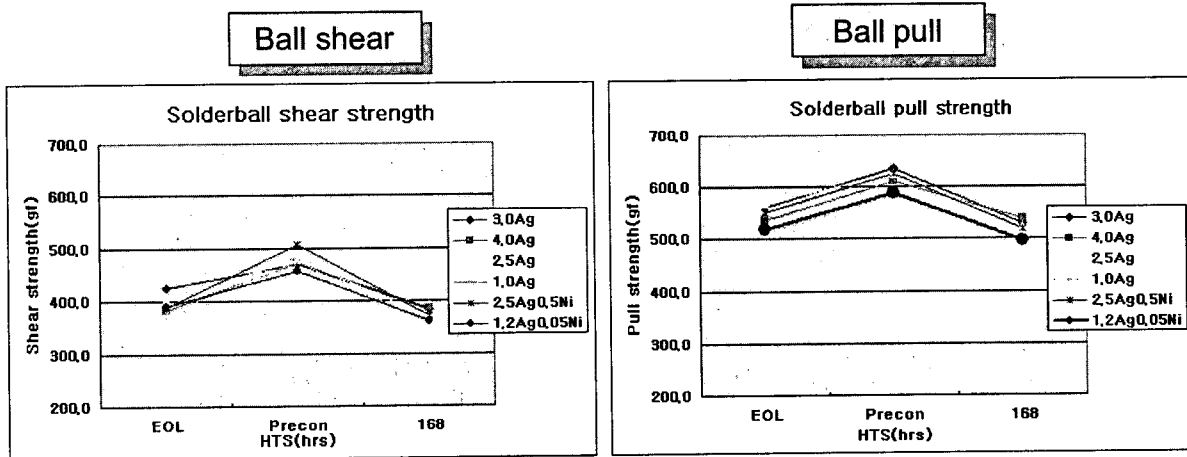


Various solder composition review



Ni/Au surface : Solder ball shear & pull strength

1. Ag contents didn't affect to ball shear & pull strength.
2. Dopant doped compositions showed similar strength with SAC solder ball.



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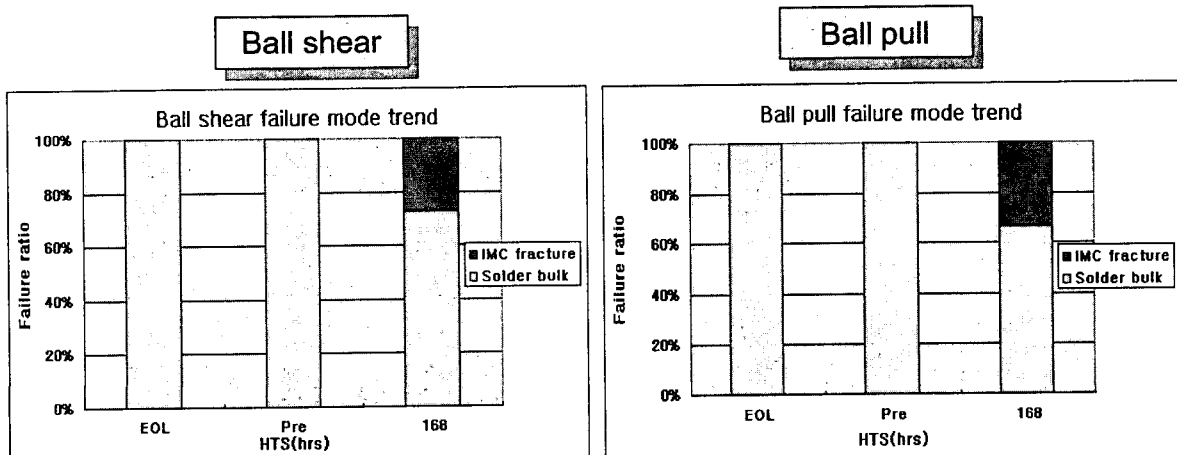
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Various solder composition review



Ni/Au surface : Solder ball shear & pull failure mode

1. Ag contents and Dopant doped compositions didn't have IMC fracture mode at EOL, Precon.
2. After HTS 168hrs, all compositions have IMC fracture mode.



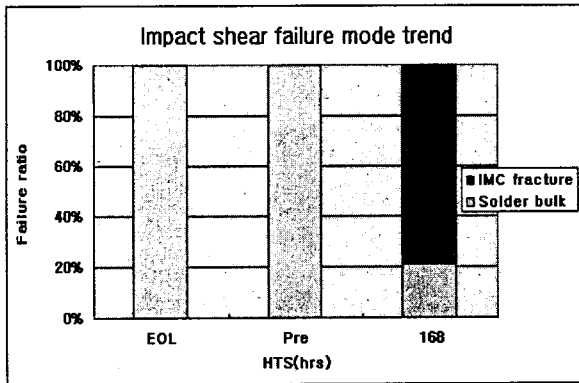
Various solder composition review



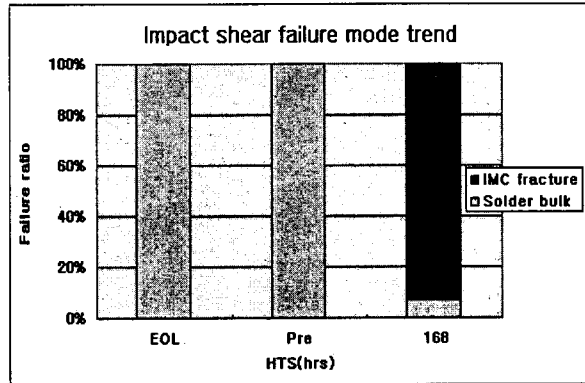
Ni/Au surface : Impact & Zone shear test failure mode

1. Ag contents and Dopant doped compositions didn't have IMC fracture mode at EOL, Precon.
2. After HTS 168hrs, all compositions have IMC fracture mode.

Impact shear



Zone shear

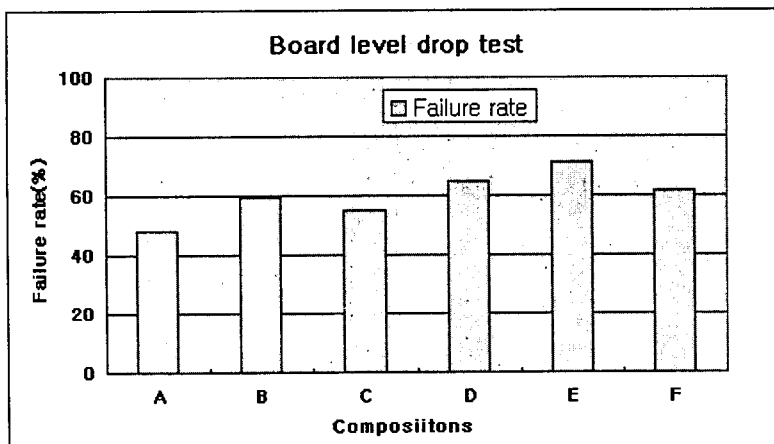


Various solder composition review



Ni/Au surface : Board level drop test

1. After 150 test board drops, all compositions showed similar failure rate.



A : Sn4.0Ag0.5Cu
B : Sn3.0Ag0.5Cu
C : Sn2.5Ag0.5Cu
D : Sn1.0Ag0.5Cu
E : Sn2.5Ag0.5Cu0.5Ni
F : Sn1.2Ag0.5Cu0.05Ni

Various solder composition review



Ni/Au surface : Summary

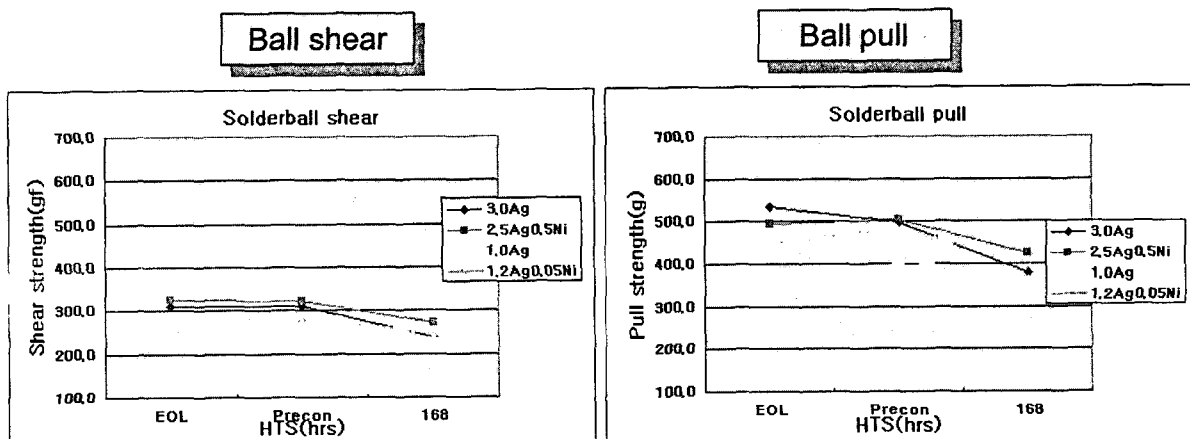
1. In this study, Ag contents didn't affect to ball shear & pull strength.
Dopant doped composition showed similar strength with SAC solder ball.
2. Ag contents and dopant doped compositions didn't have IMC fracture mode at EOL, Precon. After HTS168hrs, all compositions have IMC fracture mode through ball shear, ball pull, shock shear and zone shear.
3. After 150 test board drops, all compositions showed similar failure rate.

Various solder composition review



OSP surface : Solder ball shear & pull strength

1. Sn1.0Ag0.5Cu showed lowest ball shear & pull strength.



Various solder composition review



OSP surface : Solder ball shear & pull failure mode

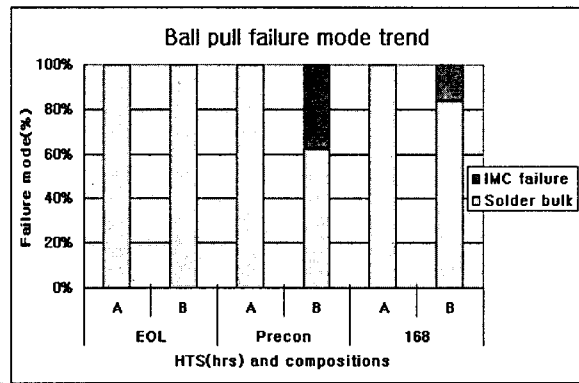
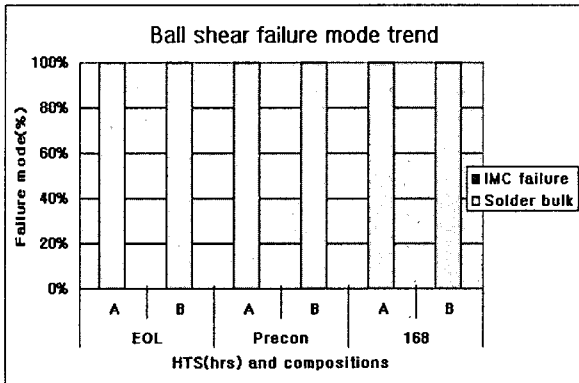
1. All compositions didn't have IMC fracture for ball shear test.
2. Only Sn1.0Ag0.5Cu & Sn3.0Ag0.5Cu showed IMC fracture mode after precon, HTS168hrs for ball pull test.

A : Sn2.5Ag0.5Cu0.5Ni
Sn1.2Ag0.5Cu0.05Ni

B : Sn3.0Ag0.5Cu
Sn1.0Ag0.5Cu

Ball shear

Ball pull



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Various solder composition review



OSP surface : Impact & Zone shear test failure mode

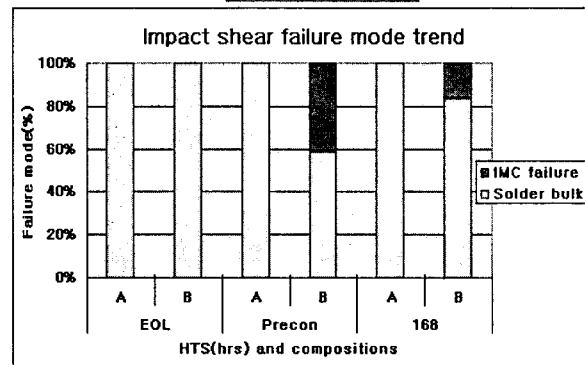
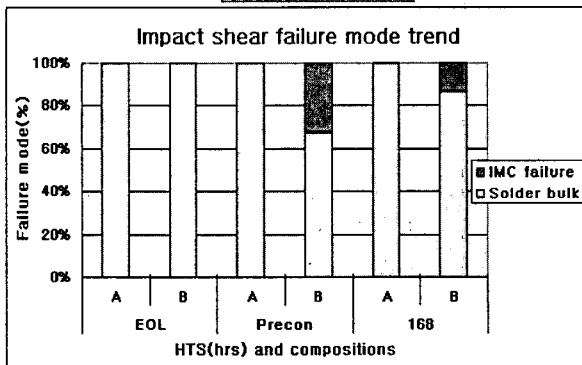
1. All candidates didn't have IMC fracture for impact & zone shear at EOL.
2. Only Sn1.0Ag0.5Cu & Sn3.0Ag0.5Cu showed IMC fracture mode for both test after precon, HTS168hrs.

A : Sn2.5Ag0.5Cu0.5Ni
Sn1.2Ag0.5Cu0.05Ni

B : Sn3.0Ag0.5Cu
Sn1.0Ag0.5Cu

Impact shear

Zone shear



Various solder composition review



OSP surface : Summary

1. In this study, Sn1.0Ag0.5Cu showed lowest ball shear & pull strength.
2. All compositions didn't have IMC fracture for ball shear test. Only Sn1.0Ag0.5Cu & Sn3.0Ag0.5Cu showed IMC fracture mode after precon, HTS168hrs for ball pull test.
3. All candidates didn't have IMC fracture for impact & zone shear at EOL. Only Sn1.0Ag0.5Cu & Sn3.0Ag0.5Cu showed IMC fracture mode for both test after precon, HTS168hrs.