History and Current State of Pb-free Soldering Technology in Japan

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2004 ISMP

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IMAPS Asia
Nagano Institute of Technology

S.Denda

Sept. 2-3, 2004 in Seoul

History of Pb-free solder development in Japan (1)

1994: (June), JIPC Pb-free solder research group started.

1996. Matsushita Photo Phase Drive SnAgBi Test Production (A)

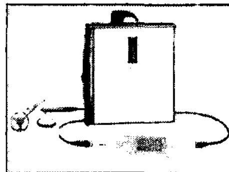
1997: (Dec.), JIPC Report published. (B)

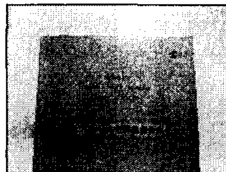
1997 NEC PDA Mobile GearTest Production, Sn-Ag Sn-Bi (C)

1998: JEIDA and JIEP Pb-free solder application roadmaps.

1998: (Oct.) JEIDA and JIPC research project started.

1998: Matsushita MD Player Mass Production


(A)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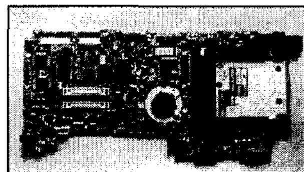
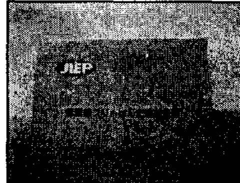

(C)

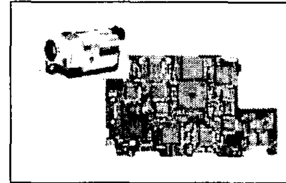
History of Pb-free solder development in Japan (2)

1999: (Jan.), NEDO Project started JEIDA/EIAJ in cooperation.
1999: (Oct.) Pb-free Solder Roadmap 2000 issued.
1999, Hitachi, Refregilator
1999, NEC, Note PC, Lavie, Versa Pro, Sn-Zn, N2 reflow (D).
2000: JIEP Low-temp Pb-free project. Report published (E).
2000: JEITA recommended standard Sn-3Ag-0.5Cu
2001: Sony, VTR, DCR TRV-30, Sn-2.5Ag-0.5Cu-1Bi (F).
2003: JIS Draft making started.
(2004: Apr. WEEE and RoHS final draft.)

(D)



(E)



(F)

DENDA PRESENTATION

European Union Directive

WEEE: Waste Electrical and Electronic Equipment, Aug.2005 effective

RoHS: Restriction of the use of certain hazardous substances in electrical and electronic equipment, July 2006 effective

Hazardous substance: Mercury, Cadmium, Lead, Hexavalent Chromium, PBB,PBDE.

DENDA PRESENTATION

Present state related to Pb-free solder technology (1)

- Pb-free application to the products have been completed in major electronics companies.
- Small factories or companies can't invest for new Pb-free equipments. They want solders suitable to conventional manufacturing line.
- Standard solder is Sn-3Ag-0.5Cu but other composition solders are being used.

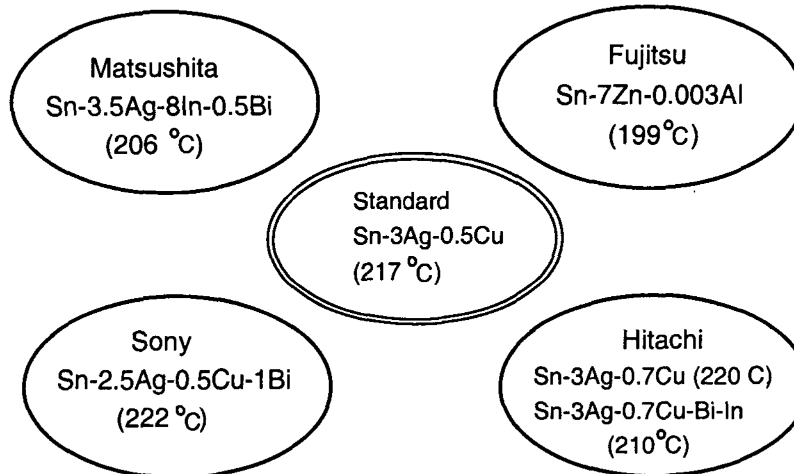
Present state related to Pb-free solder technology (2)

- Low temperature solder is becoming popular.
- Pb-free hasn't necessarily completed for semiconductor devices and components.
- Solder of different compositions are being used for flow soldering.
- Soldering fluxes are under development in solder venders

Schedule for Pb-free solder application to all of the products in major Japanese electronics manufacturers.

Company	Limit
Matsushita	2002/12
Sony	2003/3
Hitachi	2002/3
NEC	2002/10
Toshiba	2004/3
Fujitsu	2002/12
Mitsubishi	2005/12
Canon	2004/12
Oki	2003/3
Epson	2004/3

Pb-free solders of different composition in use

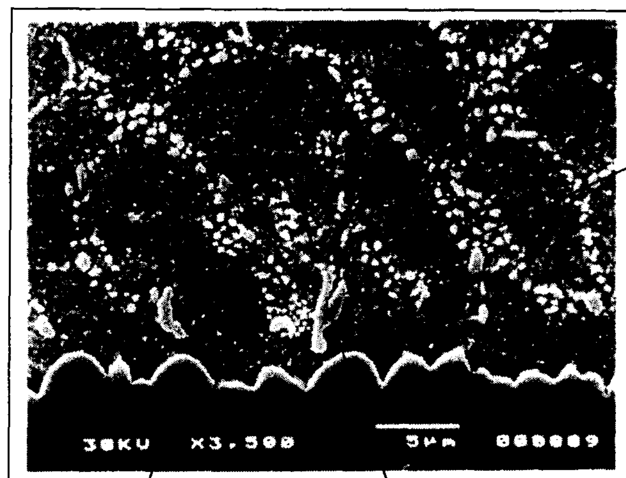


Notices for standard Pb-free solder (1)

- ○Standard solder (JEITA recommend),
  Sn-3Ag-0.5Cu (weight %)
- ○Melting point 217-219 °C , 36 °C higher
  than eutectic Sn-Pb solder.
- ○Reflow peak temperature should be 235 °C.
- ○Small temperature tolerance between peak
  reflow and maximum component temperature.

DENDA PRESENTATION

Typical Sn-Ag-Cu solder texture



Ag3Sn

Cu6Sn5

CuSn compound

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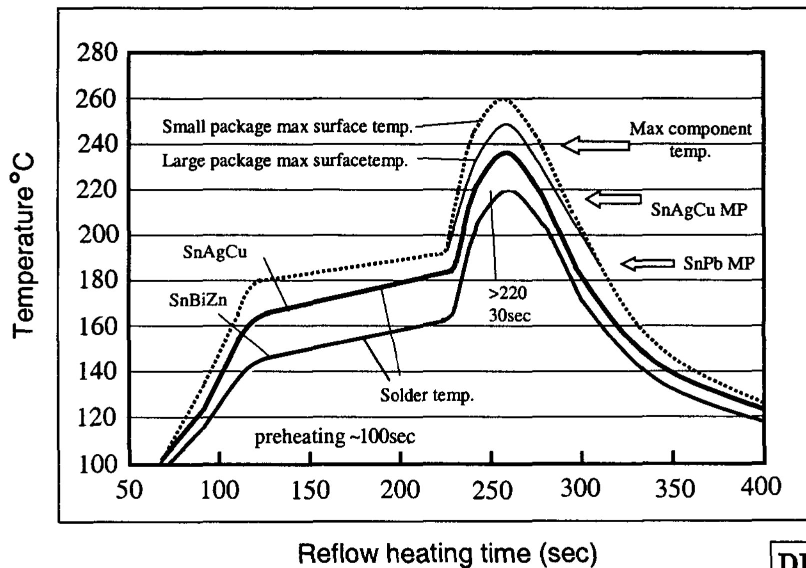
Reflow temperature profile for Pb-free solder



Reflow heating time (sec)

DENDA PRESENTATION

Notices for standard Pb-free solder (2)

- ○ Pb-free solder is harder, worse in wetting and better self alignment than Sn-Pb solder.
- ○ Chemically active to other metals.
- ○ Possibly cause flow solder bath damage.
- ○ Containing Bi in solder and using Pb dipped package lead may cause wiring pattern peal off and damage.

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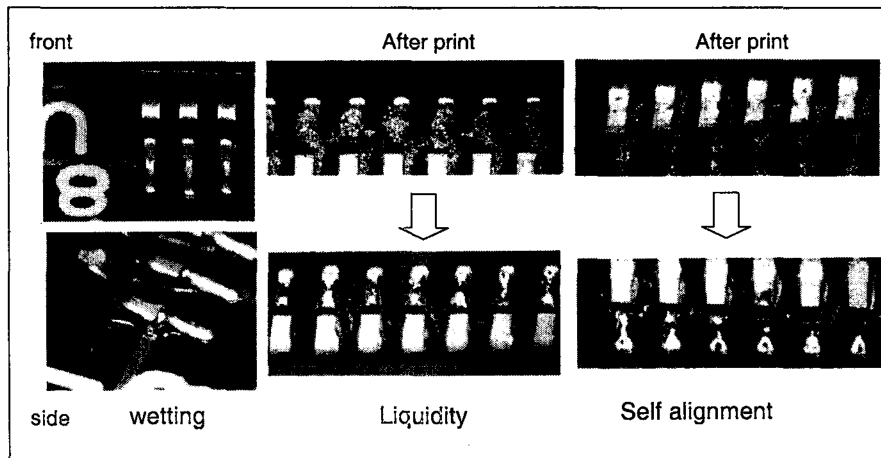
Typical Pb-free reflow soldering

Sn-3Ag-0.5Cu solder paste



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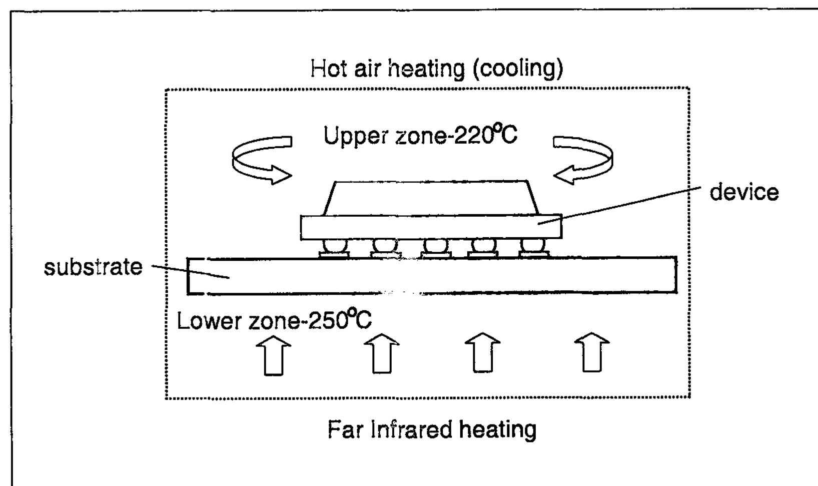
Graded heating reflow furnace



DENDA PRESENTATION

Low temperature Pb-free solder

- ○Under active development in JIEP and JEITA.
- ○Applicable to conventional soldering equipment.
- ○N_2 reflow atmosphere was needed for solder containing Zn so far .
- ○Max temperature of Intel CPU is 220°C
- ○Typical composition, Sn-8Zn-3Bi (197 C)
- ○NEC, Sharp, Hitachi are using for note PC substrate.
- ○ Air reflow solder paste is developed recently.

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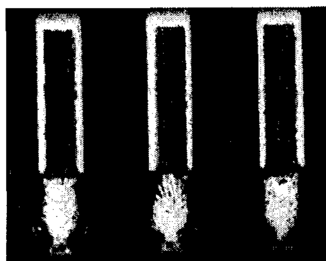
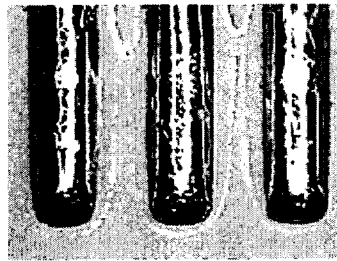
Low temperature, air reflow Pb-free solder paste

Matsushita and Senju



Sony and Nihon Genma



Sn-8Zn-3Bi 197 C
Reflow 210°C, flux activates at reflow.

Conventional solder paste, N_2 reflow.

Sn-9Zn 199 C reflow over 200 C, 30 sec peak 225 C.

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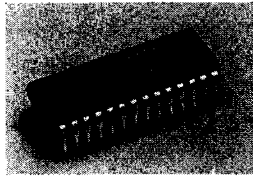
Pb-free plan for semiconductor devices

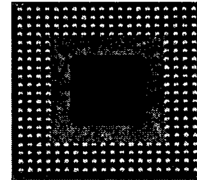


Pin insertion (DIP)

SnPb plating ⇨ SnBi plating, SnCu plating
SnPb solder dip ⇨ SnCu dip

Surface mount (QFP,SOP)

SnPb plating ⇨ SnBi plating, SnAg plating
SnPb solder dip ⇨ SnCu dip



Area array (BGA,CSP)

SnPb ball ⇨ SnAgCu ball

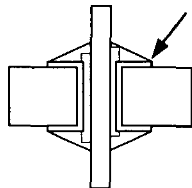
DENDA PRESENTATION

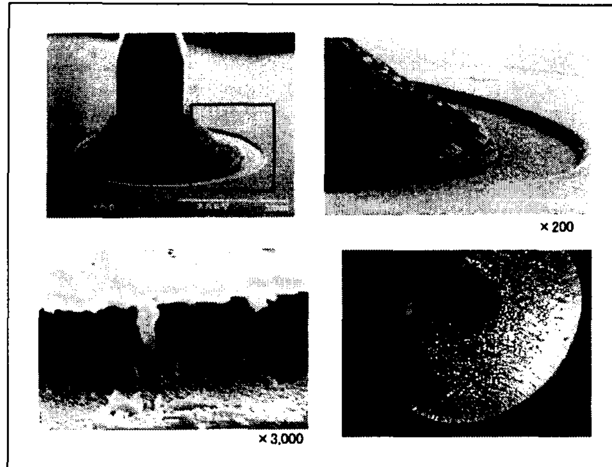
Pb-free flow soldering

- Flow soldering is made at higher temperature (250-260°C) in short time (few seconds), and larger volume of solder can exists.
- Pb-free solder containing Ni (227°C) is popular.
- Standard solder is also used.
- Solder land lift off and Cu wiring erosion observed.
- Solder bath erosion problem took place.
- New stainless bath and a surface coating are being tested.

DENDA PRESENTATION

Solder land lift off phenomenon





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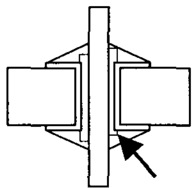
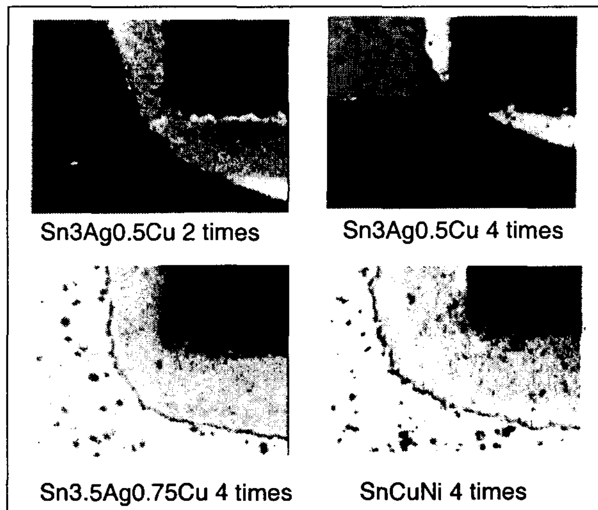
Cu throughhole land erosion in flow soldering





DENDA PRESENTATION

Flow soldering bath

Surface mount (reflow soldering) increases, partial flow soldering is needed.
Pb-free solder is less fluidity. From spout out to static pressure.
Solder. Sn-3Ag-0.5Cu, Sn-0.7Cu-Ni (227. N can be a barrier for bath erosion.
Countermeasure for bath erosion: Surface nitrization, change in stainless steel (SUS316).

spout

static

DENDA PRESENTATION

Soldering iron for Pb-free solder

- Iron tips can be damaged due to high solder temperature.
- Fine tips of pure iron coated by Chromium.
- High speed setup, 320-380 °C in 3 sec.
- Precise temperature control, ±1°C.
- High frequency heating.
- Nitrogen blowing.

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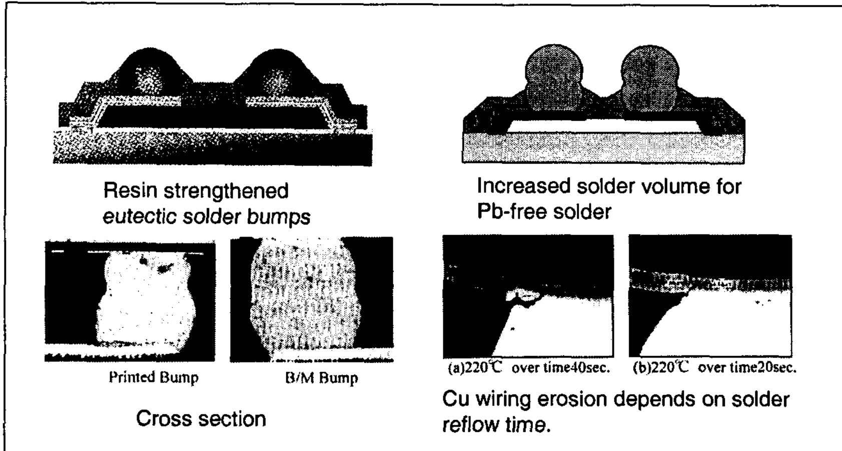
CSP with Pb-free solder bumps

Reliability problem with Pb-free solder



Tanaka,ICEP 2003 p263