Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

IZM
Fraunhofer Institut
Zuverlässigkeit und
Mikrointegration

Adaption to scientific and technical progress under Directive 2002/95/EC

Results previous evaluation
Exemption No. 14

“Lead in solders consisting of more than
two elements for the
connection between the pins and the
package of microprocessors with
a lead content of more than 80 % and less
than 85 % by weight”

(Excerpt from ERA Report 2004)

Öko-Institut e.V.

Freiburg Head Office
P.O. Box 50 02 40
79028 Freiburg, Germany
Street Address
Merzhauser Str. 173
D-79100 Freiburg
Tel. +49 (0)761 – 4 52 95-0
Fax +49 (0)761 – 4 52 95-88

Darmstadt Office
Rheinstraße 95
64295 Darmstadt, Germany
Tel. +49 (0)6151 – 81 91-0
Fax +49 (0)6151 – 81 91-33

Berlin Office
Novalisstraße 10
10115 Berlin, Germany
Tel. +49 (0)30 – 28 04 86-80
Fax +49 (0)30 – 28 04 86-88

2.8 Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 85% in the proportion to the tin-lead content (exemption until 2010)

This exemption request is from the microprocessor manufacturer AMD that uses an alloy containing <85% lead. These ICs have up to 939 pins and if one is bent or damaged, the component becomes waste. The sockets are attached to computer motherboards, which can also be damaged resulting in the PCB becoming scrap.

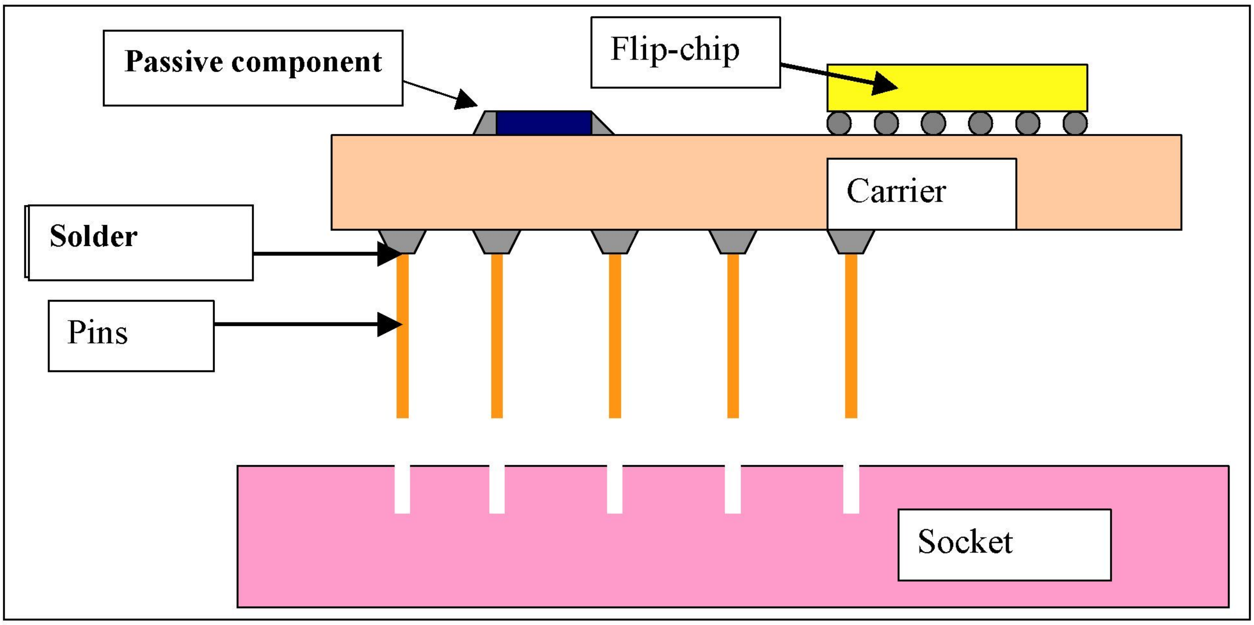

Figure 13. Diagram showing parts of pin grid array microprocessor package

Three alternatives have been considered:

1. Alternative solders.
2. Building microprocessor packages in a different way. This is not possible as the pins are attached first by a sub-contractor.
3. Alternative design.

The pin attachment solder must have a specific range of properties for maximum reliability:

- Melting point higher than the solder used to attach other components.
- Melting point lower than the decomposition temperature of the polymer carrier
- Should be an eutectic alloy to prevent grain growth during subsequent soldering steps that would reduce the strength of the solder.

- Should not be susceptible to electromigration (see section 2.9) or dendrites (silver is susceptible to this).
- Provide minimal wetting of gold plated pins. If solder flows too far along pins there is a risk that this solder be forced into socket holes causing a blockage which cannot be removed so that the socket has to be replaced or in some cases the PCB will become waste.
- Solder must have high strength to prevent pins from bending and this strength retained after three reflow cycles.

2.8.1 Possible alternative solders

Sn5%Sb (tin with 5% antimony) was evaluated but gave a lower bond strength than the lead solder. Pins attached by solder with low bond strength would be more easily bent or broken resulting in a high scrap rate. In AMD's tests, bond strength was measured after three soldering steps and the number of packages with pins damaged during trial production and testing were monitored. The bond strength after three reflow steps was significantly reduced and a statistically significant number had very weak bonds whereas, with the lead solder, the bond strength was significantly higher. In trial production, an unacceptable level of scrap packages was obtained with packages having less pins than are used in AMD's current products. Currently, some AMD packages have over 900 pins which would result in a much higher rate of defective packages based on these test results. A further disadvantage with Sn5%Sb solder is that antimony is detrimental to PCB recycling processes. It is difficult to remove and many recyclers will not accept PCBs containing even small quantities of antimony.

However, Intel has stated in its response to the Stakeholder Consultation that Sn5%Sb can be used for attachment of pins and is reliable. There have been news reports that Intel's customers have experienced difficulties with bent pins on Intel's microprocessor packages however there is no evidence that this is a serious problem and damaged pins may be due to careless handling of what clearly are fragile, very fine pins.

Clearly the experiences of these two competitors, Intel and AMD, have differed. The technical data provided by AMD shows that Sn5%Sb is a lower strength solder than AMD's current lead solder and so, unless procedures are developed to avoid damage to pins, defects that result in scrap components would be statistically more likely with a lower strength alloy. AMD has used the lead solder for many years and so has not developed the procedures required to avoid problems whereas Intel has many years experience with Sn5%Sb and would have developed during this time proprietary techniques to avoid pin damage during manufacture. Intel provides detailed instructions on their website for its customers to avoid pin damage during use.

Sn10%Sb was evaluated by AMD and gave less defects in tests than Sn5%Sb but many more than the lead-based alloy currently used. Also the presence of 10%Sb would increase melting temperature and create more difficulties with recycling.

Tin/silver/copper – the melting temperature of this alloy is too low; pins would drop off when the flip chip is attached.

Solders with >85%lead. AMD did not evaluate these alloys when these products were originally developed as the solder with less lead was found to give almost no defects. Solders containing >85% lead are not eutectics and so would theoretically give weaker bonds after attachment of the flip-chip and passive components. Also, the melting temperature is higher and so could damage the polymer carrier. The use of an increased lead content, although permitted as these solders are exempt from the RoHS Directive, would have a negative environmental impact as more lead and more energy would be used.

2.8.2 Alternative package design

AMD are developing a new package design that avoids pins using "land grid arrays". These were recently introduced by Intel as an alternative design. AMD prefer to pursue this approach to the elimination of the lead solder rather than changing to Sn5%Sb solder in the interim period and have to resolve problems with poor yields, and potentially damage to their customers products. AMD and its customers plan to change to this design by 2010.

2.8.3 Summary of the case for an exemption

AMD originally developed pin grid array microprocessor packages using a higher melting temperature eutectic solder although this contains <85 weight % lead. In their original trials, this gave much better yields than other alloys including lead-free alternatives. Their only competitor, however, uses a lead-free solder and claims good reliability. Intel now has many years experience with the lead-free alloy and so will have developed techniques to obtain a high yield.

AMD now has two options. If they change to the lead-free solder, their yields would initially be poor creating waste components and equipment until techniques are developed to improve yields. Their preferred alternative, which was originally planned prior to the introduction of the RoHS Directive, is to develop land grid array packages which avoid the need for pins and solder. AMD intends to have changed to land grid array packages by 2010.

The wording of this exemption is not clear, a possible alternative would be:

"Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 80% and less than 85% by weight."

connections to PCBs without soldering but which can be removed and re-inserted without damage to the connector or the PCB.

4.5 Lead as a coating material for the thermal conduction module C-ring

Thermal conduction modules are the central processor units used in the Z-Series main-frame computers produced by IBM. The C-ring is the seal used between the glass-ceramic circuit and the liquid cooled copper plate, which is used to remove heat from the semiconductor chips.

4.6 Lead and cadmium in optical and filter glass

Optical components used in electrical equipment such as glass lenses, optical filters and prisms where no lead-free alternative is suitable. Lead in the glass of electronic components is not included in this exemption as this is covered by item 5 of the Annex of the RoHS Directive.

4.7 Optical transceivers for industrial applications

This exemption request was made to cover optical transceivers and the solder connections made to the PCB to which they are attached. Optical transceivers convert optical signals into electrical signals using glass-fibre connected to a photosensitive semiconductor, convert electrical signals into optical signals using a laser diode or LED attached to an optical fibre or one device may contain both functions.

4.8 Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 85% in the proportion to the tin-lead content (exemption until 2010)

A lead-based solder with a melting point higher than standard lead-free solders and eutectic tin/lead but containing <85% lead which is used to attach pins to the carriers of microprocessor packages. This alloy is not covered by the exemption listed as item 7.1 of the Annex of the RoHS Directive which is for solders which contain >85% lead (see section 1.3).

4.9 Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead) and any lower melting temperature solder required to be used with high melting temperature solder to complete a viable electrical connection

This exemption is intended for internal (Level 1) connections made between the semiconductor die and the carrier in flip-chip packages which have higher power consumption and currently use high melting temperature solder bumps (>85% lead) which are connected to the carrier with eutectic tin/lead (~37% lead). The bump composition will have <85% lead. This exemption would also include situations where high melting point solder balls (e.g. on ball grid array packages) are attached to a PCB with a lead-free solder. It is not intended to permit the use of solders containing lead for