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SALT II: Soldering Aluminium at Low Temperature

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Introduction

Tracking of assets and personnel, either for security or for efficient managing of resources, is a significant problem in today's business environment. Theft, losses, misplacement of assets results in billions of dollars worth of increased costs and lost revenues. Companies currently use different technologies to track and locate assets within their work environment, for example the bar code. New low cost technologies are required to render the tags to such price level that they are affordable for use on individual items in grocery stores. Mat-tech, Philips, BE Semiconductor and TU/E Eindhoven have developed this technology.

The objectives

The test vehicle for the new technology is an RF ID tag, consisting of an RF induction coil provided with an IC. The coil will be made of aluminium on a low temperature substrate. Current RF Id identity tags contain Cu coils, which are expensive and there fore should be replaced, if possible, by a more low cost and environmentally more acceptable material as aluminium. The IC will be attached to the aluminium coil using a new type of solder.

This project intends to offer a low cost and reliable solder interconnect method to aluminium antennas for use in RF ID tags. Using this interconnect technology the RF ID tags will become low cost and therefore become suitable for use on individual items. The proposed research will remove the technical barrier to open up this market. Therefore the IS project SALTII will investigate the critical steps to make a cheap Radio Frequency Identity tag (RFID tag). A RFID tag consists of following components:

- An integrated circuit (IC)
- An interposer carrying the IC
- A flexible substrate (e.g. paper, PET) with an antenna (consisting of copper or aluminium)

Challenges & methods

The main technological issue in this project is fast soldering to aluminium. The problem is twofold:

- To obtain wetting of the aluminium despite the tenacious aluminium oxide film
- To produce soldered joints, which do not corrode rapidly

Soldering is the fastest interconnect method. Therefore, for the connection to aluminium a new Pb-free solder for the assembly process needs to be formulated. This requires of number of research activities:

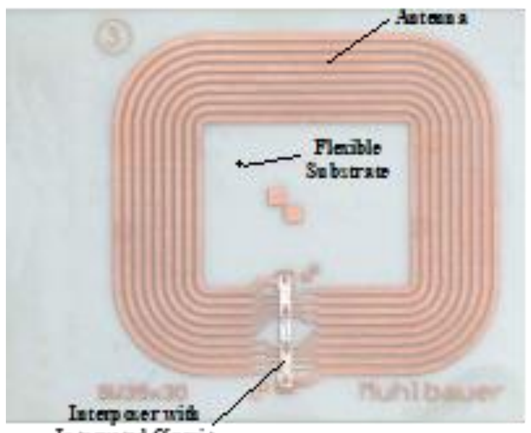
- A suitable lead-free matrix will have to be composed.
- Chemical additives, which have a reducing capability on aluminiumoxide, will have to be identified. These dispersed intermetallic phase(s) that will remain in the solder matrix during processing, will promote disintegration of the native oxide on Al-substrates. This process shall result in the formation of stable intermetallic layers. The additives, typically some 10 weight percent of the alloy, consist of metastable SnTi compounds which are environmentally compatible.
- Research into chemical additives, which function as grain refiners in the solidification process of the solder and which hamper the growth of enriched metallic phases. These grain refiner are typically taken from elements as Ce, Ge, Ga or Sb.
- Methodology for dispersion of the additives into the solder matrix.

- A fast and fluxless soldering process for soldering onto aluminium, based on heat combined with ultrasonic agitation. Typical process time will be below 1 second. The process window for soldering will be determined, under which the reliable joints can be formed.

Interfacial reactions between low-temperature solders and aluminium substrates have to be studied with regard to formation of intermetallics and reliability issues. The micro-structural evolution in the solder bump and reaction phenomena at the interfaces with aluminium will be investigated in order to understand (and predict) the joint degradation mechanisms. The reliability and failure testing will reveal the crack initiation and growth mechanisms for the solder joints.

The result

The result of the research will be a lead free low temperature soldering process to be used for aluminium components.



Novelty of the research approach

A flexible substrate will not survive the interconnect process at high temperatures, therefore a low temperature interconnect process is developed. It is the first time that soldering to aluminium at low temperature is done. A solder matrix with significantly lower melting point has to be defined, such that at the processing temperature the paper substrate of the RF ID tag will not be damaged. Sn-Bi (near) eutectic alloys provide an interesting solution. A blend of additives, based on Ti or Zn containing compounds, will be used to further modify the solder alloy.

The Ti / Zn containing low melting, lead-free solder will be processed by using a combination of heat and ultrasonic agitation. This soldering method shall be fluxless and is based on the mechanical destruction of oxide scales building up on liquid solder and substrate material. The oxide of the base material gets partially cracked, so that a chemical (metallurgical) interaction between solder and base metal constituents can take place. The solder melt undermines present surface oxides and leads to complete wetting of the base material.
In contrast with copper, aluminium is a cheaper and more environmental friendly material. Especially when large amounts of tags are manufactured and applied in the consumer market, these two aspects become very important.

Conclusions

- Explored the possibilities for a low temperature and lead-free solder for soldering onto aluminium terminals and realise a fast soldering process.
- Rendered the solder suitable for miniature soldering processes.
- Studied micro structural evolution in the solder bump and reaction phenomena at the interfaces with aluminium to improve the interconnect reliability.
- Showed a proof of concept for a RFID tag with aluminium antenna created with aforementioned soldering process.