Development, optimization and practical use of the new Au-Sn plating solution with extended lifetime

INTA Technologies, Inc.

Keywords Electroplating of near eutectic Au-Sn alloy, Extended solution life

Abstract

Electro deposition has a major advantage over other methods of thin film deposition. It allows deposition at atmospheric pressure and mild temperature, requiring relatively inexpensive equipment. However electro deposition of the alloys of metals with very different standard potentials represents a significant challenge that is addressed in the present work. One of those alloys is eutectic Au80n20.

Au80Sn20 is a well-established eutectic solder for use in the electronic industry. For many applications the solder is available as either preform or a foil that must be cut to size. The material is frequently supplied in a thickness that surpasses the minimum needed to make a good joint.

The labor of making and placing the foil with a micron scale accuracy represents a significant challenge while adding another cost to the overall process. By using INTA's AuSn plating process the material and labor costs can be significantly reduced.

Electrochemical deposition process of near eutectic Au80Sn20 alloys from the new stable plating solution is presented.

The solution remains stable for a long time (exceeding 6 months). The solution operates at acidic pH under the special pulsed current conditions. Composition of the plated alloy is defined by Au to Sn ratio in solution and is stable in the wide range of current densities. (Figures 3 and 4)

Introduction

Interest in Au-Sn plating has developed during the last few years due to increasing importance of Au-Sn bonding technology.

There are two types of Au-Sn plating chemistries currently available based on either cyanide or non-cyanide (sulfite) Gold complexes.

The plating process presented in the present work has been developed as an alternative for the other commercially available processes that are either very expensive and difficult to control, or unstable and thus have a short life span. Such an undesired combination makes these processes unsustainable and difficult to use in a production environment.

New INTA Technology, Inc. plating electrolyte belongs to the so-called dual-ligand system. Two different metals are chelated by two different complexing compounds in order to bring their reduction potentials closer to each other.

Specially selected stabilizer chemistry, surfactant and brightener system provides fine-grained alloy deposit of the stable composition within the wide range of current densities (from 4 to 8 ASF)

The process is much less sensitive to the temperature and agitation fluctuations compared to competitive electrolytes.

Special pulse current form should be utilized to maintain co-deposition of near eutectic Au -Sn alloy.

Plating rate is ~ 0.3 micron per minute at 6.5 ASF

Experimental procedure

The plating solution remains stable and demonstrates predictable results for the period of more than six month since the initial make up. Only Au and Sn compounds were added during this period to maintain desirable Au/Sn ratio.

Two alloy compositions were targeted:

- Au75Sn25 for the substrates with Au under plate (Figure 1)
- Au80Sn20 for the substrates with Ni or Pt under plate (Figure 2)

Sufficient analytical control was provided by AA determination of Au by Varian AA 240 and wet titration of Sn(II)

Au and Sn analysis have been performed before every plating session to establish metal consumption vs. charge. This relationship is used for SPC and helped to calculate additions of Au and Sn compounds.

A standard SST coupon (monitor) with the fixed platable area has been plated before each production substrate.

The plated alloy composition was measured by Oxford Instruments Measurement System CMI 900 XRF calibrated with NIST traceable standards. Reflow of the deposited alloy was performed in a CAMCO furnace with Honeywell DCP-302 controller under Hydrogen atmosphere to confirm melting temperature consistency. SEM with EDX capability was used for the phase analysis.

Deposit thickness was measured by Veeco Dektak 3030.

Dependency of alloy composition vs. Au/ Sn ratio in solution, current density at the fixed temperature, pulse regime and solution agitation has been established. The established practical current densities range was from 4.5 to 8.0 ASF.

Results and Discussion

Solution stability

Preliminary work directed to establish stability of plating solution vs. storage time had shown that the solution remained clear without any evidence of decomposition or precipitation for the period of more than 6 months.

Gradual decreasing of Sn(II) due to oxidation to Sn(IV) was compensated by adding Tin concentrate before each plating session and had no detrimental effect on plated alloy composition.

Effect of temperature

Optimum temperature that provides stable plating rate, manageable Tin oxidation rate and is "friendly" to virtually any positive photoresist was established at 104 +/- 5^{o}F.

Effect of agitation and plating cell arrangement

It was found that agitation provided either by solution movement or by the substrate reciprocating movement had very little effect on the deposit composition within the operational range.

However, the photoresist pattern which is individual for each design influences micro distribution of plated deposit. Optimal agitation parameters should be established for each particular substrate in order to achieve the best micro-uniformity.

Macro-uniformity is controlled by the properly designed an individual plating fixture combined with adjustable non-conductive shielding system.

Conclusions

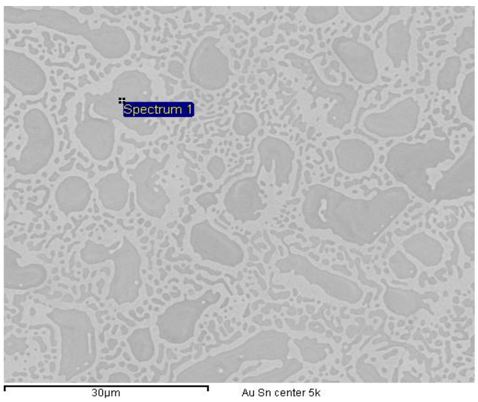
Technical and manufacturing aspects of the electroplating of near eutectic Au-Sn solder from the new plating solution composition with extended lifetime were studied.

Optimal plating parameters have been established:

- Au to Sn ratio in solution
- Plating temperature
- Pulsed current parameters
- Current densities range
- Solution agitation and plating cell arrangement

Practical monitoring of the plating results as well as metrology for composition and thickness measurements have been established.

Supporting data



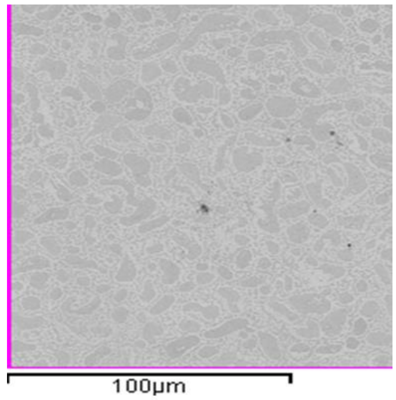
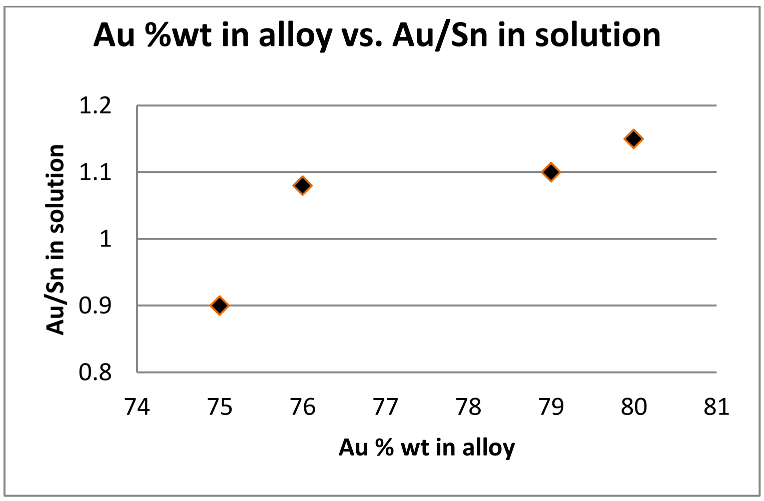


Figure 1

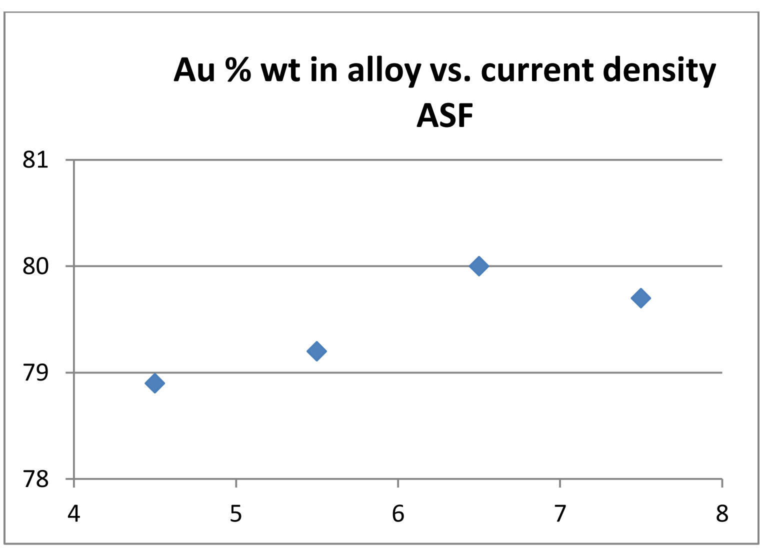
EDX SEM of Au75Sn25 plated alloy

Figure 2

EDX SEM of Au80Sn20 plated alloy



Au/Sn	Au % wt
0.89	75
1.08	76
1.12	79
1.15	80



ASF	Au% wt
4.5	78.9
5.5	79.2
6.5	80
7.5	79.7