FLIP CHIP SOLDER BUMPING PROCESS BY ELECTROLESS NI

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Abstract

In the present work, a low cost and fine pitch bumping process by electroless Ni/immersion Au UBM (under bump metallurgy) and stencil printing for the solder bump on the Al pad is discussed.1) The Chip used this experimental had an array of pad 14×14 and zincate catalyst treatment is applied as the pretreatment of Al bond pad, it was shown that the second zincating process produced a dense continuous zincating layer compared to first zincating. Ni UBM was analyzed using Scanning electron microscopy, Energy dispersive x-ray, Atomic force microscopy, and X-ray diffractometer. The electroless Ni-P had amorphous structures in as-plated condition. and crystallized at 321℃ to Ni and Ni_3P. Solder bumps are formed on without bridge or missing bump by stencil print solder bump process

Key word: Flip chip, UBM, Electroless Ni , Zincating, stencil

Introduction

Flip Chip bonding has been used as the chip level packaging because of the apparent advantages, i.e. short interconnection length, low inductance and increased number of I/Os per unit area.2-3) Many flip chip technology has been introduced since IBM developed C4 technology in 1964. Nowadays Evaporating and electroplating are the two wafer solder bump process in production. Evaporation is high cost, and can not produce eutectic bumps due to the Sn and Pb vapor pressure difference and Electroplating is a relatively low cost but Electroplating requires photoresist steps and plated bump composition is not easy to control. Recently, stencil printing for the solder bump has been applied for flip chip bumps and electroless Ni was used as under bump metallurgies (UBM) because of its many advantage, such as maskless selective metal deposition, low cost processing, good solder wettability, and good solder diffusion barrier.4) Also, Lead-bearing solders, in particular lead-tin eutectic solders, have been widely used in the electronic packaging due to low cost, low melting temperature and good wetting behavior on several substrates. However, in respect of environmental and health concerns, with awareness of the toxicity of lead, significant pressure has been put on the electronic industry to lead free solder. The Sn-Ag solder alloy is an attractive candidate system as lead free solder. This paper presents the results of a study performed to form Ni UBM and solder bump by using solder bump for flip chip interconnects.5)

Experimental

P-type 4inch Si wafer was evaporating deposited with Al a thickness of around 1㎛. The pattern was developed on the Al layer with the aid of photolithography an array of 14×14 pads on each chip. The pad's size was

$130 \times 130 \mu m^2$ with a pitch size of $500 \mu m$.

2.1 Electroless Ni UBM process

Fig.1 showed the electroless Ni bumping process. The commercial zincate was used and conducted under ambient conditions.[6-8)] Zinc pretreatment baths mainly were consisted of zinc oxide and hydroxide also it contained a little of iron, copper and nickel ions to improve nucleation. The acid solution used for soft etching was 20% nitric acid.

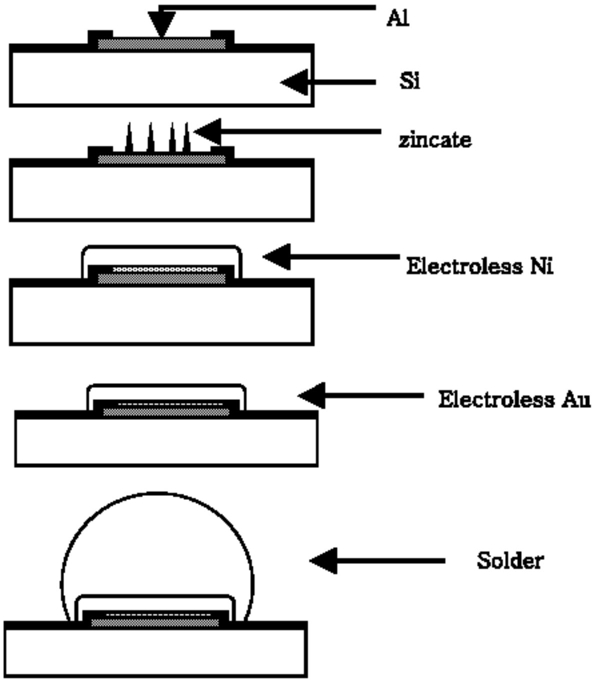


Fig.1 the schematic of Electroless bumping process

The surface morphology of the zincated Al pad was investigated with scanning electron microscopy (SEM) and atomic force microscopy (AFM). The electroless Ni used in this experimental was a commercial hypophosphite based nickel and deposited Ni layer contains about 12wt% of phosphorous. The bath was operated at a temperature of 90℃ with the pH value adjusted from 3.5 to 5.6. after bumping, $0.1 \mu m$ gold were coated by immersion plating to prevents nickel oxidation.

2.2 Properties of Ni UBM

The deposited Ni layer was investigated with the aid of heat treatments at various temperature and the transformed phase were analyzed with X-ray diffract meter (XRD) with Cu target and Ni filter. Crystallization temperature was investigated with DSC (Differential Scanning Calorimetry).

2.3 Solder ball Bumping

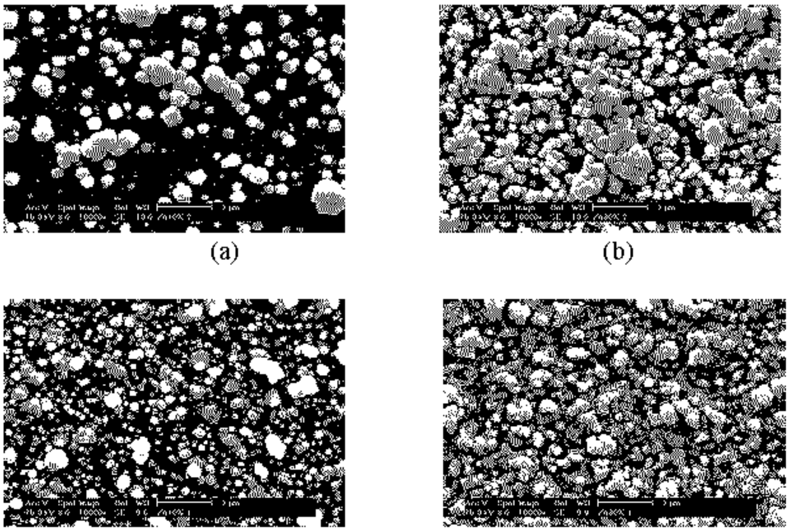
Stencil printing method for solder bumps were fabricated on the electroless Au/Ni UBMs. 96.5wt% Sn-3.5wt% Ag (eutectic SnAg, melting temperature: 221°C) was selected as solder materials.

Results and discussions

The most important step in electroless bumping is the activation of bond pads. It was conducted in the activation of bond pads to remove native oxide from the aluminum surface and to form a layer, which can initiate electroless nickel deposition. As pre-treatment process for the electroless nickel deposition on aluminum, zincate has been used and the chemical reaction of the zincating process is below.

$$3Zn^{2+} + 2Al \rightarrow 3Zn + Al^{3+}$$

zincating is mainly an exchange reaction occur between Al and Zn which deposited on Al. Fig.2 showed the surface appearance of the zinc particle deposited which was dipped for respectively 20%vol and 30%vol of zincating.



(a) (b)

(c) (d)

Fig.2 the surface appearance of first zincating deposits which was deposited for

(a) First zincate 20% (b) First zincate 30%

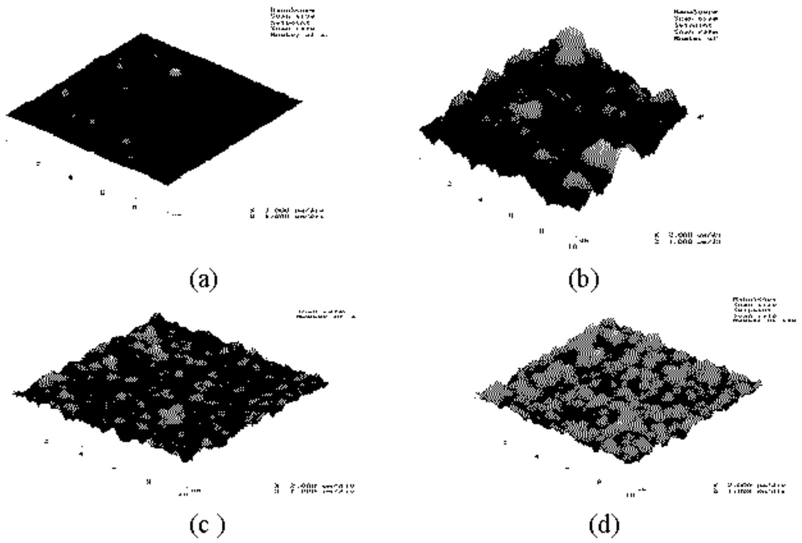
(c) Second zincate 20% (d) Second zincate 20%

The zincating reaction occurred sporadically on the Al surface. Zinc forms big clusters, which were preferentially deposited at the edges of the bond pad. Optimal zincating time is depending on the state of the aluminum it is in the range from 10 to 30s. As a result of diluting the solution with demonized water Respectively to 20% and 30% zinc particle increased with the vol. percent of the Zn in solution. after first zincation the coarse and no uniform Zn particle on bonding pad was obtained and Zn particles is up to 0.3-2㎛.

Between first and second zincate, Nitric acid was used. Through nitric acid formed a nucleus was dissolved.

A double zincating treatment improves the Zn nucleus density. The deposited Zn nuclei were formed more uniform with finer Zn grains on Al bondpads.

The Ni-P deposition process is started by an exchange reaction with Zn. by continuing the deposition of Ni; the particles become larger, grow together, and finally form a continuous layer on the bond-pad. Rough Ni layers are formed when the size distribution of the Zn nuclei is large. Ni layers depend on the particle density and the size distribution of the Zn nuclei.



(a) (b)

(c) (d)

Fig.3 The surface appearance after

(a)Al evaporated (b) First zincating

(a) Nitric acid etching (d) Second Zincating

Fig.3 (a) and (b) were respectively evaporated Al and first zincated Al. Fig. (b) showed that coarse Zn particle existed on Al. Fig.3 (c) showed Al bonding pad after Nitric acid etching, a great extent of the deposited zinc particle was removed and the pad area became smoother.

Fig.3 (d) was the morphology of Al bonding pad after second zincating. Distribution of Zn particle were uniform and size of the Zn were about 0.5㎛. the electroless nickel was plated on the zincated aluminum surface in a nickel-sodium hypophosphite bath at 90℃. The deposition of nickel based on the following reaction.

$$Ni^{2+} + 2e \rightarrow Ni$$

The oxidation of hypophosphite was expressed by the following reaction.

$$2H_2PO_2^- + 2H_2O \rightarrow H_2 + 2H^+ + 2e$$

$$3H_2PO_2^- \rightarrow H_2PO_3^- + H_2O + 2OH^- + 2P$$

The deposits from electroless nickel were Ni-P alloy include about 12wt% phosphorus. Ni started to deposit on Zn particle and the Ni grains increased with deposited time. Deposition rate and morphology of Ni depended on the pH of the plating bath. SEM observed the appearance of the deposited nickel. The result was shown in Fig.4.

Fig.4 (a), (b), (c) were respectively pH 3.6,pH 4.5 and pH 5.6. Variations of phosphorous content on Ni layer were not observed. Nickel deposition was isotropic; hence bumps became mushroom shaped and had rounded upper corners.

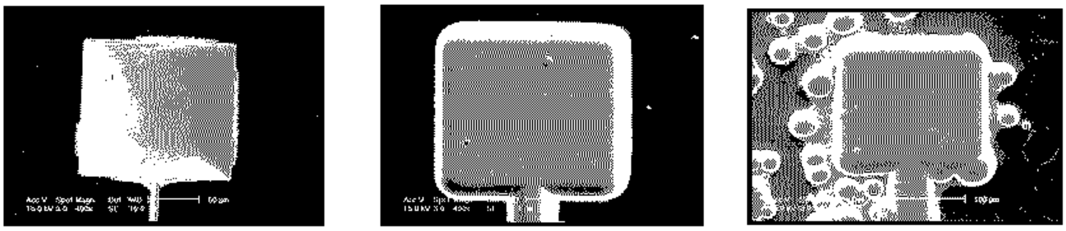

(a) (b) (c)

Fig.4 The appearance of Ni bump according to pH in Ni bath

(a) pH 3.5 (b) pH 4.6 (c) pH5.6

3.2 Properties of Ni bumps

With increasing heat treatment temperature deposited electroless Ni bump was investigated by XRD Heating temperature were respectively 200, 300, 400and 500℃.

The amorphous structure of the as-deposited sample was identified by XRD. Typical results of Ni-P were shown Fig.5. One broad peak at $2\theta = 45°$ was observed. After being heat treatment at high temperature, various sharp diffraction peaks appeared on the XRD patterns, showing the occurrence of the crystallization since the Ni-P amorphous alloys are thermodynamically metastable (Ni has no solubility of phosphorus). As shown in Fig.5 the number and the strength of those diffraction peaks increased with the heating temperature increasing, indicating that the extent of the crystallization of the Ni-P amorphous alloy increased gradually. Two kinds of crystalline diffraction peaks corresponding to Ni and Ni_3P were observed simultaneously in the XRD patterns and it indicated that the both Ni and Ni_3P were formed at the same time during the crystallization process.

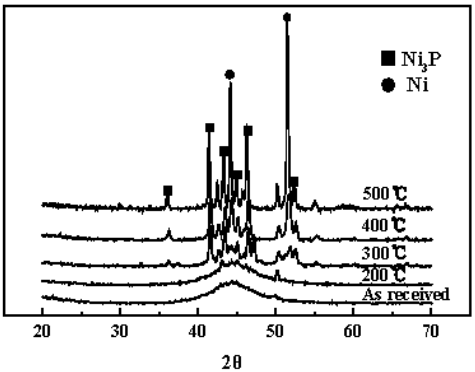


Fig.5 XRD patterns of Ni bump by heat treatment

DSC was investigated to confirm the crystallization's temperature. sharp peak was appeared at 321℃, showing the crystallization.

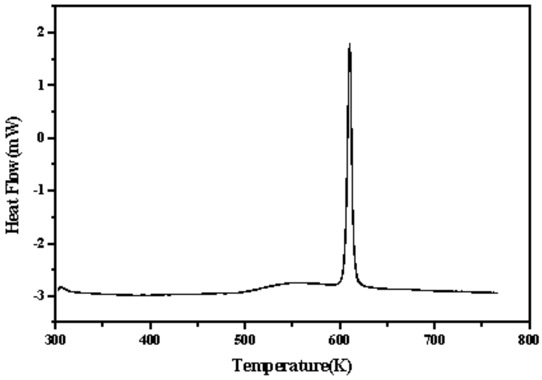
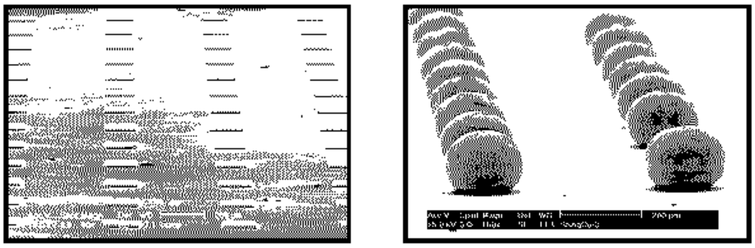


Fig.6 DSC analysis of Ni-P alloy

3.3 Solder ball Bumping

Solder was deposited by stencil method after reflow, 200㎛ solder ball was formed. Fig.5 showed the array of Ni bump and solder ball after reflow. Fig .7 showed the Ni UBM and the solder bump



(a) (b)

Fig.7 The appearance of array of (a) Ni UBM and (b) solder bump

4. Conclusion

The Flip Chip bumping process and properties of bump by electroless Ni were studied.

It is shown that multiple zincating process produced more dense and continuous zincating layer, while the first zincating step caused a roughened surface. Morphology of deposited Ni-P layer was depended on the pH in Ni bath. Deposited Ni-P layer was identified as amorphous structure and crystallized at 594K to Ni and Ni_3P with heat treatment temperature. The crystallization was considered to affect sheet electrical resistance to be decreased along with increase of temperature.

Acknowledgements

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