SILVER SPOT PLATING TECHNIQUE

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Abstract

Electroplating play an important roles in semiconductor manufacturing industries. A layer of silver or gold was selectively plated on the surface of lead frame by using electroplating technology. The purpose of depositing a layer of gold or silver on the surface of lead frame is to improve the bondability during die attach and wire bonding process. Since the bonding process does not involve all surfaces of the lead frame, selective plating is essential in order to eliminate the waste of precious metals such as gold and silver. Basically, to selectively plate precious metal on lead frame, there are several methods can be used and these methods can be grouped into two categories – masking and spot / jet plating. In this paper, a new technique to selectively plate silver coating on the copper lead frame by using improved spot plating technique will be presented. The effect of the parameters such as the flow rate of the electrolyte to the nozzle, taken out from nozzle (control by peristalsis pump), the current density (control by voltage regulator) and the plating time (control by timer) was study for the improvement spot plating technique. From the result obtain in the experiments, the optimum condition for the study parameters will be showed. At the end of the paper, the recommendations to further improve the proposed technique will also be presented.

Keywords: Electroplating, selective plating, lead frame, masking, spot plating

INRODUCTION

Electrochemical technology entered the electronics industry some 50 years ago as a manufacturing process for low-end printed-circuit boards. Today, electrochemical technology is employed widely for the processing of advanced microelectronic components, including high end packages and interconnects, thin film magnetic heads and micro-electro-mechanical systems (Landolt & Datta, 1999). Electrochemical microfabrication technology is expected to play an increasingly important role in the electronics and microsystems industry because of its cost effectiveness and achievable high precision. In addition, electrochemical processes are attractive from an environmental point of view because material deposition or removal is highly selective thus minimizing waste (Landolt & Datta, 1999). With the miniaturization of electronic devices, the connection reliability between integrated circuit (IC) and the external circuits has become important. Electroplating and electroless plating have been applied for the metallization of electronic components. Recently, advanced plating technology is strongly in demanded for the manufacturing of electronic components, because many devices are becoming finer and more complicated (Honma, 2001).

The electrodeposition of semiconductor has been investigated in detail and demonstrated by a large number of workers over many years (Schlesinger & Paunovic, 2000). This effort is primarily motivated by the fact that electrodeposition is a relatively simple and inexpensive deposition technology that may be scaled up easily. In general, the films deposited by this method do not possess the crystalline perfection or low levels of electrically active impurities of single crystal epitaxial films deposited by techniques such as molecular beam epitaxy or chemical vapor deposition. Nonetheless, in applications where large area of semiconductors are required, such as photovoltaic power generation or corrosion protection as opposed to integrated circuit fabrication, the low cost and comparatively low material demands make this deposition technology attractive in terms of ultimate commercialization (Schlesinger & Paunovic, 2000). During the past decade, electroplating technology has played a decisive role in the phenomenal advancement and growth of storage, interconnection, packaging and other aspects of the microelectronics industry. Due to it efficient cost-performance capability, electroplating has now emerged as a technology of choice for the manufacturing of a variety of electronic components from "low end" consumer products to advanced "high end" microprocessors (Datta, 2003).

In lead frame manufacture process, center of lead frame and connector is usually plate with a layer of gold or silver to improve the bondability during die and wire bonding process. Since the bonding process does not involve all surfaces of the lead frame, selective plating is essential in order to eliminate the waste of precious metals such as gold and silver. Beside that, to assure good adhesion between the die, the lead frame and the plastic sealant with which the finished device was enveloped, selective plating is essential since the plastic sealant adhere substantially better to the lead frame base metal than to the gold or silver (Uchytil et al, 1972). Basically, to selectively plate precious metal on lead frame, there are several methods can be used and these methods can be grouped into two categories – masking and spot / jet plating. Currently, masking is the most common used method in lead frame manufacturing industries to achieve the selective plating purpose. However, proper masking of the sheet so that only those portions of each lead frame which require plating are actually plated has encountered a great deal of difficulty. The masking of the narrow apertures with plastic materials frequently failed or was too expensive for incorporation in a commercial process. Furthermore, the proper alignment of the sheet surface masking with the multiplicity of etched lead frames in the sheet was difficult, time consuming and expensive. Frequently, the masking was unsatisfactory and misaligned which required further work on the lead frames such as the removal of excess plating to assure good adhesion between the semiconductor, the lead frame and the plastic sealant with which the finished device was enveloped (Uchytil et al, 1972).

Spot plating is the others option to achieve the selective plating purpose. However, due to less research have been done on this method, it was still not used in the real production line. In this paper, a selective silver spot plating technique will be proposed. The proposed technique has been designed to improve the existing spot plating technique. A silver spot with the size 1mm in diameter is expected to be produced on the copper plate with this method. The proposed technique will be fabricated and several experiments will be carried out to determine the performance of the design technique.

SILVER SPOT PLATING TECHNIQUE

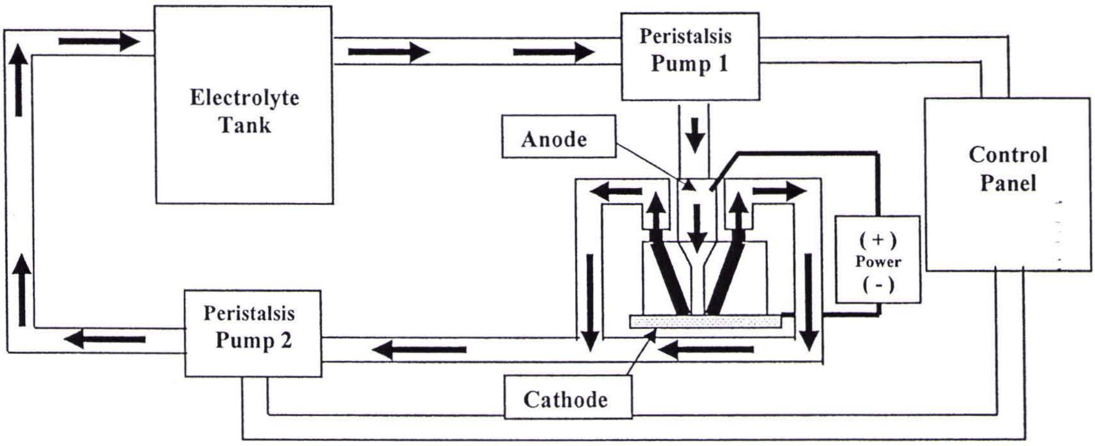

Figure 1: The proposed spot plating technique

Spot plating is a method to selectively deposits precious metal on the substrate by impingement the electrolyte to the point or the area that required plating. This method is more simple and involve less process step if compare with the normal masking method. Since the process is simplifier, the process cost is also more economy. According to the literature review from the US patent, there are few spot plating technique have been invented such as the "precision spot plating process and apparatus" by Beck (Beck, 1983) and "scanning nozzle plating system" by Oliver and Flecther (Oliver & Flecther, 1974). The advantages of these process is that both of the method eliminate the used of masking. According to Oliver and Flecther, the elimination of the masking requirement would contribute greatly to the process cost since masking increases the complexity and cost of the process. Beside that, masking also is a contributing factor to the limited pattern resolution. Tank dipping is also quite undesirable since the solution in the tank tends to become contaminated, thereby contaminated the substrate surface. So, this method capable of producing patterns with very fine line resolution without requires a masking process.

Figure 1 shows the proposed spot plating technique that has been designed to improve the existing spot plating mention above. In this technique, two peristalsis pumps have been used to control the flow of electrolyte into the nozzle and take out the electrolyte from the nozzle. Beside control the flow rate of the electrolyte, these pumps also will ensure the continuous flow of electrolyte to the substrate during the plating process. The electrolyte tank is used as reservoir for the plating bath. The electrolyte will be taken out from electrolyte tank by the peristalsis pump 1 to the nozzle and will be recycling back to the electrolyte tank through peristalsis pump 2. Compare with the existing spot plating technique, this method is more safety and environment friendly due to the electrolyte (which contains the cyanide) will not direct exposed to the environment. The stainless steel nozzle with outer diameter 20mm and inner diameter 5mm is used as the anode for this system. This outlet of the nozzle is connected to the Teflon with 20mm diameter and 10mm height. A hole with 1mm diameter has been drilled through the center of the Teflon. This hole will function as a guide to ensure the electrolyte impinges to the point that required plating. Beside that, the size of the hole also will determine the size of the spot. For the same Teflon also, two holes with the angle 30° from the center hole is proposed to drilled (please refer to figure 1). These holes will function as outlet to take out the electrolyte from the nozzle continuously. However, during the fabrication, due to the difficultly to drill the hole with angle 30° on both side of the center hole, thus only one hole is managed to drilled.

A control panel is used to control the speed of the peristalsis pump. The speed of the peristalsis pump is varied from 0 rpm to 100rpm. During the performance testing, the speed of the electrolyte to the nozzle (pump 1) and speed of the electrolyte out from nozzle (pump 2) is change accordingly to study the effect of the pump speed (inlet and outlet) to the size of spot deposited. Voltage regulator is used as the power source for the system. The positive terminal of power supply is connected to the stainless steel nozzle and the negative terminal is connected to the substrate (copper plate). A pneumatic system with a timer has been used to control the movement of the nozzle head to the substrate. To start the plating system, a power supply must be on first before start the timer which will move the nozzle head down to the substrate. With the continuous flow of electrolyte to the substrate when the nozzle head with the substrate is contacted, plating will happen. A silver spot is successful to produce with this method. Several experiments have been carried out to study the effect of pump speed, supply current and plating time to the size and shape of the spot been produced.

EXPERIMENT SETUP

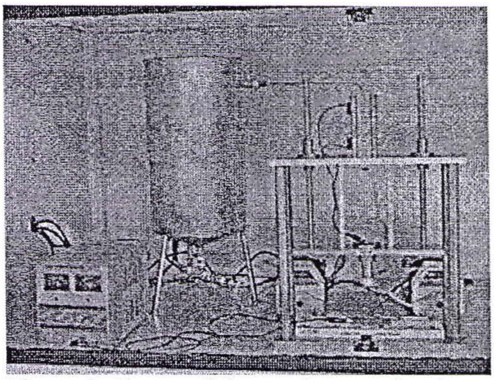

Figure 2: Setup of the equipment for the proposed technique

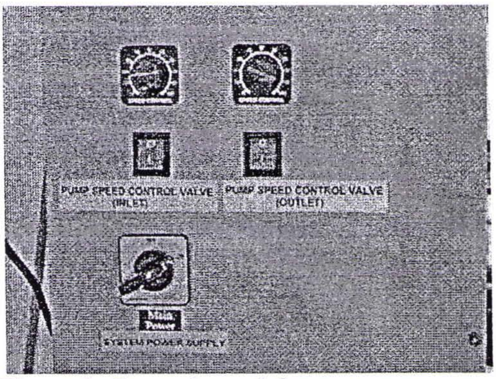

Figure 3: Control panel for system power supply and pumps speed

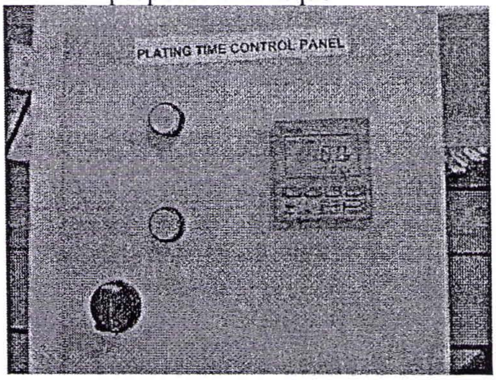

Figure 4: Control panel for the plating time

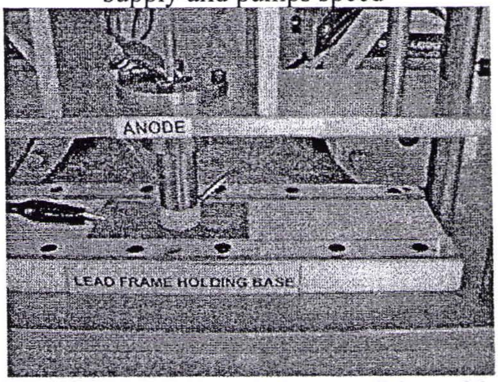

Figure 5: The actual plating condition with the nozzle head move down and direct contact with the substrate

Figure 2 shows the setup of the equipment for the proposed technique. As mention before, the equipment including two peristalsis pumps, a voltage regulator, stainless steel nozzle which connected with Teflon (anode), electrolyte pump, copper plate (cathode) and pneumatic control system. The control panel which controls the power supply to the system and the speed of the peristalsis pumps (inlet and outlet for the electrolyte) is shows on figure 3. Meanwhile the control panel for the plating time is shows on the figure 4. Figure 5 shows the condition for the equipment during the plating process in which the nozzle head is move down by a pneumatic system and direct contact with the substrate.

To study the effect of the pumps speed (the flow rate of the electrolyte into the inlet of nozzle and the flow rate of the electrolyte take out from nozzle), 7 different experiments have been carried out. In this case, the supply current, plating time and the inlet pump speed (pump 1) is set as constant. Table 1 shows the detail parameter setting for this experiment.

Table 1: Operating condition for the experiment to study the effect of pumps speed

No.	Current (A)	Plating time (s)	Inlet pump speed (rpm)	Outlet pump speed (rpm)
1	0.05	10	10	20
2	0.05	10	10	40
3	0.05	10	10	60
4	0.05	10	10	70
5	0.05	10	10	80
6	0.05	10	10	90
7	0.05	10	10	100

In the case to study the effect of plating time to the spot size, 9 experiments have been carried out. The plating time is varied from 2.5s to 60s and control by the timer shows on figure 4. Table 2 shows the operating condition for this experiment.

Table 2: Operating condition for the experiment to study the effect of plating time

No.	Current (A)	Inlet pump speed (rpm)	Outlet pump speed (rpm)	Plating time (s)
1	0.05	10	65	2.5
2	0.05	10	65	3.5
3	0.05	10	65	5.0
4	0.05	10	65	10.0
5	0.05	10	65	15.0
6	0.05	10	65	20.0
7	0.05	10	65	25.0
8	0.05	10	65	30.0
9	0.05	10	65	60.0

Finally, to study the effect of the current supply to the system, 7 experiments have been carried out. In this study, the current is varied from 0.05A to 3.00A and control by the voltage regulator. Table 3 shows the detail operating condition for this experiment.

Table 3: Operating condition for the experiment to study the effect of current supply

No.	Plating time (s)	Inlet pump speed (rpm)	Outlet pump speed (rpm)	Current (A)
1	5	10	65	0.05
2	5	10	65	0.25
3	5	10	65	0.50
4	5	10	65	1.00
5	5	10	65	1.50
6	5	10	65	2.00
7	5	10	65	3.00

RESULTS AND DISCUSSION

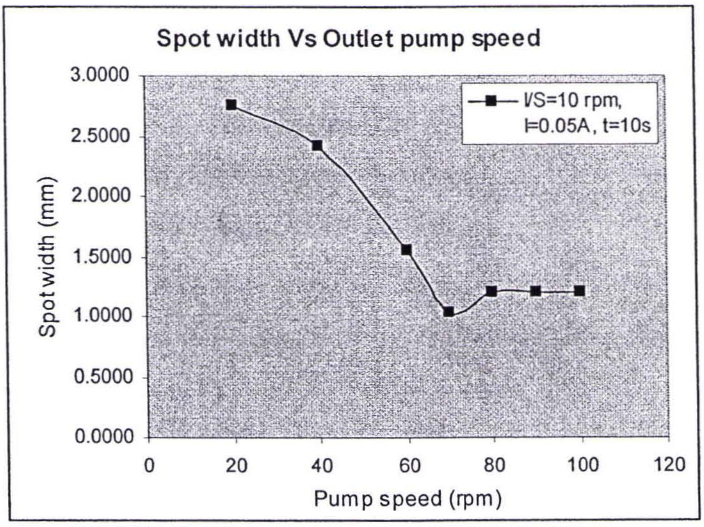

Figure 6: The effect of pumps speed (outlet speed) to the spot size

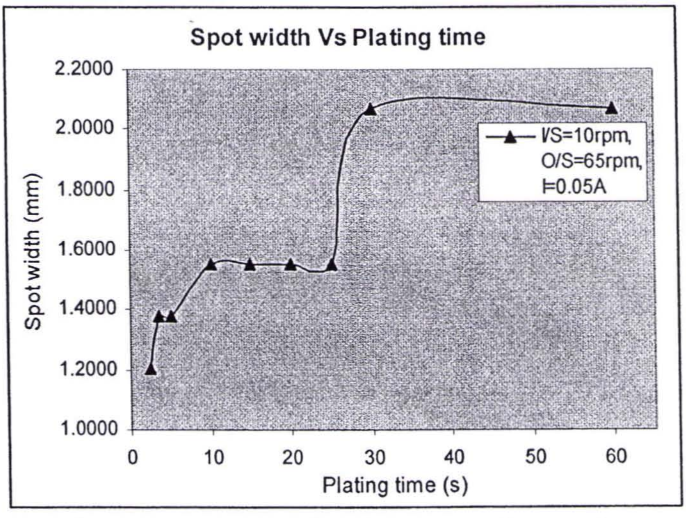

Figure 7: The effect of plating time to the spot size

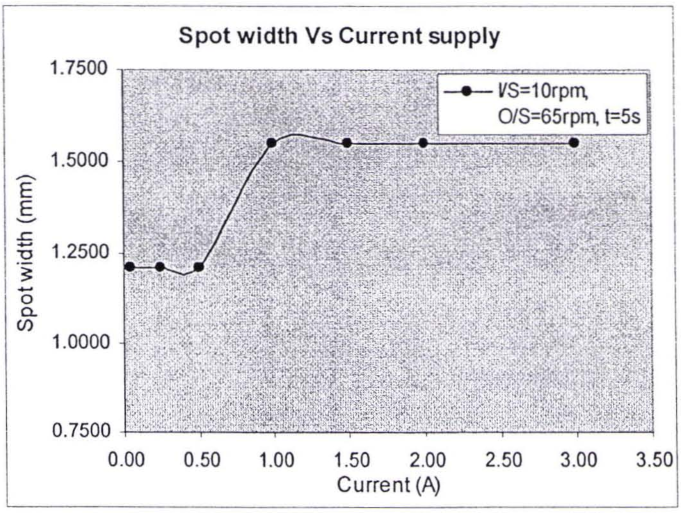

Figure 8: The effect of current supply to the spot size

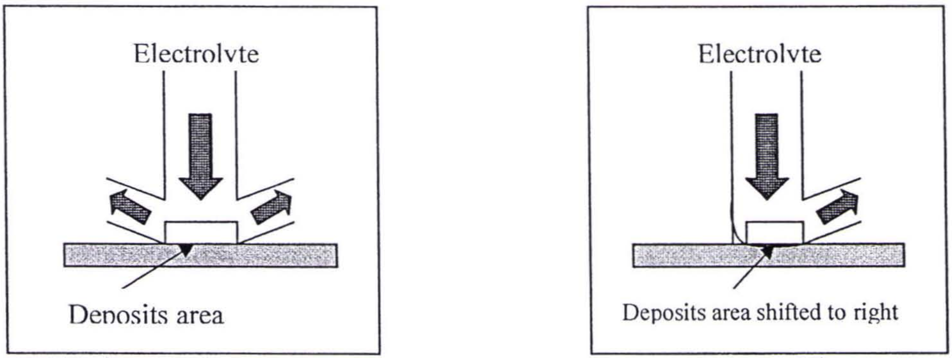

Figure 9(a)

Figure 9(b)

Figure 9 (a): Ideal case for the spot produces by the proposed technique
(b): Actual case for the spot produces by the proposed technique

Figure 6 to 8 shows the results obtain from the study of the effect of pumps speed (outlet pumps speed), plating time and current supply to the plating system. From figure 6, it shows that with the increases of the outlet pump speed from 20 rpm to 70rpm, the size of the spot produce is reducing from around 2.7mm to 1.0mm. This happen due to the force to take out the electrolyte is increasing when the speed of the outlet pump is increases. With the increasing of the suction force, the surface area of the electrolyte that will direct contact with the substrate will be reducing. Consequently, this causes the reduction of the spot size. However, with the further increases for the outlet pump speed (from 80rpm to 100rpm), the shape of the spot produce becomes not more circular and change to the shape of ellipse (increases the spot width to around 1.2mm). This happen due to the suction force is become greater and causes the electrolyte impingement point shift from the center to the right side. As mention before, the proposed technique should have two outlets to take out the electrolyte and balance the suction force (refer figure 9(a)). However, in this equipment, only one outlet has been created (refer figure 9 (b)). Thus resulting the spot produce having the size more than the expected.

Figure 7 shows the results obtain from the study of the effect of plating time. From the graph, it shows that with the increase of plating time from 2.5s to 3.5s, the spot width increases from 1.2mm to 1.4mm and maintain at 1.4mm when the time increases to 5s. The spot size further increases to 1.6mm with the plating time increases to 10s and maintain with this value with the further increases of the plating time. However, with the plating time further increases to 30s, the spot size is increases to around 2.0mm which is 2 times bigger than the size of the Teflon diameter. From the theoretical point of view, the size of spot should maintain around 1.0mm and only the thickness of the spot increases with the plating time increases. However, in the practical condition, this was not happen and the thickness of the spot is increasing slowly with the plating time. From the result obtain in the experiment, it can be conclude that the spot size is increases faster than the spot thickness with the increases of the plating time. This happen due to the suction force created by the outlet pump will take out some of the silver deposits on the upper layer if the force created by the outlet pump is greater than the Van der waaf force between the silver atom. Beside that, the suction force also might cause the split down of the silver layer deposits near to the suction point and this consequently increases the size of the spot produce.

Figure 8 shows the results obtain from the study of the effect of current supply. From the results, it shows that the spot size is maintained on the value of 1.2mm with the increases of current supply from 0.05A to 0.50A. The further increases of the current supply (1.00A) cause the spot size increase to 1.5mm and maintain on this level even the current supply is further increases. From the results, it can be conclude that current supply is generally not much affect to the spot size produce (around 0.3mm different with the current increases from 0.05A to 3.00A). However, in term of the point of cost, the smaller current supply is preferred.

CONCLUSION

The results obtain from the experiments shows that:

a. The optimum condition for the pumps speed is:
   Inlet pump speed 10 rpm
   Outlet pump speed 70 rpm
   With this speed, the spot with 1mm diameter was managed to produce.
b. The optimum condition for the plating time is 2.5s to 3.5s, since with this plating time, the spot produce having the smaller size (1.2mm). In term of cost, 2.5s is more preferred.
c. The current supply to the system was not much affect the spot size. Thus a smaller current is preferred due to the smallest the current is use, the lowest the production cost can be achieve. In this case, the optimum current supply is 0.05A.

In the future research, the nozzle head with the smaller diameter is plan to use to produce the spot less than 1mm. Beside changing the size of the nozzle diameter, the nozzle with 2 outlets is prefer to use instead of one for current equipment. With the 2 outlets, more circular spot is expected can be produce with this technique. The motors with the movement in X and Y direction is proposed to add on the holding table for the substrate. With these 2 motors, the movement of the substrate can be control and any shape of the deposit area can be draw by controlling the movement of these motors.