Effect of Pulse Reverse Plating Using Silver On Printed Circuit Boards

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ABSTRACT
Plating process is one of the most critical steps in the manufacturing process of PCB. The thickness distribution in the hole is an important factor in double sided and also multilayered PCB . Here the plating process is carried using pulse reverse plating on the printed circuit board . Pulse Reverse Electroplating is similar to DC plating but it has a square wave along with a periodic reverse current.[1]In periodic reverse current process a layer is produced on the cathode surface with a lower metal Concentration. Periodic reverse current help to obtain a plating thickness which is uniform in nature and also in nano structured grain size which results in high binding of the metal with the substrate

Keywords:
Pulse reverse plating, PCB, silver, Nanostructured coating, current density

1. INTRODUCTION

Printed circuit boards are electronic circuits created by mounting electronic components on a nonconductive board, and creating conductive connections between them. The creation of circuit patterns is accomplished by using both additive and subtractive methods. The conductive circuit is generally copper whereas here silver is used for the purpose of plating. The development of PCB industry has increased the circuit densities. The task of the plating department is to obtain high quality plated products especially by increasing the performance of the product. In more recent times it has been discovered that through controlling the grain size and microstructure, metals can be strengthened and hardened with little or no loss of ductility[13]. The electrochemical deposition of pulse reverse current plating plays a new role for Printed circuit Boards. The idea here is to obtain space qualified PCB by using reverse pulse plating technique. As the name suggests, Pulse reverse is the direction of the current that alternates so that the sample acts as both cathode and anode. Pulse reverse plating helps in obtaining an improved quality deposit such as reduced grain size, increased conductivity and reduced porosity[4].Pulse plating lead to grain sizes less than 100 nm and leads to nano structured coating[11].In conventional type copper is used for this purpose . Here silver is used for filling the vias between the layers of the PCB. The biggest obstacle in via filling is the distribution of current density[2].Silver has 7% higher conductivity than copper and the hardness of the board also increases. When the current is reversed ,the dependence on current density is same for dissolution as for deposition. At lower anodic current density the rate of dissolution is higher at the central Parts of the structure and at high current density the rate of dissolution is faster at the edges, this feature is exploited for mass distribution control by finding suitable parameters for the anodic and cathodic current pulses[5].Lowering the Current density also increases the throwing power. When the current is reversed in pulse plating it reduces the polarisation effect causing the metal dissolution [6] that restricted the dissolution at the high point of the cathode. In Pulse reverse Current (PRC) technique plating current is interrupted and a stripping time is introduced into the plating cycle [8].PRC has the same effect of replenishing the diffusion layer pulse plating and selectively dissolves the protrusions of the metal surface to ensure a uniform deposit. Pulse-reverse plating system can reduce the surface thicknesses and has good ability to filling high aspect hole. When there is longer reverse time it reduces the quality of deposit[12].

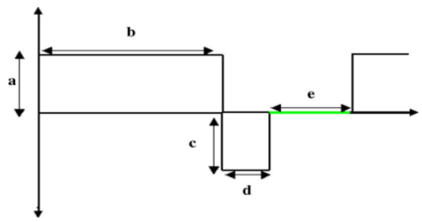

Fig. 1. Pulse reverse current waveform with the five parameters highlighted:
(a) cathodic current intensity amplitude,
(b) cathodic pulse duration on time,
(c) anodic current intensity amplitude,
(d) anodic pulse duration on time, and
(e) off-time of the pulse

Table 1:Tabulation for Pulse reverse Plating

Definition	Mathematical expression
Frequency	f = 1/(b+d+e)
Average current intensity	Id = (a x b + c x d)/(b+d+e)
Current ratio	R = c/a
Off time	T_{off} = e
Positive duty cycle	δ+= b/(b+d+e)
Negative duty cycle	δ^- = d/(b+d+e)
On duty cycle	δ^{on} = (b+d)/(b+d+e)

During the Design of Experiments (DOE), the background conditions kept constant are: concentration of metal salts, conductive salts and buffering agents, concentration of impurities, electrolyte temperature, electrolyte pH, plating cell geometry, composition and condition of the anode, anode/cathode surface area ratio, the nature and condition of the substrate as well as its conductive seed layer.[3]

2. Design of Experiment

2.1 PULSE REVERSE PLATING

The composition of the electrolyte for PR plating are as follows. The electroplating cell consists of a standard parallel electrode setup. The main advantage of pulse reverse plating is that there are 5 parameters that can be controlled whereas in conventional DC plating only one parameter that is current density which can be controlled. So when PR technique is used it leads to better control of plating parameters.

2.2 Bath composition:

Potassium cyanide, Silver Potassium cyanide and Commercial Brightener are the main composition of the bath with a silver content of 30gms/litre (Canning W, 2005). The purity of the anode silver is 99.99% .Anode and cathode size ratio should be 2:1. Silver metal concentration is normally maintained by anode dissolution which needs small additions of metal salt occasionally. This is processed further by adding either silver cyanide or potassium silver cyanide. Silver is present as potassium silver cyanide, and its concentration must be maintained by making periodic additions of this double salt.

Table 2:Tabulation for pulse plating

S.no	Rev. duration (min)	Rev.ON time(min)	Rev.OFF time(min)	Rev. duty cycle	Avg.effective values(fwd values-rev values)
1	15	10	5	60	0.2578
2	20	15	5	70	0.3245
3	25	20	5	80	0.3974

Peak current ampere	Peak current density A/dm^2	Duty cycle/ Frequency	Current Efficiency (%)	Hardness (VPN)
2.1	3.2	60% 10Hz	94.78	85.3
2.4	3.75	20% 10Hz	91.93	83.2
3.7	4.55	80% 25Hz	99.77	89.8
4.5	4.55	80% 100Hz	81.42	198
5.1	4.55	20% 10Hz	96	112.3

Buffer salt is added to maintain the pH level. Here the pH

level maintained is 11.76.[7].Here the cathode is a double sided printed circuit board. The size of a cathode is 8cmX8cm.The objective is to obtain a space qualified PCB. Here duty cycle is calculated as follows .Duty cycle is the ratio of the ON time to the total period.

There are 3 possible periods.

1 Forward ON +OFF

2 Reverse ON+OFF

3 Forward+Reverse

The most important part of calculation is that at any time in the opposite direction is same as OFF time to the direction being calculated and that all of the ON time must be considered for the direction being calculated and not the ON time of one ON +OFF period. Here it is always considered that there are even number of ON +OFF cycles. Now the Total ON time is calculated. Now the Total ON time is divided by the sum of the Time (Fwd) + sum of the Time (Rev).This is called as effective duty cycle and it is multiplied by the peak current to obtain the average current. From the ampere time preset the plating thickness is determined.While electroplating it is also observed that if the current efficiency is close to 100% the material deposition will be equal to current distribution.[10]

2. Conclusion

The maximum and minimum are determined as follows:

The frequency, f, should be greater than 1 Hz. Literature states that no benefit is gained over dc plating at or below1 Hz.
The frequency should be less than 500 Hz which is the maximum switching frequency permitted by the pulse rectifier.
The average current density, Id, should be more than 10mA/cm
The average current density should be less than 60mA/cm . DC deposition beyond this value leads to poor quality deposits.
The anodic to cathodic current ratio, c/a, should be greater than 1. This parameter is reported to be the most influential in obtaining conformal depositions.
The cathodic current density should be greater than the anodic current density. This condition is required for metal deposition on the cathode
When silver is used for plating it enhances tarnish resistance .Such type of plating is used for giant magneto resistance applications[9]

4. Acknowledgement

The authors gratefully acknowledge the Nanomaterials and micromachining laboratory present at Sona college of Technology for pulse plating facility.

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