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EMAP International Conference on Electronics Materials and Packaging

Horizontal Reel to Reel Copper Plating with InPulse 2

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Abstract

This paper presents the latest innovation in the Inpulse 2 plating system which has been modified to allow reel to reel processing. Reel to reel plating is a standard technology for production of thin core flexible material where the substrate is treated as a continuous roll and where material handling is critical to ensure uniform results. The Inpulse 2 system uses insoluble anodes and a novel copper replenishment system to ensure uniform working conditions. The electrolyte agitation is managed by use of frequency controlled pumps which is critical for thin materials to ensure no surface damage during plating. The electrical contact to the substrate is made by the use of large contact area clamps along one edge of the material to be plated. This combination of features in the equipment allow the use of high production current densities even with flexible base materials with thin conductive layers. The clamping system at one edge of the material allows varying foil widths with no further equipment modifications necessary. The use of segmented insoluble anodes with individually controlled rectification is critical for thin flexible production to ensure optimum copper plated surface distribution. Results are shown from the production system being used to copper plate flexible material which is currently in production. The substrate has laser drilled through vias which are metallised and subsequently through hole copper plated in the reel to reel system. Data from optimization of plated copper surface distribution are shown illustrating the dependence of plated distribution on fluid flow within the plating module. The installation of the handling devices uncoiler and coiler is shown together with the special devices to ensure correct tensioning and position of the substrate in the plating system.

Introduction

InPulse 2 systems for electrolytic copper plating are in full production for thin core and flexible base materials for conformal copper plating and also for blind micro via filling applications. Such horizontal equipment is ideally suited for this type of production due to the handling capability for thin core and especially substrates with thin copper foil. The systems show significant advantages over traditional vertical processing systems as has been described in [1]. For the metallisation of the substrate before electrolytic copper plating horizontal processes have become the system of choice, in particular the combination of horizontal Uniplate metallisation with wet to wet transport into Uniplate Inpulse is the standard for PTH applications. For flexible and also flex-rigid circuits the metallisation process must be modified to meet the specific base material characteristics critical aspects are discussed in [2]. The flexibility of the base material is the critical aspect in any production system, figure 1 shows the variation in relative bending of substrate foils in relation to the copper foil thickness and also the base material thickness. The thinner the material and the copper foil the more flexible it becomes and the more difficult to transport safely through a production line. In addition to this the copper foil thickness has implications on the surface plated copper distribution due to the reduced specific resistance of the thin copper foil used in HDI applications. Material clamped only on one side as is typically the case will have a poor surface distribution at relatively high plating current densities, such high current densities are required to gain the necessary productivity from the equipment. Reduction of current density will give improved results but at the cost of production volume.

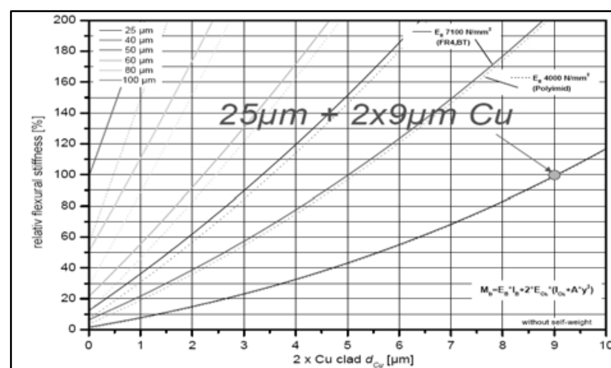

Figure 1. Relative Rigidity of base materials

Figure 1 shows as a reference point the flexibility of a base material 25 µm thick with copper foil 9µm however future requirements for fine line circuit applications require copper foil at approx. 3 µm, this has in the region of only 20% of the rigidity of the material with 9 µm copper foil. An alternative to single sheet processing is the use of reel to reel plating systems which offer handling advantages due to the continuous material.

InPulse 2 Reel to reel copper plating

The Inpulse 2 copper pulse plating module has been modified to allow reel to reel production by addition of dedicated handling devices and optimization of the existing features of the equipment. The metallisation process has also been optimized for reel to reel and uses a stand alone Uniplate LB electroless copper line, the process is completed as a continuous roll which is then transferred to the Inpulse line for electrolytic copper plating.

Handling equipment for reel to reel applications

The dedicated handling equipment consists of an uncoiler at the start of the line as shown in photograph 1.

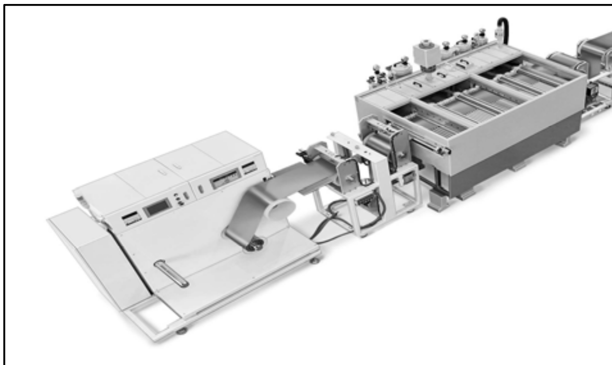

Photo 1. Uncoiler and Pretreatment

The photograph shows the equipment configuration together with the pretreatment before the copper plating module. The pretreatment consists of acid cleaner followed by a triple rinse, the acid cleaner process is based on sulphuric acid together with special low foam cleaner and has been optimized to handle the thin continuous material with electroless copper in the through holes. In the processing line special handling devices are incorporated to prevent any misalignment of the material and to ensure accurate transport and synchronization with the clamp drive, one of these is shown in photograph 2.

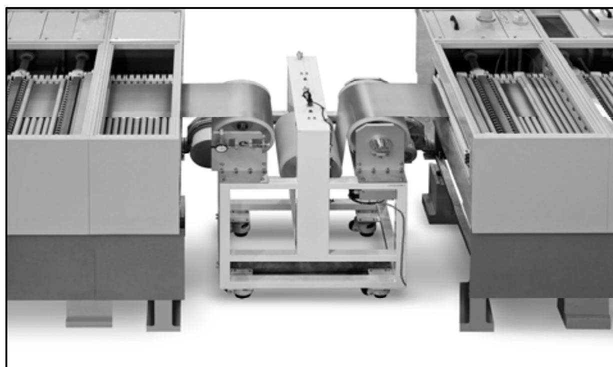

Photo 2. Handling device

After copper plating the material is rinsed, treated in an anti tarnish process followed again by rinsing and then dried. The dryer must ensure no moisture is present on the surface before the coiler accepts the plated material from the production line. Photograph 3 shows the coiler and also the anti tarnish module followed by triple rinse and dryer.

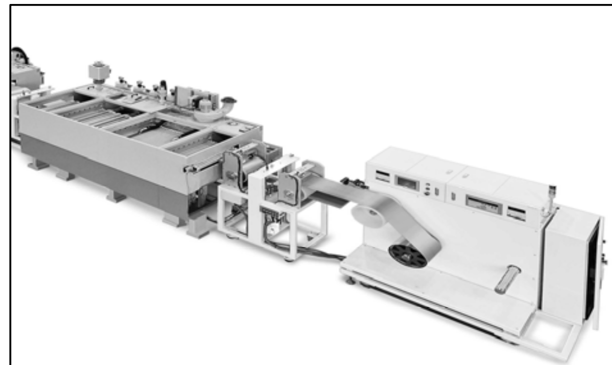

Photo 3. Post treatment and Coiler

Horizontal reel to reel plating equipment features

The acid copper plating module is equipped with a special clamping system designed for flexible base materials which are immersed in the working electrolyte this acts to cool the contact area and is one factor enabling high current density operation. Together with the clamp drive system the clamps ensure accurate transport of the material synchronized with the handling devices and also good electrical contact to the copper foil. Due to the accurate and large surface area of the clamping system a relatively high current density can be used in the production of reel to reel materials whilst maintaining acceptable plated copper surface distribution. Photograph 4 shows the clamping system in the partly disassembled plating module which also shows the position of the plated material and the upper and lower anodes.

Photo 4. Clamp system

The anodes in the plating module are segmented and insoluble consisting of a titanium mesh coated to ensure uniform copper deposition. The use of insoluble anodes means that the plating window is constant and time consuming anode maintenance is not necessary and no dummy plating is required which saves processing time, copper metal is replenished using the patented iron redox replenishment system which has been described in [3]. The use of anodes with 4 segments enables optimum copper plated surface distribution even with thin copper foil and at high current densities. Each of the anodes is connected to a separate pulse plating rectifier with separate control system which means that the copper deposit can be controlled over the whole plating window. The plating electrolyte and all active solutions are maintained by fully automatic dosing systems to ensure constant working conditions. The dosing is made based on actual ampere hours plated or

the area of material processed in the equipment. A correction factor is applied to each anode segment depending on the type of material being plated, the copper foil thickness and also the applied current density to ensure uniform deposited copper. The electrolyte flow in the copper plating module is adjusted with frequency controlled circulation pumps, the flow of electrolyte to the top side of the plated substrate and to the bottom side may be set independently. This capability was found to be important in controlling the transport of thin material in the line. Different flow settings were used for different substrate thicknesses for example a material 150 µm thick with copper foil 3 µm used different settings to those for a 60 µm thick substrate. All materials required a different setting for top and bottom pumps, for best results with 150 µm the setting for the top was double that for the bottom circulation pumps. The working level of the electrolyte in the plating module is controlled by the circulation pumps and also by the rate of flow of electrolyte back into the module sump. This return flow is governed by pneumatic valves in the piping which are adjusted according to the type of material being processed. Ultra thin materials require reduced flooding from the circulation pumps but the working level in the plating chamber must be maintained to enable copper deposition. In photograph 5 the valve actuation system can be seen separated from the piping.

Photo 5. Pneumatic valve

Use of this system allows rapid and accurate adjustment of the circulation and flooding within the plating chamber without any equipment down time. The equipment may be set up for ultra-thin material or for thicker more rigid material with no loss in production time. All modules in the plating line with active process steps and also rinse steps use an air knife system to prevent excessive drag out and resulting loss of electrolyte or rinse water. A schematic of the air knife system in a triple rinse is shown in photograph 6.

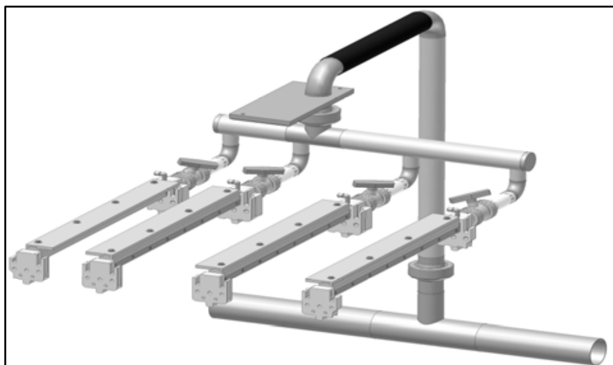

Photo 6. Air knife in triple rinse

The air knife system minimizes drag out loss and thereby reduces waste water loading and also enables reduced surface contact to the substrate being plated. The system is adjustable depending on the type and thickness of substrate being processed.

Plating results in reel to reel equipment

The reel to reel plating system as described is capable to handle substrates between 150 µm thick down to 20 µm thick in both cases with 3 µm thick copper foil. Through hole pulse plating at forward current densities of up to 10 A/dm² have shown excellent throwing power in material 150 µm thick and with hole diameter 100 µm. The average current density is a maximum of 10 A/dm² depending on the width of the material being processed. Conveyor speed is variable but with a target copper thickness of 17 µm on the surface a speed of 0.7 m/min has been used, at this speed accurate transport of the material was seen with no web misalignment. The plated copper surface distribution with 150 µm base material and 3µm copper foil as shown in figure 2 is within ± 10% absolute variation within the critical area for the application based on a continuous material with active width 300 mm.

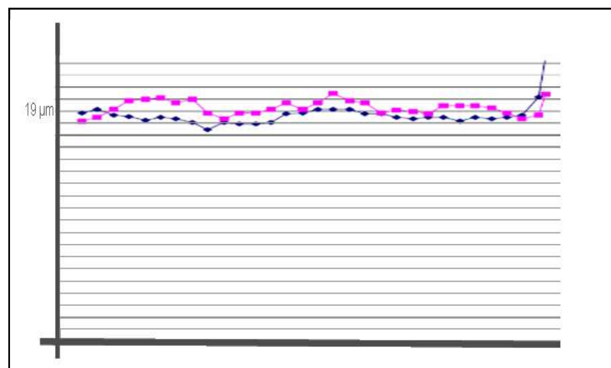

Figure 2. Plated copper surface distribution

SUMMARY

The Uniplate 2RtR system allows easier handling of continuous roll material and at higher applied current densities in comparison to conventional plating equipment. The large area clamp system which is under electrolyte working level gives a reliable contact even onto thin copper foil which meets required surface distribution specification. The equipment for continuous roll handling was very effectively incorporated into the Uniplate transport system to ensure reliable transport under production conditions.

References

[1] S. Kenny, *Blind Micro Via and Through Hole Filling for Thin Core and Flexible Base Materials*. Circuitree Live, 2006.

[2] T. Magaya, *Pre-treatment and PTH Solutions for Flex-rigid PCB´s*. Circuitree Live, 2006.

[3] S. Kenny, K. Matejat, *HDI Production Using Pulse Plating with insoluble Anodes*. EIPC, 2000.