A Novel Green Technology for the Plated Through Hole Process

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I. Abstract:

Electroless copper has long been the dominate process for plated through hole (PTH) metallization. The technology is widely used by printed circuit board fabricators and driven by a long standing acceptance by OEMs. However, this established technology has many drawbacks that have a direct impact on our environment. Namely, it contains a known carcinogen, consumes a lot of water and is inherently unstable leading to increased demands on waste treatment operations. Through the years there has been significant work done in this area of the manufacturing process to overcome the challenges associated with electroless copper technologies. The ultimate goal being an environmentally friendly PTH process that maintains well established performance and reliability standards.

In recent years, we have developed and perfected a carbon-based direct plate PTH technology that successfully eliminates the use of hazardous chemicals, drastically reduces water consumption, and decreases the burden on industrial wastewater treatment systems. This innovative technology offers the same performance as electroless copper with the added benefits of less cost, less space, reduced labor requirements and a better working environment for the operators. Our efforts on improving conductivity, copper cleaning and product reliability have yielded an incredible process for the manufacture of printed circuit boards.

II. Introduction:

In today's marketplace PWB quality is expected and taken for granted. Until recently the major task for the PWB fabricators was to effect cost reduction programs throughout the manufacturing process in order to remain competitive on a worldwide basis. Recently, the impact of this manufacturing process on the environment has quickly become a significant factor for manufacturers to consider as local governments are demanding the use of cleaner, "greener", and more environmentally compatible processes. Electroless copper technology, a standard in our industry, is still the predominant PTH metallization technology in use today. Yet, this existing technology is plagued with challenges that make it difficult to achieve environmental expectations. To conserve water and energy usage, and more importantly, to protect our environment from further pollution and protect our workers from health risks, it is important for us to establish a more environmentally friendly technology for the plated through hole metallization process by replacing the traditional electroless copper process. Fortunately, long standing, production proven technologies do exist that provide a cleaner and safer environment. One such novel process, carbon-based, is successfully used in the PTH manufacturing operation. It incorporates horizontal automation, a non-dynamic chemistry that contains fewer process steps and much lower and simpler analytical controls.

III. The Process Cycle:

It is clear to see in Figure 1 that a comparison of process cycle alone shows the dramatic impact a novel alternative PTH process alone can have.

Process Step	Electroless Copper	Process Step	Novel Green Technology
1	Clean/Condition	1	Clean/Condition
2	Rinse	2	Rinse
3	Microetch	3	Carbon-based Dispersion
4	Rinse	4	Dry
5	Predip	5	Microetch
6	Activation	6	Rinse
7	Rinse	7	Antitarnish
8	Acceleration	8	Rinse
9	Rinse	9	Dry
10	Electroless Copper		
11	Rinse		
12	Acid Dip		
13	Rinse		
14	Antitarnish		
15	Rinse		
16	Dry		

Figure 1 Process Cycle Comparison

The rinsing requirement in our novel alternative metallization process can be reduced to less than half of what is required in conventional electroless copper. This signifies a dramatic decrease in the amount of water required to run the process and the amount of water that needs to enter the waste treatment process. Additionally, the number of process steps is also a good indicator of the number of chemistries that ultimately require waste treatment. Again, this alternative process to convention electroless copper will cut waste treatment requirement in half.

A. Reduction in Rinse Water

Electroless copper processes use a substantial amount of rinse water and generate a large volume of waste waster that must be treated. With upwards of seven rinse station in a conventional electroless PTH process, PWB manufacturers are facing increasingly demands in their waste treatment areas. The carbon-based PTH process brought much needed improvements in reducing rinse water usage and waste water treatment through the use of automated horizontal process equipment and only 3 rinse stations required (Figure 2). Vertical electroless copper processes can use 11.7 gal/ssf of water whereas the efficiencies associated with this horizontal conveyorized carbon-based process requires less than 1.29gal/ssf.

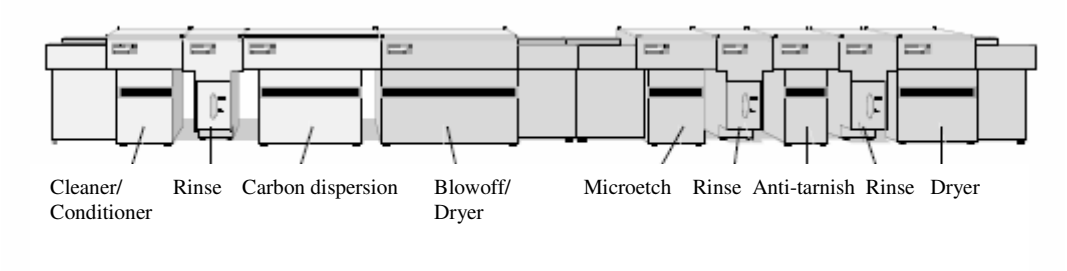

Figure 2 Horizontal Equipment Diagram

B. Reduction in Chemistry Usage

The number of process steps in a traditional electroless copper process means more processes requiring waste treatment. If you specifically evaluate the consumption of just one of the baths, namely the electroless copper, it typically consumes 40-50ml of chemistry per surface square foot for 80µin thickness. However, this carbon-based process only uses about 2ml per surface square foot.

C. Waste Treatment Reduction

Carbon-based metallization simplifies wastewater treatment. In the electroless copper bath, chelating agents, such as EDTA, are used to keep metal ions in solution. These agents inhibit precipitation of metals during wastewater treatment. Carbon-based metallization process eliminates chelating agents, and reduces the need for water treatment chemicals that are used to breakdown chelators. In addition, treatment of the carbon-based process produces less sludge than that of the electroless copper process.

D. Non-Dynamic Chemistry

Unlike electroless copper, carbon-based metallization process does not deplete components selectively, and it does not have non-productive side reactions (Figure 3). This indicates the instability of the electroless process ultimately leading to an increased frequency of bath dumps and waste treatment.

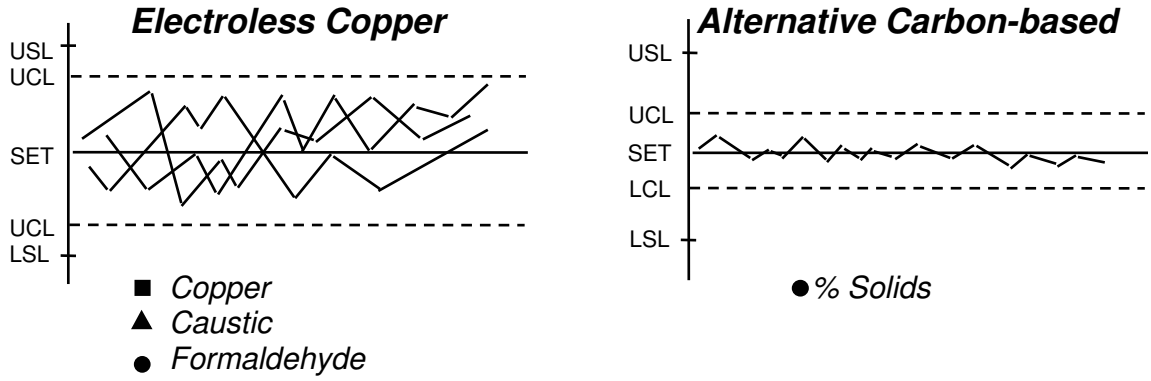

Figure 3 Process stability comparison

E. Reduction in Energy Consumption

Energy use has also become an important consideration because much of the PWB manufacturing process requires energy-intensive operations. Carbon-based process uses substantially less energy per ssf of PWB produced. At a speed of 1.0 meter per minute, carbon-based process has a throughput of 28.6 panels. Power consumption, including heating and drying, is estimated to be 37.9KW. To process 200 panel square meters per day, the equipment is required to operate for 7 hours. Therefore, total power used would be 265.3KW hours. For the same output, a high build electroless copper needs to operate for 20 hours per day at 54 KW power requirement, which comes out to be 1080KW hours. The power saved by this technology is a whopping 75%!

IV. Effect on the Environment

A. Minimize Worker Health Risks

Non-conveyorized electroless copper processes expose workers to chemicals by breathing air containing vapor or aerosols from the process lines. Formaldehyde is one such hazardous chemical associated with electroless copper baths. In contrast, carbon-based conveyorized process lines are enclosed with central

extraction venting to the outside. Therefore, the inhalation exposure to chemicals associated with carbon process is assumed to be negligible. Additionally, in the non-conveyorized electroless copper process, inhalation of formaldehyde (probable human carcinogen) may present a cancer risk.

B. Minimize Ecological Risks

The concentration of the chemicals that may be discharged from industrial facilities is highly regulated by government agencies. Ecological risks of PTH technologies can be evaluated in terms of aquatic toxicity hazards. Copper compounds can result in aquatic toxicity problems if discharged to surface waters. According to a USEPA study, electroless copper process contains 11 chemicals with high toxicity to aquatic organisms, while carbon process only contains 2.

V. High Performance Reliability and Capability

Close to twenty years of experience and a thorough knowledge of operation and technical expertise by both suppliers and PWB manufacturers have helped to promote our carbon-based process to a mature status. Continuous improvement of this technology continues to drive this process beyond standards that can be achieved with electroless copper. Carbon-based product reliability has proven to be not only equivalent but also superior to electroless copper. The reliability of this carbon direct plate process has been tested according to various different standards with typical results shown below:

Test	Test Method	Qualifier	Cycles	Results
Solder Dip	IPC-TM-650	2.6.8	6	Passed
Thermal Shock	IPC-TM-650	2.6.6	400	Passed
Solder Rework	IPC-TM-650	2.4.36	5	Passed
Fluidized Sand	AT&T (heat shock)		40	Passed

Figure 4 Reliability Test Results

Our process enables a uniform electrolytic coating and an intimate copper to copper bond for the highest reliability interconnects.

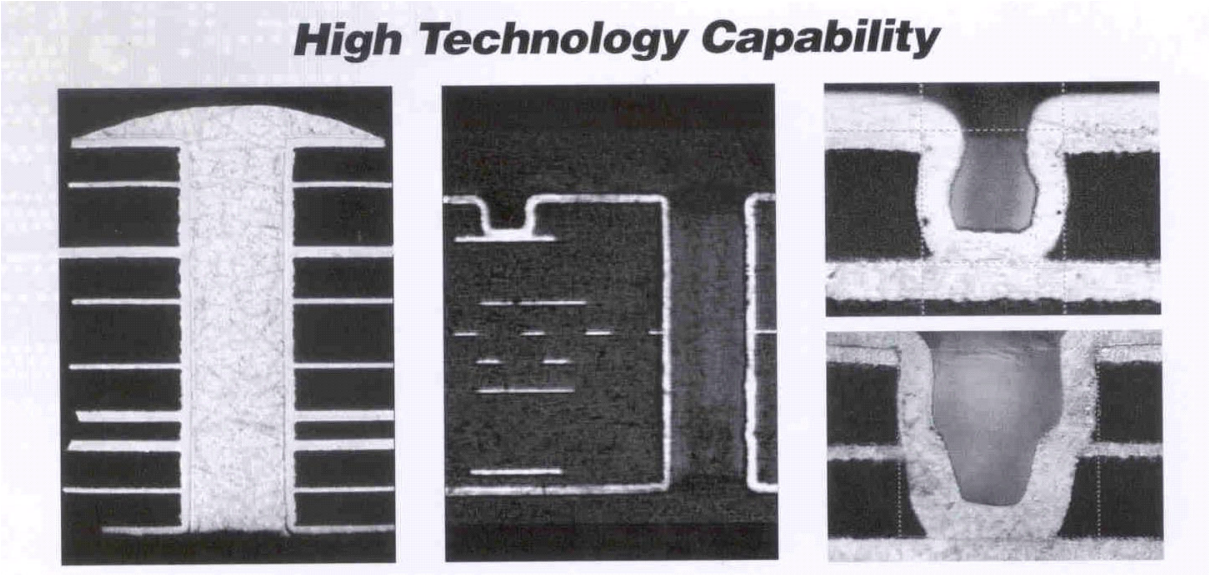

Figure 5 Cross sections of process capability

VI. Conclusion

This carbon-based technology provides the greenest through-hole metallization process in the market. Its environmental benefits can and will have a significant impact on how PCBs are manufactured. More and more countries are becoming increasingly aware of and questioning the impact manufacturing processes can have on their environment. This carbon-based technology is one such process that can provide an immediate answer to these questions and concerns.