SERFILCO® CASE HISTORY

PRINTED CIRCUIT BOARD

Reducing metal usage and improving PWB quality through the use of SER-DUCTOR® agitation

by Charles Reichert, CEF-SE, Charles Remied, Boro Vujasin

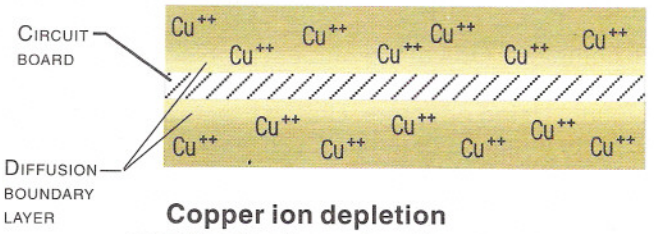
ABSTRACT

The rate of acid copper plating on printed wiring boards for many years has been limited by the current density to which we could subject the boards. No one could safely run above 25 ASF because of burning in the high current density areas. Agitation of the solution by a combination of cathode rod "rocking" and air sparging brought us to, but not beyond, 25 ASF. Without these tools, acid copper deposition on PWB's would be highly ineffective.

The breakthrough to higher productivity has occurred with the introduction of the SER-DUCTOR airless agitation system. Carefully engineered clusters of eductor nozzles sweep away cathode films swiftly, allowing faster plating at lower voltages with much higher current densities. More even plating results in significantly lower metal usage. This is the story of how one shop significantly reduced the cost of acid copper plating by installing the SER-DUCTOR air-free agitation system.

AGITATION OF ACID COPPER

Conventional acid copper baths used in PWB manufacturing must be agitated to operate properly. The diffusion boundary (Figure 1) is the layer of electrolyte adjacent to the circuit board which provides the immediate source of copper ions. Once those copper ions are depleted, conductivity drops significantly, burning occurs at high current density areas, voltage rises and plating in through-holes and low current areas is virtually nonexistent. Therefore, the mission of any agitation system used for acid copper is to evenly sweep the surface of the board, minimizing the thickness of the diffusion layer. The agitative action must also allow sufficient solution transport in the through-holes to allow acceptable throw in these holes.



Copper ion depletion in diffusion boundary layer

Figure 1

Mechanical (cathode rod) and air agitation replenish the copper ions in the diffusion layer at a rate that allows plating at 20 to 25 ASF. Cathode rod agitators (Figure 2) move slowly, providing horizontal oscillation at one or two inches per second with linear travel of two to four inches. A fairly sophisticated apparatus is required to transfer the rotational energy of the drive motor to the linear motion utilized in this device. Since the moving parts of the cathode rod agitator must also transfer current to the boards, the cathode rod heats up, accelerating the corrosion of these moving parts. Thus, cathode rod agitators are usually a maintenance problem.

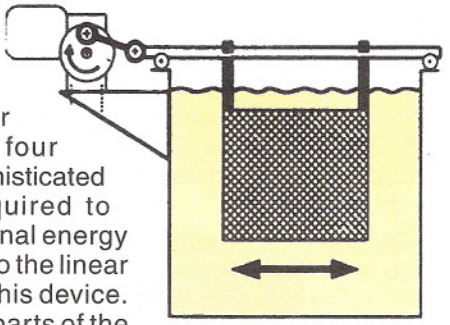


Figure 2

Air agitation systems (Figure 3) consist of a blower to provide air at constant pressure and distribution piping with perforations to bubble air through the solution. The sparger is typically deployed under the boards to provide random motion of the solution. A general upward current is established in the tank, "rolling" the solution. This system is inefficient since the bubbles are easily diverted from truly vertical ascent and a great excess of air is necessary to assure sufficient agitation. Furthermore, in acid copper, a sulfuric acid mist is forced into the air above the tank which increases the ventilation demand and results in the corrosion of nearby equipment.

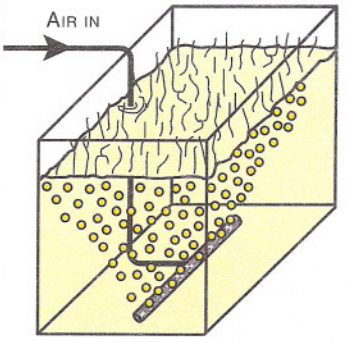


Figure 3

Regenerative (oil-less) blowers, which are used to provide the air for these systems are fairly noisy with 80 to 90 dB ratings. Also, since these devices must run at specific air flow and static pressures, once a system has been sized for a certain tank condition, no further expansion of capacity is possible. Furthermore, it is impossible to build expansion capacity into the system by oversizing the blower unless the excess capacity is vented. Throttling the blower will cause damage from heat buildup.

Any airborne contamination in the room with the blower will be dispersed into the solution. Although these blowers have intake filters, they usually remove only particles in excess of 100 micron diameter. Obviously, fumes in the air will find their way into the tank. Filter loading increases accordingly, along with the danger of chemical contamination from the airborne fumes.

SER-DUCTOR AGITATION

Figure 4 illustrates the principle of SER-DUCTOR agitation. The plume that emanates from the eductor nozzle has predictable geometry which assists in designing an effective system. Every gallon per minute of solution pumped through the eductor produces four more gallons of induced flow. Since no air is used, there is no concern that surface bubbles will inhibit copper deposition on the flat surfaces or in the holes. Furthermore, no oxidation of metallic ion species or organic additives will occur from oxygen in the air. Ventilation demand is minimized, as is the corrosive effect of the sulfuric acid mist carried along with the air.

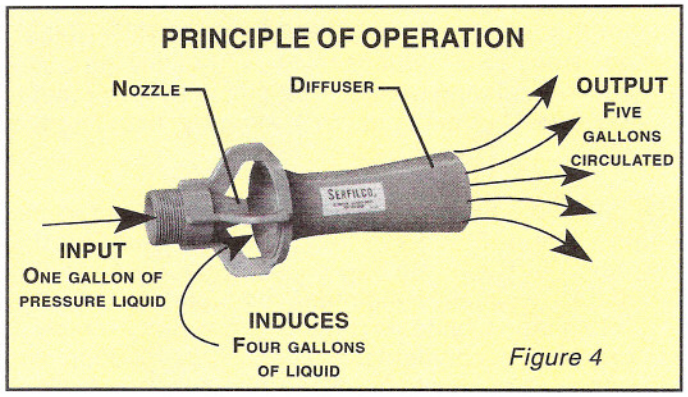


Figure 4

The eductors are ganged on a pipe manifold to provide even distribution of flow and are driven by a pump of sufficient power to achieve the desired level of agitation. Two possible schemes are shown in Figures 5 and 6. The vertical deployment (Figure 5) of the pipe manifold is most effective in cases where the anodes and cathodes are closely spaced and run across the narrow width of the tank. The horizontal configuration shown in Figure 6 is better suited to anodes and cathodes spaced farther apart and running the length of the tank.

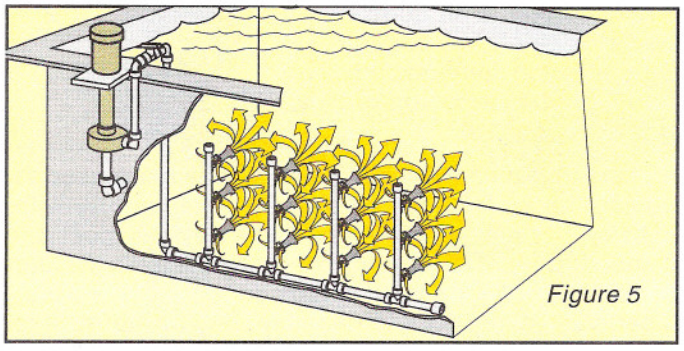


Figure 5

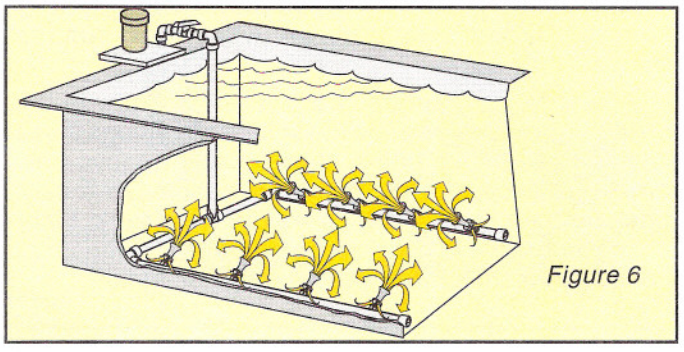


Figure 6

Each tank geometry needs to be addressed individually.

CASE STUDY: UNITED ELECTRONICS

United Electronics Corp. of Rosemont, Illinois manufactures high volume two-sided circuit boards and specialty multi-layer circuit boards. Their new manufacturing facility boasts state-of-the-art equipment which was specified to maximize production rates while lowering reject rates as much as possible. Key to this goal was the design and installation of the SER-DUCTOR air-free agitation system.

HIGH SPEED ACID COPPER ELECTROLYTIC PLATING

In 1994, SERFILCO introduced a new concept for copper plating called SER-DUCTING which utilizes eductors and a high horsepower pump to significantly increase the rate of deposition. When SERFILCO recommended SER-DUCTING to them, the personnel at United Electronics had no idea of what to expect. Nobody in the PC industry had experience or knowledge or had ever seen high speed electrolytic copper plating with eductors and bath chemistry that had the proper composition to work with eductors. The SER-DUCTOR systems were installed on two 2,000 gallon plating tanks. Each system was composed of a 15 HP pump, 60 ME 3/4 eductors and related piping.

In addition to the selection of equipment and design of the SER-DUCTOR systems, United Electronics had to consider chemistry and rectification. Delta D. C. Power, Inc. made the operation possible with two 4000 amp low ripple, low/high voltage rectifiers. Shipley and LeaRonal were very helpful with their HS brightener systems that were instrumental in this success.

Once the new SER-DUCTOR system was operational, United Electronics not only cut plating time in half, they improved the quality of the plating as well. What was a 24 hour work load at one time, now takes only 10 hours to complete. One of the biggest problems in the printed circuit industry until now was uneven electrolytic copper plating. Using eductors, United Electronics is now able to plate much more uniformly at 30/50 amps per square foot. Plating 2 mil lines, 2 mil spaces and .006 and .002 blind vias is now much easier and faster, due to high volume solution turnover of 2000 gallons per minute.

In the two years since the SER-DUCTOR system was installed, plating at United Electronics has improved even more, thanks to the new technology and teamwork. Variations in deposit thickness used to be 1 to 2 mils; now it is .2 to .5 mils. They also wondered how the SER-DUCTOR system would impact their reject rates. State-of-the-art PWB manufacturing never tolerates excessive reject rates. Process adjustments (i.e. plating at lower current density on tough jobs) keeps reject rates < 1%, but at a sacrifice to productivity. They determined that with SER-DUCTOR agitation their critical jobs can now run at much higher current density with no increase in reject rates.

Of further (and perhaps greatest) significance, is the savings in copper usage attributed to reducing the variation in plate thickness. The new line was projected to use 30,000 pounds of copper anodes annually at the

improved productivity rate, which is 1.6 times the throughput of the old line. However, only 22,200 pounds are now being consumed, a savings of 26%.

BENEFIT ANALYSIS

Metal savings:
7,800 lbs. copper @ $1.20/lb. = $9,360 / year

Operating cost reduction:
Estimated line operating cost reduction = $15,000 / year

Total annual savings: = $24,360

PAYBACK

The system cost was recovered in a short period of time. Other intangible benefits include:

- Decrease in corrosive deterioration of process equipment
- Reduced demand on ventilation system
- Less employee exposure to acid mist
- Lower brightener consumption

In addition, the plating line personnel at United Electronics can now enjoy cleaner air, free of acid mist.

POSTSCRIPT

In 1996, eductors moved on to new technology — the immersion nickel / gold and palladium processes. At United Electronics, Boro Vujasin designed new lines, called the "high speed immersion nickel / gold" and "palladium" lines. They utilize SERFILCO eductors and high temperature vertical pumps, LeaRonal chemistry and an Everon SMT line.

The use of eductors eliminates the need for air in the nickel bath. The old technology required air to be used as a stabilizer. Consequently, air entrapment on the circuit board created uneven deposition and very high surface temperatures, at which point the solder mask would peel off the circuit board. Also, missiling, a typical defect in this process, has been totally eliminated.

Biography

Charles R. Reichert is Midwest Regional Manager of SERFILCO, Ltd., Northbrook, Illinois, USA. Reichert is a Certified Electroplater - Finisher and an Electronics Specialist - Certified, awards of the American Electroplaters and Surface Finishers Society of Orlando, Florida, USA. A chemist, he has worked in various management positions in the metal finishing industry since 1973. Mr. Reichert is active in the Metal Finishing Suppliers' Association, American Electroplaters and Surface Finishers Society, National Contract Management Association and is a Senior Member of the Society of Manufacturing Engineers.

Charles A. Remied is Central Regional Manager for SERFILCO, Ltd. with whom he has been associated for over 30 years. Mr. Remied is currently Membership Chairman for the Chicagoland Circuit Board Association. He is also Past President of the Chicago Branch American Electroplaters and Surface Finishers Society and a member of the Metal Finishing Suppliers' Association.

Boro Vujasin is Operations and QC Manager at United Electronics Corp., Rosemont, Illinois. He has worked in the electronics field for the past 22 years, during which time he has served in a variety of capacities, including plating supervisor, environmental manager and industry consultant. Mr. Vujasin has invented a number of waste treatment systems, the most recent of which resulted in the ability to recycle 100% of the waste generated by the plating facility. He is also the designer of various processes for high speed electrolytic copper plating utilizing eductor agitation systems. Vujasin is currently on the committee of the Chicagoland Circuit Board Association.

Acknowledgements:

The authors wish to thank the following individuals without whose cooperation this study could not have been completed:

Mr. Steven Schaefer, LeaRonal, Inc., Freeport, NY
Mr. Russell J. Marasco, Delta D. C. Power, Lombard, IL