A Cooperative Project between the U.S. Environmental Protection Agency and PWB Manufacturers Nationwide

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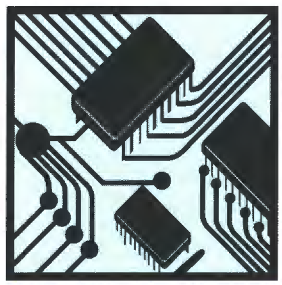
PRINTED WIRING BOARD CASE STUDY 5

PRINTED WIRING BOARD PROJECT



A Continuous-Flow System for Reusing Microetchant

To stay competitive in the Printed Wiring Board (PWB) industry, many manufacturers have developed cost-effective methods that not only improve environmental performance, but also make production more efficient. Even minor process changes can result in more efficient chemical use, which in turn reduces waste and chemical costs, and improves process control. As PWB Case Study 3 (Acid Recovery and Management) illustrates, a sulfuric acid-hydrogen peroxide microetchant can be regenerated and reused by plating out the copper electrolytically from the spent solution. That system maximizes use of microetchant, improves process control, and saves money.

Power Circuits of Santa Ana, California, has adopted an alternative approach to conserving microetchant. With a relatively small initial investment, they have implemented a continuous-flow system for reusing sulfuric acid-potassium persulfate microetchant. Spent microetchant from one process flows to the microetch tank for another process that requires a lower etch rate and thus a weaker solution. Spent solution from this second process line can then be reused to clean plating racks and tanks. In this way, a single tank of fresh microetchant is used and reused in a sequence through four different cleaning processes. As a result, Power Circuits has realized immediate waste reduction and cost savings.

This case study describes how a continuous-flow system works, the benefits of reusing microetchant, and the costs and potential concerns a company may face when implementing this type of system.

Power Circuits — Who Are They?

Power Circuits, established in 1985, manufactures nearly 700,000 surface square feet of double-sided and multilayer printed wiring board annually. With 165 employees, this company specializes in complex printed circuit boards in a short lead-time environment primarily for the computer, medical, and telecommunications industries.

Although Power Circuits has been engaged in pollution prevention activities for a number of years, the company created a formal pollution prevention program in January 1995 and began to document more fully their accomplishments in waste reduction and water conservation. For their achievements, Power Circuits received the 1996 "Industry of the Year Award" for the Southern California region from the California Water Environment Association.

Before implementing the continuous-flow system, the company had been dumping a total of 800 gallons of spent microetchant per week from four different baths. Each of the tanks was monitored separately by different individuals. The operator of each process would take a sample of the microetchant manually and send it to the lab for analysis of available oxygen, which determines etch rate. Chemical additions were made as needed by each operator. When the microetch solution was spent, it was pumped to the electrolytic plate-out cell, which removed copper from the spent solution prior to sending it to the wastewater treatment unit.

Why Reuse Microetchant?

Microetching is a ubiquitous process found as a pre-clean step for many of the stages of PWB manufacturing. Microetching removes anywhere from 4 to 70 microinches of copper to rid the panels of oxidation prior to the subsequent process, such as soldermask application, oxide treatment, electroless copper plating, pattern plating, or hot-air-solder-leveling. This cleaning process is also used to strip copper build-up on plating tanks and racks. Power Circuits uses a sulfuric acid-potassium persulfate microetchant.

Although Power Circuits does use an electrolytic recovery process to plate-out copper from spent microetch solution, the sulfuric acid-potassium persulfate microetchant cannot be regenerated due to the buildup of sulfates that results from the breakdown of the microetch chemistry. A hydrogen peroxide-based microetchant, on the other hand, can be regenerated using this technology because the breakdown product is simply water. For Power Circuits, therefore, electrolytic recovery serves to remove copper before the solution goes to the wastewater treatment unit, but not to regenerate microetchant.

Power Circuits was initially motivated to conserve microetch solution because their electrolytic plate-out unit frequently failed to meet capacity needs for processing spent solution. Excess waste had to be placed in drums until capacity was available. Because the amount of copper that must be removed from the board varies among the different process lines, a microetch considered spent for the purposes of one process line may still be useful for microetching in a line requiring a lower etch rate. At Power Circuits, for example, the microetch step for an electroless copper line must remove 40 to 60 microinches of copper from the PWB, whereas the preclean step for pattern plating requires a microetch rate of 4 to 6 microinches. Using this process knowledge, a Power Circuits manufacturing engineer designed a scheme to reuse microetch solution.

The continuous-flow system developed by Power Circuits required little more than installing some new plumbing and pumps. It was not even necessary to interrupt production because most of the installation was done on a Saturday by Power Circuits' maintenance personnel.

How the Continuous-Flow System Works

(1) Day Tank.

The continuous-flow system begins with a single tank of microetch solution, prepared daily. This "day tank" is formulated to the specifications for the electroless copper line's preclean step, during which 40 to 60 microinches of copper must be removed from the panels.

(2) Microetch for Electroless Copper Plating.

A photocell provided by the electroless copper equipment vendor measures copper ion concentration in the microetch bath and automatically feeds fresh microetchant from the day tank to the bath when the copper concentration reaches a threshold of 10 g/l. Before this automated system was installed, the bath was dumped three times per week, the copper concentration in the bath ranged from 0 to 13 g/l, and the etch rate ranged from 14 to 60 microinches. The autofeed arrangement maintains copper concentration between 9 to 11 g/l, allowing for better process control and a more stable etch rate of 33 to 57 microinches. Although the flow of microetch could be triggered manually (i.e., without using a photocell), frequent analysis would be required to feed fresh solution into the microetch bath for electroless copper at the appropriate time. The benefits would not be as substantial.

(3) Microetch for Pattern Plating.

Next, as additions are made to the microetch tank for the electroless copper line, the excess overflows and is gravity-fed to the microetch prior to pattern plating. This preclean process needs to remove only 4 to 6 microinches of copper. Therefore, a weaker solution — one that has a higher copper concentration and less oxygen available — can be used. Because the etch rate is determined by temperature, concentration, and dwell time, the latter has been adjusted to achieve the desired etch rate based on the copper concentration of the incoming solution.

(4) Electroless Copper Rack Strip.

The excess from the microetch bath for pattern plating flows, in turn, to a tank used for electroless copper rack stripping. During the electroless plating process, copper is deposited on the wire racks that hold parts to be plated, as well as on the inside of the plating tank. It is not necessary to use fresh microetch solution because etch rate is not a critical parameter in cleaning racks and tanks. Microetch solution can be reused from other processes to remove copper build-up.

(5) Electroless Copper Tank Strip.

When the rack-strip tank is full, the microetchant is then pumped to a holding tank. Each weekend, the solution is pumped back into the electroless copper tank to remove copper build-up from its walls.

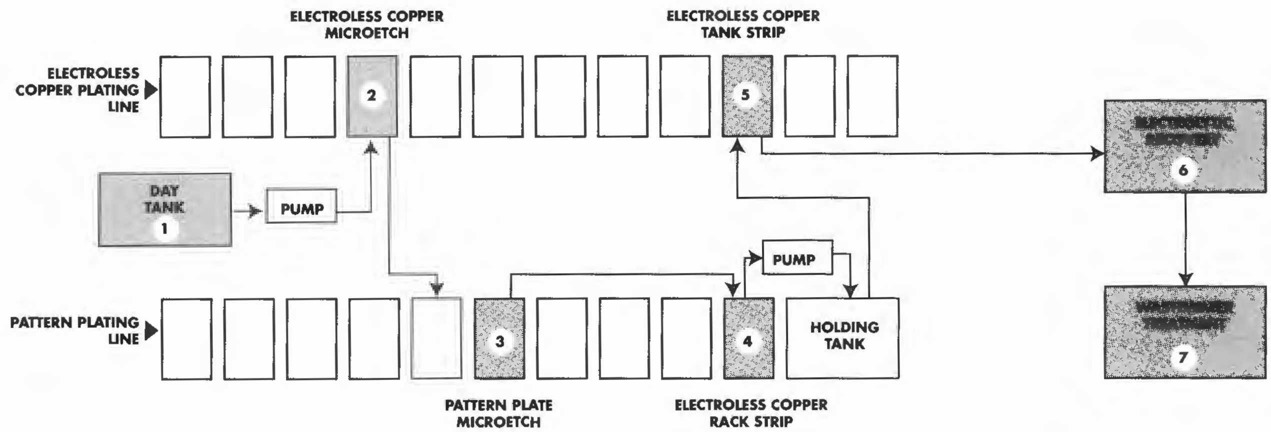
(6) Electrolytic Recovery.

After cleaning the electroless copper tank, the microetchant is pumped to the electrolytic plate-out cell, where copper is plated out and sold to a recycler at $0.80/lb.

(7) Wastewater Treatment.

The remaining spent microetchant, consisting of sulfates, sulfuric acid, residual copper, and water, is sent to wastewater treatment.

CONTINUOUS-FLOW SYSTEM FOR REUSING MICROETCHANT



Designing a Continuous-Flow System

The first step in implementing a continuous-flow system for reusing microetchant is to identify the microetching processes to include. For Power Circuits, it was a logical choice to begin the flow with fresh microetchant on the electroless copper line, due to the solution volume, precision, and relatively high etch rate required. Spent microetch flows to the preclean step for pattern plating because of its proximity to the electroless line and its lower etch rate.

Other microetching processes were not incorporated because of the quality of microetchant required and tank location. The oxide line was not incorporated into the system because the preclean step requires essentially the same etch rate as for the electroless line. Microetch solution is also more fully utilized on the oxide line before it is considered spent because the cleaning process for the oxide line does not require the same level of precision as does the process for the electroless line. When the bath is considered spent for the purposes of the oxide line, it is essentially unusable for microetching elsewhere.

It was not practical to include the microetchant for the hot-air-solder leveling process in the continuous-flow system because of its remote location in the facility. In designing a continuous-flow system for your facility, you will need to consider microetch rates and other process requirements, tank location, and floor layout.

Benefits of Reusing Microetchant

Better process control is a key objective shared by most successful PWB manufacturers. In addition to improving process control by stabilizing etch rates, the continuous-flow system for reusing microetchant yields other benefits throughout the production process.

First, process line operators no longer have to prepare, maintain, and dump four microetch baths several times per week. Instead, a single tank of microetchant is prepared daily by one individual. This change in materials handling saves about two hours of labor time per day and decreases chemical exposure risk.

Next, by reusing microetchant, Power Circuits reduced the weekly volume of spent solution flowing to wastewater treatment from 800 gallons to 120 gallons. Also, because this smaller volume of spent solution has a higher copper concentration than before the continuous-flow system was installed, a lower electrical current is needed to plate out the copper. Less waste translates into reduced chemical use and less labor time for treatment as well as lower electricity costs.

Finally, Power Circuits was able to reduce annual use of persulfate by 16,460 pounds and sulfuric acid use by 1,646 gallons. By reusing microetchant through the continuous-flow system, they needed less virgin microetchant for the same level of production.

Savings and Costs

Annual Savings

Reduced materials handling/labor time associated with bath maintenance	$11,000
Potassium persulfate purchases	$29,463
Sulfuric acid purchases	$1,500
Waste treatment chemical purchases	$2,800**

Capital Costs

Photocell	$0*
Plumbing and pumps	$1,200
Installation (labor costs)	$250**

*Photocell was provided by a vendor; commercial cost is approximately $1,200.

**Estimated value.

Payback

~12 days

Other Issues to Consider

- Power Circuits uses gravity feed for some flows. Your facility may require more pumps.
- A spread out, complex floor layout may limit the feasibility of installing additional plumbing. This system may be best suited for smaller shops, or a facility may design a smaller continuous-flow system that reuses microetchant only one or two times.
- Some facilities have sales agreements with chemical suppliers that guarantee purchase cost based on square feet of boards produced, provided that process chemicals with certain specifications are used. Ask your supplier whether reusing microetch on the process line will affect your purchasing agreement.

What is the Design for the Environment (DfE) Printed Wiring Board Project?

Representatives of the printed wiring board industry and other stakeholders entered into a partnership with the U.S. Environmental Protection Agency (EPA), called the Design for the Environment (DfE) Printed Wiring Board Project. This project is a cooperative, non-regulatory effort in which EPA, industry, and other interested parties are working together to develop technical information on pollution prevention technologies specific to the PWB industry. This information includes comparative data on the risk, performance, and cost of alternative manufacturing options.

To date, the DfE Project has focused on conducting a comprehensive evaluation of alternative technologies for making through-holes conductive. The Project is also beginning to evaluate alternatives to the hot-air-solder-leveling process. By publishing the results of these evaluations, DfE is able to provide PWB manufacturers with the information they need to make informed business decisions that take human health and environmental risk into consideration, in addition to performance and cost. The Project is also identifying and publicizing other pollution prevention opportunities in the industry through the development of PWB case studies, like this one.

Acknowledgments

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Additional Pollution Prevention Resources for the PWB Industry

In addition to this case study, the DfE PWB Project has prepared other case studies that examine pollution prevention opportunities for the PWB industry, including:

Pollution Prevention Work Practices
On-site Etchant Regeneration
Acid Recovery and Management
Plasma Desmear

These case studies, and other documents published by the DfE Project, are available from:

Pollution Prevention Information Clearinghouse (PPIC)
U.S. EPA 401 M Street, SW (3404)
Washington, DC 20460
Phone: 202-260-1023 Fax: 202-260-0178

e-mail: PPIC@epamail.epa.gov
DfE PWB information: http://www.ipc.org

The DfE Program welcomes your feedback. If you have implemented any of the ideas in this series of PWB case studies, please tell us about it by calling the DfE Program at 202-260-1678 or via email at oppt.dfe@epamail.epa.gov

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