Aqueous Processing

Eliminating solvent-based dry-film resists improves PCB imaging.

Elmer Hayes

Electronics manufacturers were first challenged to reduce chemical residues and solvent emissions in the late 1960s. Although the challenge still exists in some circles, a quarter century later the production of a great many more circuit boards generates far less waste.

Aqueous-developing dry-film photoresists were a major breakthrough in reducing wastes in PCB facilities. Introduced in the early 1970s by Dynachem, now Morton Electronic Materials (Tustin, CA), the new resists allowed manufacturers to phase out 1 ,1,1 trichlorethane and methylene chloride in processing dry-film resists. Solvent-based dry-film resists first appeared in 1968, when chlorinated hydrocarbons were considered safe. Their rapid acceptance over the next five years was primarily due to their suitability for automation. The hot-roll laminator that accompanied the technology allowed the manufacturer to apply resist to both sides of a board simultaneously, and the introduction of conveyorized developer/stripper systems logically followed. These process steps, however, were the major contributors to chemical waste in the imaging process. Due to the trim loss of dry film between panels, an average of 10% of the dry film exiting a manual hot-roll laminator was usually scrapped and hauled away to a chemical landfill. The 1,1,1 trichlor developer contributed to the stream of waste in evaporation from the developing unit, solvent drag-out into rinse waters, and resist residue from distillation units that had to be placed in chemical landfills.

If a stripper system wasn't properly maintained, a 55-gallon drum of low-boiling methylene chloride could be lost to the atmosphere on every shift. In Southern California, the waste treatment cost for a drum of resist residue from a methylene chloride stripper was about $45. Today the cost is a prohibitive $500, and the evaporation losses would be legally unacceptable.

Even during their heyday, solvent systems were expensive to operate. Developing cost about 20 times the penny/sq. ft. cost of today's aqueous materials. Additional costs included bulk storage tanks for the solvents, solvent recovery stills, and ventilation and other safety considerations for the facility and its personnel. Today, 1,1,1 trichlorethane and methylene chloride are on the community's right-to-know list and are included in the EPA's Genetic Toxicology Program.

Aqueous Dry Films

The new chemistry of aqueous dry films presented a radical change. The resists are formulated to develop in a 1% solution of sodium carbonate, and stripping after plating or etching is done in a 3% potassium or sodium hydroxide solution. As opposed to $2.70/gal. for trichlor, the cost of fresh solutions of these chemicals is about $0.15/gal., and spent solutions can easily be disposed of in the average printed circuit board waste treatment facility. Regardless of the cost advantage, early aqueous dry films were initially unsuccessful as pattern plating resists because of the aggressive nature of the electroplating chemicals. Very tolerant of print-and-etch chemicals, the films were immediately phased into this technology. By establishing a separate process for innerlayers, manufacturers were able to realize the benefits of going aqueous. Further research and development efforts by the dry-film manufacturers brought the technology to outerlayer production.

In 1973, semiaqueous films were developed that combined the superior imaging properties of solvent resists with the cost-effectiveness and environmental friendliness of aqueous materials. The new resists were formulated for both developing and stripping in alkaline solutions with 3 to 10% water-miscible solvent. Their performance enabled manufacturers to eliminate chlorinated solvents and the need for distillation equipment, stainless-steel equipment, and water decanters for the developing tanks. Semiaqueous developers provide an extremely broad process window for harsh plating conditions and are still in use today.

With solvents phased out in favor of aqueous dry-film resists, an integrated Advantage Waste Treatment System was developed by Morton International for the disposal of developer and stripper wastes. In-1ine filtration units remove strip resist particles during processing, greatly extending the life of the stripping solution. When the filtered stripper solution becomes saturated, pH adjustment precipitates the dissolved resist for filtration. *In* both cases, the filtrates are treatable in normal waste treatment systems, and the filter cakes are disposable in commercial landfills.

When operated as a batch system, the developer chemistry can be mixed with the spent stripper solution for treatment in the same system. When operated as a feed-and-bleed system, the loading of resist per gallon is so low that the solution can usually go directly into the waste stream for in-house treatment or treatment by the local sewage plant.

Additional Improvements

A recent article in *Chemical Engineering*[1] stated that 47% of environmental managers believed their companies were driven by regulatory compliance, 43% by pollution prevention (P2), and 10% by both. Preventing pollution at its source is the most direct approach to complying with regulations and treating wastes. Imaging industry suppliers had P2 in mind when an automatic cut-sheet laminator was developed that eliminated trim loss between boards during resist lamination. When resist is applied like postage stamps only on PCB areas that need to be imaged rather than in a continuous ribbon, manufacturers use all the resist they purchase. High-volume manufacturers save more than 10% of their dry-film cost and eliminate the disposal cost for resist trim losses.

Today's trend toward thinner resists for etching applications also reduces the amount of waste treatment required. The conversion from a 2-mil-thick resist to 1 mil cuts processing chemical costs and waste treatment costs in half.

Switching from solvents to aqueous products for the imaging process has allowed PCB manufacturers to meet the challenge of operating "greener" shops. Other innovations will continue to have a significant impact on waste minimization. FAB

References

[1] "Pollution Prevention: Reinventing Compliance." *Chemical Engineering,* November 1993, pp. 30-43.

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