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Conformal Coating Made Easy

Tom Charlton

Companies looking to save costs and improve their environmental compliance should consider 100% solids, UV curing materials.

The biggest challenges for my company, a contract house specializing in the conformal coating of rigid and flexible printed circuit boards (PCBs), are to deliver the customer's order almost immediately and, of course, run a profitable business.

Fewer and fewer companies want to be involved in coating printed circuit boards. Coming at the end of the board assembly process, conformal coating is seen as messy, hazardous, time consuming, inconvenient and costly. However, more and more boards are being designed for use in challenging environments requiring protection.

Luxury automobiles may now have as many as 30 electronic modules per vehicle. Circuit boards are found in everything from parking meters to telecommunications, water treatment systems and outdoor scoreboards. These electronics require protection; hence, the need for conformal coatings. And, most manufacturers of these high performance, critical electronic applications are generally happy to farm out the coating process.

Because conformal coating is the last step in the manufacturing process, most customers want an instant turnaround. We usually apply the coating, cure and ship—immediately. One-day turnaround requests are common, and, to be successful, we need to provide this service. One way is to use 100% solids, light curing, aerobic, acrylic coatings, and, with an automated, programmable application and curing system, we can coat and cure hundreds of boards per shift at a competitive price (Figure 1).

When customers approach my company to apply traditional coatings, I usually tell them that, if they use 100% solids, light curing, aerobic, acrylic materials, the cost is "x" per board. However, if the order has to be done with another coating technology, the price will be two or more times the previous figure. Plus, delivery time with a light curing material will be the same or the next day. Traditional materials usually add at least another day to the turnaround time depending on the size of the job.

Table 1 shows the cost difference between using 100% solids materials and solvent-based resins on one conformal coating run. This case history of a coating contract for a relatively small board manufacturer serves to illustrate the savings and the improvements in environmental quality, personal safety and convenience these materials can provide. The example in Table 1 is based on 50 parts/hour, or 400 per shift for I shift, 2.5 days per week, which equals 50,000 coated boards per year. The calculations assume a minimum required thickness to meet UL 94 VO specification, ultraviolet (UV) cure of aerobic, acrylic coating material to ensure full cure before shipping, and heat cure of silicone material to ensure full cure before shipping.

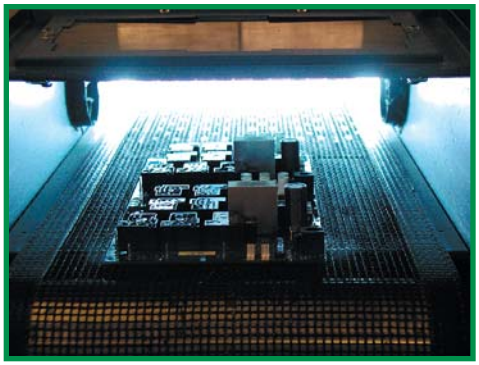


FIGURE 1: The combination of 100% solids, light curing, aerobic, acrylic coatings and an automated, programmable application and curing system is efficient and effective.

Cost Factors	Conformal Coating Resins	
	UV Curing Coating	Solvent-Based Silicone
Board area (sq. in.)	10	10
Thickness (final) (in.)	0.002	0.005
Sides	2	2
Grams/part	0.66	2.75*
Cost per liter, USD	$50.00	$30.00
Material cost/part	$0.033	$0.0825
Liters/year	33	137
Material cost/year (50K Boards)	$1,650.00	$4,125.00
Typical energy, labor overhead/year	$1,950.00	$4,500.00
Total cost per year	$3,550.00	$8,625.00

**Calculations assume 60% of solvent coating is silicone.*

TABLE 1: Basic cost to coat 50,000 printed circuit boards to meet UL 94 VO specification.

Hidden Costs of Traditional Conformal Coatings

Most customers are surprised to hear of hidden costs in some conformal coatings because they know that the cost per pound of traditional materials can be half the cost of 100% solids, UV, aerobic, acrylic coatings. Few customers are aware that the hidden costs of using solvent-based or silicone coating processes can double or triple their cost. Fewer still realize the cost reductions that can be achieved using solvent-free, 100% solids, environmentally friendly UV conformal coatings. When they understand the cost reductions, most customers are able to qualify the MIL 46058 and UL approved light curing coatings quickly.

So, where do the hidden costs of using the traditional materials come from and why do the UV aerobic acrylics save so much time? First, in comparing the cost of a solvent-based to a solvent-free coating, 80% of the volume of the coating is going out through the ventilation system. Most solvent-based materials contain a minimum of 20% solvents as supplied by the factory. These materials include acrylic, urethane and silicone solvent-based conformal coatings. To apply these coatings with selective coating spray equipment, most coating manufacturers suggest blending their coating with a minimum 50:50 mixture of coating and thinner (solvent). In this case more than half of the applied coating is lost to evaporation of the solvent up the ventilation system. This loss is more than doubling the applied cost of the coating, in addition to the hidden environmental, health and safety costs associated with solvents.

Second, the extra time and handling needed to cure the solvent-based systems adds to the cost. Because these systems cannot be handled for minutes or hours, the extra labor required to rack and stack and then move them onto other stations such as quality assurance for inspection or shipping adds time and labor cost.

As manufacturers become more aware of worker health and safety and the environmental impact of using solvents, the use of light curing coatings becomes more attractive. Health, safety and the regulatory compliance cost of traditional coatings raise major cost issues. Customers frequently approach my company with specifications to use either silicone or other solvent-based coatings containing hazardous and flammable materials such as toluene, xylene and heptane. Even non-solvent containing silicones react with atmospheric moisture to produce methyl alcohol or acetone as a byproduct. All of these are solvents that require the costly installation of complete ventilation systems to the outside and include fire suppression systems. Many states now require the addition of expensive scrubbers to lower or eliminate these volatile organic compounds (VOCs). The 100% solids, light curing, aerobic acrylics require only simple localized fume extraction systems.

FIGURE 2: Inspecting a brightly fluorescing board.

Health Hazard to:	UV Urethane	RTV Silicone A	RTV Silicone B
Eyes	Possible irritation	Moderate irritation	Moderate irritation
Skin	Possible irritation	Moderate irritation	Moderate irritation
Inhalation	None	May cause drowsiness	May cause blindness and damage nervous system
Oral	None	Not listed	May cause blindness and or death

TABLE 2: Typical health hazard comparisons found on material safety datasheets.

Other Warnings	UV Urethane	Silicone A	Silicone B
Spill Hazard	None	Very slippery	Very slippery; respirator required for clean up
Transportation Restrictions	None	Flammable liquid/ hazardous goods	Flammable liquid/ hazardous goods
Flash point	>200°F	88°F	66°F

TABLE 3: Other warnings that appear on material safety datasheets.

Tables 2 and 3, taken from the material safety datasheets of the UV aerobic acrylics with a 100% solids moisture cure silicone and a solvent-based silicone, draw a comparison of the hazards.

Some silicone coatings cure in as little as a couple of minutes, but some take as much as 24 hours. During this time solvents and reaction products continue to evolve so that both storage and processing areas must be well ventilated. Solvent-based acrylics and urethanes have similar health issues as silicones due to the solvent carriers in these coatings. All these older technologies are increasingly threatened due to environmental regulatory compliance issues.

Benefits of Light Curing Coatings

The best feature of UV curing, aerobic, acrylic coatings is their almost instant cure speed. Using these coatings, customers needing an immediate turnaround and shipment of their boards can be satisfied. Conveyors typically run from 5 to 10 feet per minute, turning out as many as 250 coated boards per hour. The more boards that can be coated in a given period of time, the more jobs that can be run to keep the facility operating at full capacity, which optimizes efficiency and keeps costs competitive.

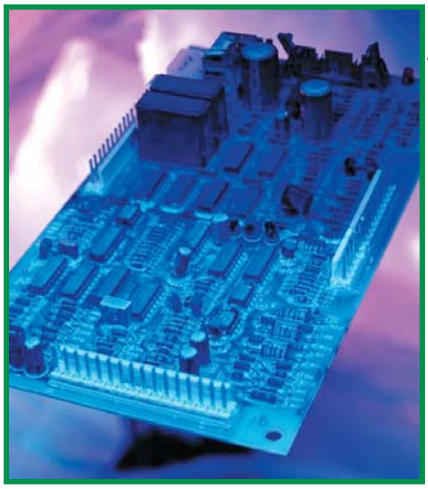
Use of the solvent-free, light curing coatings with programmable application equipment further reduces costs by minimizing the amount of material used. A number of manufacturers now supply equipment that assures placement and thickness of coatings. Thus, the material is applied only where it is needed. Because the UV curing, aerobic, acrylic coatings can be supplied in viscosities from 60 to 600,000 cP and valves are available for their application, coat-

ing rarely migrates to where it may not cure.

Another plus for light curing materials is that, since no cure occurs until the coating is exposed to the light, dispensing equipment maintenance is very low. Silicone and other solvent-based conformal coatings that cure rapidly in the air without application of an external catalyst like heat or light will thicken and rapidly clog dispense nozzles and valves. As long as the coating process is running constantly with these materials, it runs well. However, when breaks occur, these materials begin to cure in place, and time consuming maintenance is necessary to remove cured or partially cured, gummy material from the dispensing equipment before it can be restarted.

Courtesy of Dymax

FIGURE 3: Black and deep blue coatings serve to hide circuitry and components. These materials may also be used for marking. These opaque materials can cure in seconds upon exposure to high intensity UV light.



Courtesy of Dymax

FIGURE 4: Clear coatings fluoresce brightly upon exposure to black light, which allows convenient in-line inspection of the coating to assure that complete coverage has been achieved.

Another convenience with light curing coatings is their ability to fluoresce brightly upon exposure to black light. Whether cured or uncured, when exposed to black light, these materials easily show any defects; correcting them either before or after cure is simple (Figure 2).

Another advantage is that light curing, aerobic acrylics exhibit superior surface wetting so that defects such as bare spots are rare. As compared with silicones and solvent-based conformal coatings, generally, the UV aerobic acrylics seem to be more tolerant of no clean fluxes.

Sometimes, when some of our larger customers see how easy conformally coating PCBs with light curing technology can be, they reconsider and install their own systems. As always, this choice comes down to cost—material handling, shipping, capital outlay and work flow all affect a customer's decision to outsource coating or keep it in house. In addition, manufacturers contemplating setting up their own conformal coating lines have a considerably heavier cost burden with silicone and other solvent borne materials than with the 100% solids UV urethanes.

When Light Curing Is Not Best

Of course, not all PCB coating applications are suitable for UV curing urethanes. Solvent-based materials, moisture cure and thermal cure conformal coatings still have a place in industry. While most UV/visible, light cured coatings applied with the appropriate equipment can be successfully cured in all areas of the board, occasionally the topography of a circuit board does not lend itself to UV cure. Applications with tall components such as board-mounted transformers or other large devices can cause shadowed areas that make UV curing difficult. These applications are best done with traditional solvent-based or moisture cure coatings.

Another factor that can affect selection of conformal coating is end product operating temperature. If constant high operating temperatures are a factor (175°C), a silicone may be the best choice.

FIGURE 5: A number of UV coatings and encapsulants are available for bonding to difficult substrates such as Kapton and Mylar. Other adhesion problems may be encountered when coating over certain solder masks.

Additional Benefits

In addition to the lower capital equipment, coated board cost and safety and handling benefits, UV urethanes are available with a wide range of properties to suit many demanding requirements and

both performance and special processing needs. These products often have the following features:

- opaque black or blue coatings (Figure 3)
- fluorescent clear coatings (Figure 4)
- repairable grades
- MIL Spec and UL qualified grades
- high performance for challenging environments
- coatings to handle conditions to –85°F
- high adhesion to difficult substrates
- thick and thin layer coatings
- coatings for Kapton and polyester flex circuits (Figure 5)
- hard and rigid to soft flexible coatings
- excellent moisture and thermal shock resistance.

Summary

UV light curing conformal coatings, as well as the equipment for dispensing and curing them, have come a long way toward providing better and more cost-effective board protection in the last few years. Now, companies that are looking to both save cost and improve their environmental compliance position have a variety of 100% solids, UV curing materials from which to choose. ■

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