Removing Conformal Coating

Causes of Failed Conformal Coating Films, Their Removal and Replacement

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Help!! My Board is Failing, but It's Already Coated!

Conformal coatings are designed to protect printed circuit boards (PCBs), assuring they work under all operational circumstances. However, cases emerge where boards fail to function despite conformal coating protection. Such non-performance can be a consequence of:

- problematic conditions already existing on the PCB prior to coating,
- using the wrong coating materials for the particular project, or
- inappropriate coating methods.

PCB manufacture is a complex process, open to numerous sources of board failure. In some cases, failure mechanisms develop slowly enough their origins can be detected, and compensated for, maintaining the unit's function. More rapid and unexpected PCB failures can lead to immediate PCB failure, often negating the prospect of repair.

This is unfortunate. Due to their properties, conformal coatings should protect your board unless the wrong coating material is used, or it is applied inappropriately. However, this PCB security is of little value if:

- the coating is applied to unclean components and/or surfaces, or
- the unit itself is poorly constructed or installed.

Inspection Before Coating

To safeguard against these potential threats to optimal performance, board inspection prior to coating is strongly recommended. Inspection is essential because it verifies the PCB meets workmanship standards and customer specifications. Testing during product certification processes helps identify conditions that generate board failure after conformal coating is applied. These include:

- Component failure, the inability of one or more PCB components to function independently or in union with other parts of the board assembly. Included are elements like diodes, driver chips, IGBT modules, microprocessors, rectifiers, resistors, transformers, and transistors. Inadequate board thickness can cause the PCB to bend or break.
- Contaminants like dirt, oil, or even the presence of insects under conformal coatings can gradually degrade PCBs. These debris corrode assemblies, reducing their overall lifespan and destabilizing performance prior to breakdown. Thorough cleaning of all substrates is essential prior to coating application, to assure contaminants do not nullify PCB function.
- Divergent thermal expansion rates among such basic PCB materials as component pins, PCB trace/trace coating and solder represent a further source of assembly failure despite coating. All materials within the PCB experience temperature changes (heating and cooling) during operation. Each PCB component has a specified range of heat it can absorb, a quantity dependent on its size and structure. Overheating can generate considerable mechanical stress which may

disrupt physical solder connections, damage the effected component, or delaminate the PCB trace. If insufficient space exists around the component, in relation to others in the assembly, high operating temperatures can cause component overheating and burning, underneath coatings.

- Solder improperly heated during board construction can generate cold solder joints and bad surface-mount connections that may burn components and cause power issues. Left over soldering-flux may also produces PCB-corrosion. Electromigration of the elements in the solder occurs when the wrong type of solder is used within a PCB. Brittle, intermetallic layers form, generating broken solder joints that often are undetected, even with inspection.
- Loose connections may lead to poor connectivity between board layers causing inefficient performance.
- Tin whiskers' growth from lead-free solder joints can bridge contacts or break-off, causing short circuits. Conformal coatings can combat the formation of tin whiskers during operation, but are less effective when whiskers exist within the assembly prior to coating application.
- Traces are the conductive pathways, tracks or signals etched from copper/silver coated sheets and laminated onto the non-conductive substrate. If accidentally placed too near each other, they can short circuit during operation. Use of inappropriate acid core solder is one source of trace shorts, and an example of a pre-existing PCB condition that good inspection can uncover and correct. Conformal coating cannot protect a board from a problem already extant when coating is applied.

Coating Crises

It is also possible that none of these pre-coating issues are a problem, and your board still malfunctions, despite being treated with a conformal film. In some cases, it may be that the coating was inappropriately applied, leaving pinholes or gaps in the covering; larger-scale delamination can develop, rendering the conformal film ineffective.

Not all coating materials – acrylic, epoxy, parylene, silicone or urethane – work equally well for all projects or purposes. If the wrong coating material was selected, PCB breakdown can occur even though the assembly is conformally coated. Under these circumstances, conformal protection alone is unequal to the task of maintaining PCB functionality.

Conclusion

PCB failures occurring despite the ostensible protection of conformal coating can compel a multitude of testing, probing and preparation processes, enacted to determine both:

- the precise failure mechanisms effecting board performance, and
- appropriate repair/rework procedures.

Poor manufacture or stresses to the assembly emerging during operation that may cause failure can be minimized by:

- thorough board inspection prior to coating, and
- ensuring the selected coating methods/materials are germane to project specifications.

The objective in all cases is to maintain board function and avoid coating repair, removal or reapplication.

Removing Conformal Coating

Conformally coated PCBs are expected to work without fail, largely because of the protection the coatings provide them. In addition to PCB-manufacturing issues, coating problems can trigger failure mechanisms for the assembly. For instance,

- Conformal coating applied incorrectly can cause PCB malfunction.
- Selecting the wrong coating material from among acrylic, epoxy, parylene, silicone or urethane can be a source of board failure, if it does not support the PCB's operating environment.

Removing the coating may be necessary if these conditions prevail.

Reliable Methods of Removing Conformal Coating

Coating removal methods are determined by their impact on the film, its thickness, and effect on the substrate. Major removal methods include:

- **Chemical** solvent methods are used most frequently for conformal coating removal. Much depends on the coating material. No single solvent is equally effective for all applications. Used essentially for wet coatings – acrylic, epoxy, silicone, urethane – chemical methods are generally ineffective for chemically-inert parylene. Solvents remove specific soluble-type coatings on a spot-basis by brushing or swabbing the local area with controlled solvent-application until it is free of the conformal film; larger-scale immersion may be necessary for quicker coating-removal from entire PCBs.
- **Laser ablation** is a cost-effective method for difficult removal conditions, controlling the process to areas as small as a single micron. Removal is generally a one-step procedure, and especially useful for parylene, converting the coating to gas or plasma. While precise removal is the result, it can be slow; each laser pulse separates only a minute segment of the existing film's material thickness.
- **Mechanical** removal techniques involve cutting, picking, sanding or scraping coating from the surface, requiring time-consuming, precision control. Poorly enacted mechanical removal processing can accelerate damage to the coating and PCB. Less dependable than other removal techniques, thorough masking of non-removal surfaces is mandatory in all cases.
- **Micro abrasive blasting (abrasion)** is environmentally friendly, and inexpensive. A tiny nozzle attached to a stylus directs project-specific formulas of abrasive media and inert gas/dry air at the coated surface, by means of automated or human handheld-technologies. Electrostatic potential

is dispelled by grounding devices; filtration processes dispose coating debris removed from the substrate. The process can be focused onto targeted areas as minute as an individual test node or those as large an entire PCB.

- **Oxygen-based plasma** is often used in situations requiring highly selective removal of coating from specific components – such as connectors -- within an assembly. However, this fine-scale procedure can also be used to strip entire PCBs.
- **Peeling** is used only in special circumstances, like removing thickly-applied silicone coating, using a dull knife/blade to slit the film, so it can be peeled off the PCB by hand.
- **Thermal** is a less-recommended method of coating removal. Relying on very high temperatures generated by a soldering iron, thermal removal's longer duration of exposure can cause delamination/discoloration, overheat temperature-sensitive components, negatively impact solder joints, and leave surface residue. Difficult to manage, thermal methods should be confined to spot-removal; toxic fumes can result from careless thermal application.

One needs to match the appropriate removal method to the coating material, its age, thickness and the board's specific function.

Removal According to Coating Material

Since the possibility of defective coating or PCB components can develop after manufacture, removal strategies are an integral element of design, based largely on the assembly's specific coating material and operational function.

- **Acrylic:** The solvent butyrolactone is frequently used for chemical removal of most of the acrylic coatings. This substance replaces the far more flammable ketone, methylene chloride and trichloroethane, used in the past. In addition to chemical solvent removal, acrylic films also respond to mechanical, micro-abrasive and thermal treatment for coating removal.
- **Epoxy:** Thermal treatments are most frequently used to remove super-hard epoxy coatings. Mechanical and micro-abrasive methods are also recommended. Chemical removal methods are generally ineffective.
- **Parylene**: Tetrahydrofuran (THF) is the only chemical solvent that effects parylene removal on a persistent basis. Micro-abrasion and scraping are currently most consistently used, while developments in laser technology may soon transform it into a more common removal source. Spot-removal is achieved with mechanical and plasma methods. Thermal methods also have some use for spot-removing parylene, but are difficult to control.
- **Silicone:** Chemical removal via methylene chloride or hydrocarbon-based solvents is recommended. The hydrocarbons are safer, far less likely to damage PCBs, components, metals and plastics. In descending order, thermal, mechanical and micro-abrasive techniques will effectively remove thin-layered silicone films. Thicker silicone coatings respond to peeling or mechanical techniques.

- **Urethane:** Thermal and mechanical methods are recommended for urethane removal. The solvents methanol-base/alkaline activators and ethylene glycol ether-base/alkaline activators efficiently remove silicone films, as does micro-blasting.

Summary

Because the process of removing conformal coating from PCBs can vary from simple to complex, it is important to correctly match the removal methodology with both the type of coating material used, and the project/purpose of the circuit board. Stripping fluids that work for some materials (acrylic) may be useless for others (parylene). Determining the appropriate coating erasure procedure assures optimal removal without interfering with PCB function after it has been recoated. THF is the only chemical solvent that consistently removes parylene from assembly substrates; the limited chemical options remaining are highly specialized and seldom applied. Abrasion and scraping techniques work best for parylene films; laser may also develop further as a major parylene removal process. Mechanical and plasma-based techniques are useful for spot-removal assignments.

Reapplying Conformal Coating After Its Removal

Defects to either the PCB assembly or its conformal coating can be sufficient to cause coating removal. Whether repair technologies address the circuit board's components or the conformal film, subsequent post-repair coating (recoating) processes need to address:

- the correct match between conformal material and PCB function, and
- the most advantageous method of applying recoating materials.

Old Coating Removal

The complexity of stripping damaged or otherwise unwanted conformal coating from a circuit board is largely dependent upon the type of coating targeted for removal. Different film materials require different removal strategies, and need to be appropriately monitored to ensure further damage is not done to the assembly. The type of components comprising the assembly, and the extent to which conformal coating actually covers the board (and in what surface areas), are also important factors. Safely removing old coating supports the subsequent recoating process.

Conformal Coating Materials

Basic conformal coating materials are acrylic, epoxy, parylene, silicone and urethane. Only parylene does NOT use a liquid application procedure, wherein wet conformal coating is applied to the circuit board via brushing, dipping or spraying methods. Difficulty of their removal varies according to material type; only acrylic can be removed very easily. However, most liquid coating types can recoat PCBs, if the targeted surfaces have been appropriately cleaned of old coating residue and prepared for recoat.

In contrast, parylene uses a chemical vapor deposition (CVD) procedure that penetrates deeper into the substrate surface. Although its resultant coating is in many cases superior to wet material films, parylene has disadvantages for removal/repair/recoating. Removal for rework is very difficult, requiring abrasion techniques, and without access to vapor phase deposition equipment, recoating with parylene is impossible.

Conformal Coating Reapplication

Recoating procedures focus on pairing the new film with the PCB's operational environment. In most cases, this will entail:

- testing assembly components to ensure they function as intended,
- updating/repairing component performance standards as necessary,
- ensuring board cleanliness, and
- recoating per client/component specifications,
- with close attention to film material selection and coating procedures.

When selecting the coating material, you'll want to align its properties with those of the PCB, in terms of the unit's:

- dependability requirements,
- electrical effects,
- life cycle expectations, and
- total operational environment,
- for determining the optimal mix of coating/assembly materials and methods.

This will entail accurately ascertaining the assembly's surface energy during operation, to ensure the PCB can be coated with the chosen material. It is also important to establish (1) what the PCB needs to be protected from during use, (2) the most advantageous coating-thickness, and (3) the kind of coating materials that will support this capacity. Keep-out areas, regions of the board not to be coated, also need to be identified and appropriately masked prior to initiating recoating processes.

Conformal coating reapplication implemented according to these procedural standards has a superior chance of eliminating defects to the new film.

Summary

After removal of the original conformal coating from the PCB, recoating with the conformal coating type most pertinent to the assembly's operational environment is essential. This priority is further abetted by use of the coating method that best supports the PCB's operational requirements. Circuit boards need to be thoroughly inspected both prior to and after recoating to assure conformal film reapplication is complete and directed to the correct physical regions of the PCB. For instance, reapplication is of no use if coating materials cover either the underside of the board or interior regions, for parts like connectors, that should never be coated.

Reapplication is already process downtime, and must be carefully managed in all cases, to limit further production delays. For recoating to be effective, there needs to be a reliable confluence of material, process and board. Ensuring this condition minimizes the development of future failure mechanisms within the PCB due to conformal coating problems.

Removing Conformal Coating Instead of Repairing It

Sometimes problems with conformal coating are too complicated or difficult to repair. This can occur when bubbles develop in the coating during the application process; bubbles cause voids in the coating that defeat its protective, insulating purpose, suggesting the need for removal. Other situations that lead to inadequate coverage, and may favor coating removal, rather than repair include:

- Coating application that's either too thick or thin for the project's purposes.
- Component surface finishes that adapt poorly to the conformal material chosen for coverage.
- Disparities in surface tension/surface energy.
- Gravity issues that negatively impact application of liquid coating.
- Improper mixture of two-part materials.
- Inadequate fixturing or placement of assembly components in the coating area.

- Inadequate masking implementation.
- Incorrect interpretation of coating requirements.
- Residue on the coating surface during coating application.
- Poor, uneven coating application.

Overly thick film application or use of coating equipment/materials unsuited to the assignment are major causes of coating problems. In these cases, complete or partial removal of the conformal film from the PCB may be the best solution.

Thus, it is important before beginning any conformal coating assignment for designers and users to recognize the various types of conformal coatings and their interactions with the parts/materials they cover, to protect the products in their respective end-use environments, for the expected design-life of each component.

Industry Standards

When removal is the best option for your coating problem, it is advisable to consult prevailing industry standards for appropriate process guidelines. For instance, **IPC-7711/7721** delineates recommended procedures for conformal coating removal from, and replacement onto, PCBs. **IPC-A-610** is a widely-held standard for electronic assemblies, offering users limited but valuable criteria for conformal coating applications. Designed and constructed with the intent of obtaining maximum confidence in the materials with minimum test redundancy, **IPC-CC-830B** qualifies the definition, use and conformance of all conformal coatings types for PCBs. In most cases, coating removal is required when assemblies don't meet the requirements of IPC-CC-830**,** concerning overall quality conformance of each

The Logistics of Coating Removal

The logistics of coating removal are largely dependent on the type of coating material, its position on the PCB, and the board's components. Proper identification of the coating material, and the methods used for its original application, are essential to correct determination of the removal method. Once these have been identified, determination of the appropriate removal method can be achieved.

In many cases, chemical strippers can dissolve conformal coatings from PCBs. Acrylic films are typically removed easily by soaking in a solution of stripping fluid, followed by mild mechanical abrasion if necessary. These two processes also work for coatings such as epoxy, silicone and urethane; however, since these substances have higher levels of chemical resistance than acrylic, complete coating removal is more difficult and time-consuming. In all cases, the stripping solution's compatibility with the PCB's components needs to be verified to minimize potential damage during the removal process.

Chemical removal does the least damage to PCBs; it is effective for the liquid coatings -- acrylic, epoxy, silicon and urethane. Chemical methods work less well for parylene films, since the substance is chemical inert. Abrasion, laser, mechanical, plasmatic and thermal removal methods are more successful for parylene films; they also work for liquid coatings in many cases.

Recently applied coating is more easily detached from substrate surfaces than older coatings, regardless of the material, unless the coating itself has begun to decay with age. Larger areas of the board respond best to complete submersion in a tank of stripping fluid. Gentle abrasion using a soft bristle brush will also eradicate coatings.

Summary

Please remember that the removal of conformal coating generally requires use of exceptionally caustic and potentially dangerous chemicals; the safety of process operators, the product being treated and the immediate environment can be jeopardized by use of inappropriate removal materials and methods. Consultation with a certified conformal coating specialist is highly recommended prior to removing conformal coating. To this end, the professionals at Diamond MT are eminently qualified, and would be glad to be of assistance.

When to Think About Conformal Coating Removal Services

It is possible to remove unwanted conformal coatings from PCBs in-shop. The process can often be accomplished by either the assembly's original equipment manufacturer (OEM) or an end-user, but the capacity to do so doesn't always exist. For these parties, conditions affecting the poor coating may:

- be beyond the purview of their experience with conformal materials or
- exceed the capacities of their available removal equipment/supplies.

In addition to poor coating finishes, the need for removing conformal films can arise any time following PCB completion. There can be many causes; an extreme variety of process/product requirements or component replacement issues can significantly diminish a coating's functional integrity. When these circumstances develop, or if the process is just too complicated/inconvenient to complete, it is advisable to seek the assistance of professional conformal coating removal services.

Coating Conditions Leading to Removal

When the coating is beyond repair, removal may be the only way to save the assembly. Conditions that can lead to coating removal include:

- **Contaminants**: Contaminated substrate surfaces interfere with coating adhesion. If left untreated too long, removal may become necessary.
- **Delamination**: Separation of the conformal coating from the substrate produces a finish characterized by torn, unattached, and non-conformal coating, defeating the film's purpose.

- **Masking/prep**: Poorly implemented masking of component surfaces not targeted for coating disrupts their ability to function as designed.
- **Outgassing**: Gaseous emissions from a processed layer of coating film generates poor coating performance, potentially leading to the need for coating removal.
- **Solder joint defects**: Depending on their properties and application processes, conformal coatings can increase assembly solder joint fatigue, if the coating material is not suitable to the PCB's purposes or is improperly applied to the assembly.
- **Tin whiskers**: Spikey, whisker-like protrusions along the surfaces of metal components, these are responsible for PCB arcing and short-circuits. Eliminating their presence can require coating removal.
- **Vessication**: Blister formation between semi-permeable film coatings and another surface material can become severe, rendering the original conformal film dysfunctional.

Skill and Conformance Requirements

Successful removal of conformal films largely depends on the levels of operator skill and experience. Advanced operator skill levels, at the upper echelons of technician proficiency, are necessary for many removal functions. As important is the ability to accurately identify the coating material, mandatory for successful removal. This is simple enough if recoating is being done by the original manufacturer, since the specific coating used is known as a matter of company record.

However, this is not always the case, compelling appropriate material identification prior to commencing removal processes. Stripping materials can also be hazardous. Caustic removal materials demand application of highly specialized aptitudes and technical procedures, frequently beyond the means of OEM personnel or end users.

Skilled professionals are better equipped to properly test the film for reliable identification of coating characteristics, to more precisely determine appropriate removal procedures. Hence, they can closely duplicate the physical characteristics of the original, within the constraints of such conformance issues as the assembly's environmental, functional, and serviceability requirements.

Final Thoughts

Diamond MT's considerable experience removing conformal coating from PCBs minimizes the risks involved to board assemblies, whether localized or complete removal is needed. Successful removal is cost effective, minimizing downtime. Diamond MT offers a highly skilled workforce and rapid turnaround on coating-removal assignments, also providing highly reliable recoat, according to your precise specifications. Our established quality program, combines with knowledge of commercial manufacturing requirements, competitive pricing and on-time delivery, to offer clients superior conformal coating removal services, followed by recoat, if requested.

About Diamond MT

Diamond MT was founded in 2001 as a firm specializing in contract applications of conformal coatings for Department of Defense and Commercial Electronic Systems. Since our beginning, Diamond MT has established a reputation for providing the highest quality services in the industry. Our commitment to quality, integrity, and customer satisfaction combined with an unmatched expertise in applications and processes has provided every one of our customers with superior results.

Diamond MT operates out of a freestanding 12,000 square foot building in Johnstown, Pennsylvania, which is located 60 miles southeast of Pittsburgh. Diamond MT is located near three major interstates and is supported by the Cambria County Airport, which serves as a primary freight terminal for south central Pennsylvania. Diamond MT maintains a strict program per NSI ANSI Standard 20.20 for ESD protection. All work areas are safeguarded with the latest in protection devices including wrist straps, garments, and workstations.

Quality Assurance: Diamond MT’s quality manual ensures every employee is focused on continuous improvement and service excellence. Our ESD safe facilities stretch over 12,000 square feet dedicated to your conformal coating requirements. We are continually researching and updating our equipment to make sure we provide the best ESD protection available.

All employees have been trained in proper ESD procedures. We operate at a class 3 level to ensure the job is done right the first time, and to the highest quality standards set forth in accordance with the MIL-STDs, IPC, J-STDs as well as having our biomedical and ITAR certification. Furthermore, all assemblies are tracked through every step of the process with documentation/serialization spreadsheets as well as each assembly going through a 100% visual inspection.

Diamond MT has a strong organization consisting of highly motivated personnel, modern facilities, and diverse capabilities. Diamond MT operates one of the most modern, well-equipped facilities in the region. Our highly skilled and reliable workforce adheres strictly to our established quality performance standards, with rapid turnaround for all coating removal projects. Diamond MT always provides these services with competitive pricing and on-time delivery.

Rapid Turnaround: Diamond MT understands that oftentimes conformal coating is overlooked because it’s the last step in the process. We are committed to serving the industry with rapid turn times for parylene, (normally 10 business days), with expedited service in as little as 2-5 business days depending upon the complexity and quantity.

For liquid coatings, our normal turnaround time is five business days, with expedited service in as few as 2-3 business days. We understand that there are times you’ll need a project completed FASTER. We will accommodate your needs in a budget-friendly manner. This service is offered on a FIFO basis.

To learn more about Diamond MT, please contact us today!

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