empfasis

A publication of the National Electronics Manufacturing Center of Excellence *December 2009*

ISO 9001:2000 Certified

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Atomic Layer Deposition

Is it possible to coat electronic assemblies with a thin, uniform in thickness, pinhole-free, moisture impervious, truly hermetic (by the MIL-STD-883 definition) film of ceramic material that is far more affordable than placing the same electronic assemblies in the currently used glass-to-metal sealed, thick, heavy, metal-and-ceramic-based hermetic enclosures? Since the coating (called a "conformal coating") would be both hermetic (moisture proof) and hundreds or thousands of times thinner than the currently used enclosures, it would be both less expensive, lighter, and still just as effective in excluding moisture (hermetic) as the current heavy, bulky, expensive electronic enclosures are.

Such a coating might indeed be possible.

Atomic Layer Deposition (ALD) is a vacuum-based process of depositing a very pure, well-controlled-composition chemical compound film on a surface, one "atomic layer" at a time. One single "atomic layer" (actually a molecular layer) of reactant products is deposited by controlling the presentation of a single reactant (usually a gas) to the initially bare surface. The deposition stops when all of the reaction sites on the surface are reacted, giving one "atomic layer" per deposition cycle. All of the remaining reactants are completely flushed and removed from the deposition chamber so that only one layer of reaction product molecules can be deposited in each deposition cycle. No further reaction is possible until a different reactant is introduced into the deposition chamber.

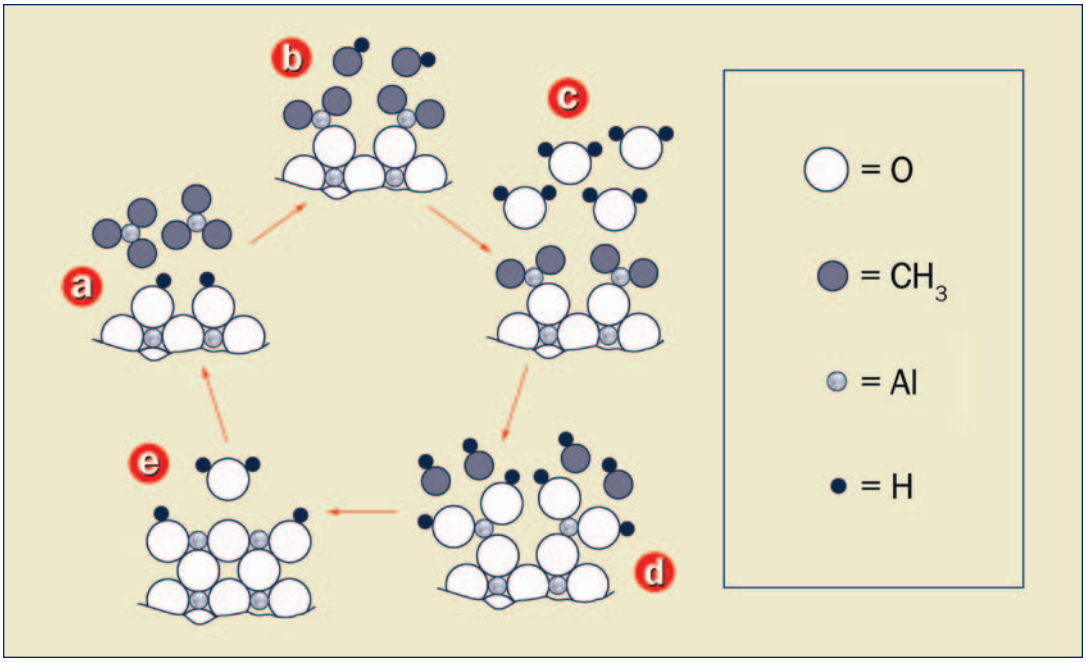

*Figure 1-1: Five-step cycle (**a** through **e**) to produce one monolayer of Alumina ceramic (Al_2O_3) on a surface. Courtesy of Sundew Technologies LLC.*

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Ask the EMPF Helpline!

Corrosion Analysis

Recently, a customer contacted the EMPF helpline to conduct elemental analysis on several assemblies displaying severe corrosion.

The customer submitted several board assemblies that failed in the field and exhibited areas of corrosion in close proximity to onboard components. The most common source of corrosion on electronic assemblies is residual flux. Fluxes are specific chemistries applied during the soldering process which improve the wetting of the solder to both the pad and component when forming the solder joint. They can be highly reactive chemicals that, if left on the assemblies, can lead to corrosion, electrical degradation, and decreased reliability. In the presence of moisture and electrical bias, flux residue can enable dendritic growth as a result of electrochemical migration (ECM).

To establish the source of the corrosion products, the technical data sheets and materials safety data sheets (MSDS) can be used to help evaluate the chemistries of the approved fluxes. The cleaning process is also evaluated to assure the efficacy of cleaning the fluxes used in the manufacturing process. Furthermore, by establishing a correlation between the composition of the residues and the flux chemistries, one can eliminate or confirm the source of the corrosion. Analysis of the residues may be accomplished by employing scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDS).

The introduction of chemistries promoting the advancement of corrosion in electronic assemblies may appear paradoxical. However, with the selection of a proper flux and effective cleaning processes, any impact upon performance and long term reliability can be effectively negated. An abundance of flux types are currently available. IPC standard J-STD-004B characterizes flux by type; Rosin (RO), Resin (RE), Organic (OR), and Inorganic (IN) which are described further in the IPC standard. Flux activity is also designated by the degree of its ionic and corrosive actions (Table 2-1). A halide-free flux providing adequate soldering performance with low residue levels may appear ideal. However, flux selection may rely on board type, material compatibility, standard specifications, component mounts, and solderability. IPC CH-65A is the "Standards and Guidelines for Cleaning of Printed Boards and Assemblies" and states; "Cleaning operations after soldering should be chosen on the basis of degree of cleanliness required, type of flux residue to be removed, and accessibility of this residue to cleaning solvents."

Flux Type	Activity
L0 and L1	Low or no flux/flux residue activity
M0 and M1	Moderate flux/flux residue activity
H0 and H1	High flux/flux residue activity

Table 2-1: Flux types are identified using a 0 or 1 to indicate the absence or presence of halides.

Optical microscopy was used to obtain images of the white residue (Figure 2-1) and green residue (Figure 2-2) observed on the assembly and its components. SEM/EDS can provide a qualitative representation of these residues using high magnification microscopy in conjunction with EDS for quantitative purposes. Analysis revealed the white areas of corrosion to be consistent with tin chloride residue (Figure 2-3) and the green areas to be consistent with copper chloride residue (Figure 2-4). These residues may form when copper and tin react with chloride ions, which likely came from an aggressive flux that had an extended exposure time on the assembly. Carbon, nitrogen, and oxygen also were present in both residues and are typical organic components of the flux. A review of the technical data sheets for the flux materials used in the manufacturing process referenced the use of L0 materials. L0 materials are halide free and were neither the source of the chlorides nor the cause of the residue. Further review of the materials revealed an aggressive flux was also used in the selective soldering process. The designator ORH1 indicates the highest flux activity level in the OR category and halide concentrations greater than two percent. It is likely this flux is the source of the chlorides and the cause of the residue.

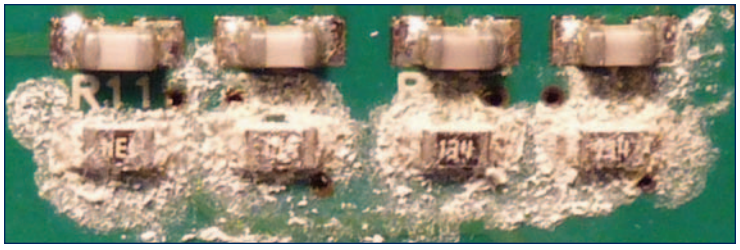

Figure 2-1: Optical micrograph of white residue residing on components.

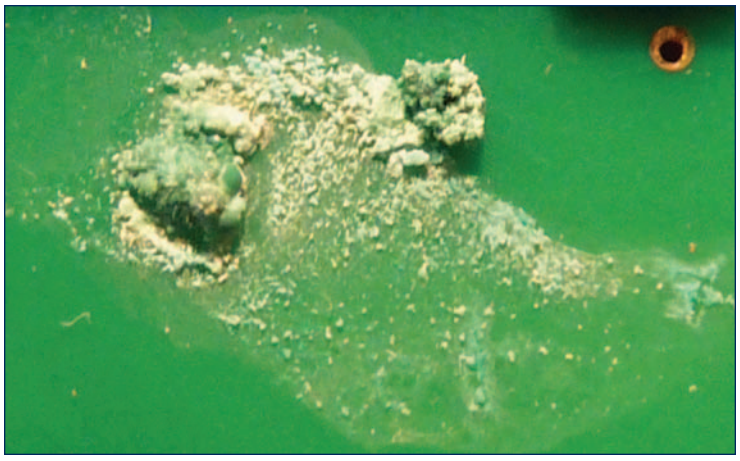

Figure 2-2: Optical micrograph of green residue residing on board assembly.

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One of the most critical factors in preventing corrosion from occurring in electronics is maintaining the state of cleanliness. This is not an easy feat to achieve. Corrosion is defined as the deterioration of a material or its properties due to a reaction of that material with its chemical environment.[1] So, to prevent corrosion from occurring, either the material or the chemical environment must be adjusted. Adjusting the material usually means application of a protective coating or replacing a more reactive material with a less reactive material. Adjusting the chemical environment usually means removing ionic species through cleaning, and removing moisture, usually with a conformal coating or hermetic package. Ionic species and moisture are problematic because they form an electrolyte which is able to conduct ions and electricity. Any metal that comes into contact with the electrolyte can begin to corrode.

Several types of corrosion can commonly occur on electronics assemblies.

Gas Phase Corrosion

Some of the metals used in electronics assemblies, such as copper, nickel, and silver, are susceptible to gas phase corrosion. In the cases of copper and nickel, the metals react with oxygen in the air to form a thin oxide layer and an unsolderable surface. This is why surface finishes are used in electronics assemblies. They serve as protective coatings by preventing the copper from oxidizing and retaining a solderable pad on a bare board. One of the surface finishes, immersion silver, is able to protect its underlying copper, but the silver itself is susceptible to attack from sulfur-containing materials and gases in the atmosphere, leading to tarnish (Figure 3-1). Prevention of exposure to sources of sulfur is key to preventing tarnish from occurring. Sulfur is found in air pollution, rubber bands, latex gloves, desiccant, and sulfur bearing paper used to separate parts.

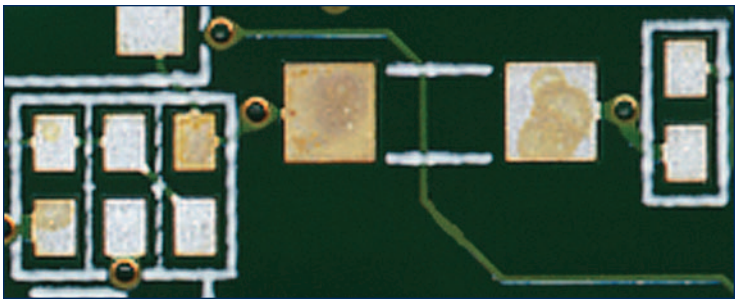

Figure 3-1: Areas of tarnish on a board with an immersion silver finish.

Uniform Corrosion

Uniform corrosion is evenly distributed across the surface with the rate of corrosion being the same over the entire surface (Figure 3-2). One way to determine the severity of the corrosion is to measure the thickness or penetration of the corrosion product. Uniform corrosion is dependent upon the material's composition and its environment. The result is a thinning of the material until failure occurs.[2] Uniform corrosion can be mitigated by removing or preventing ionic residues and preventing moisture.

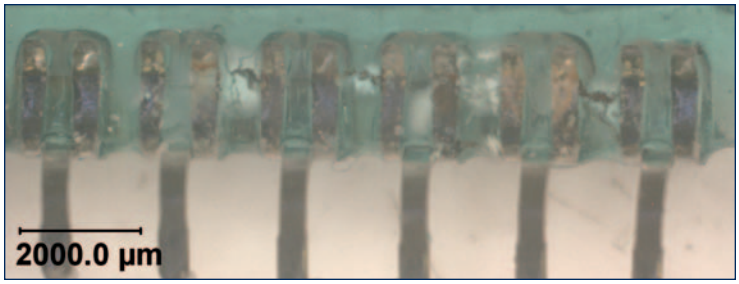

Figure 3-2: Uniform corrosion observed over all of the metallic surfaces.

Pitting Corrosion

Pitting corrosion is a localized form of corrosion where the bulk material may remain passive, but pits or holes in the metal surface suffer localized and rapid surface degradation (Figure 3-3). Chloride ions are notorious for forming pitting corrosion and once a pit is formed, the environmental attack is autocatalytic,[3] meaning that the reaction product is itself the catalyst for the reaction. Pitting corrosion can be mitigated by removing or preventing ionic residues and preventing moisture.

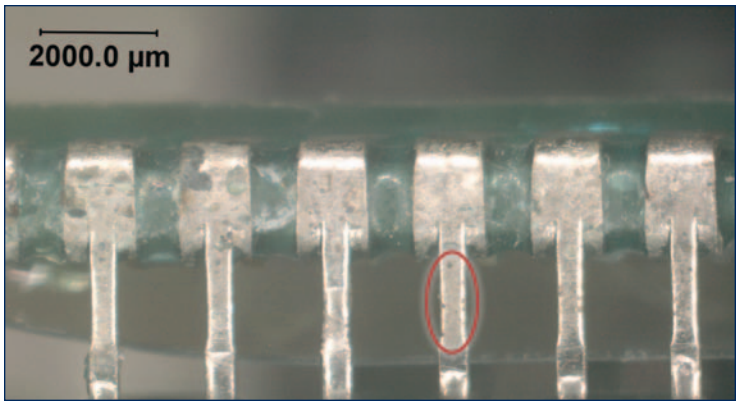

Figure 3-3: Pitting corrosion observed along the pins of the component.

Electrolytic Metal Migration

In the presence of moisture and an electric field, electrolytic metal migration occurs when metal ions migrate to a cathodically (negatively) charged surface and form dendrites. The dendrites grow and eventually bridge the gap and create an electrical short. Materials susceptible to metal migration are gold, silver, copper, palladium, and lead. These metals have stable ions in aqueous solution that are able to travel from the positive electrode (anode) and deposit on the oppositely charge negative electrode (cathode). Less stable ions, such as those of aluminum, form

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Tech Tips: Thermal Interface Materials Testing

High performance heat exchangers are used to lower the operating junction temperature of power devices so that their steady state output, as well as their short duration on demand output, is significantly improved. Use of better thermal interface materials were evaluated using a test vehicle similar to an actual design. While the thermal conductivity of thermal interface materials (TIMs) are always reported by the manufacturer, the value alone is not sufficient to determine which TIM would be better for any particular application. Other parameters may also affect the thermal resistance, thereby influencing the effectiveness of the heat transfer as much, or more than just the thermal conductivity of the TIM. The interface surface roughness, wettability, area, and pressure all affect how well a TIM performs in a particular application. While the manufacturer tests and reports a value of thermal conductivity using optimal conditions for their material, actual use of the material may provide substantially different results. By manufacturing a test vehicle modeled from an actual application, most of the interface parameters can be held constant and the cooling effectiveness of different TIMs can be directly compared and contrasted.

This test vehicle design uses a thermal interface material between the heat source and the coldplate (Figure 4-1).

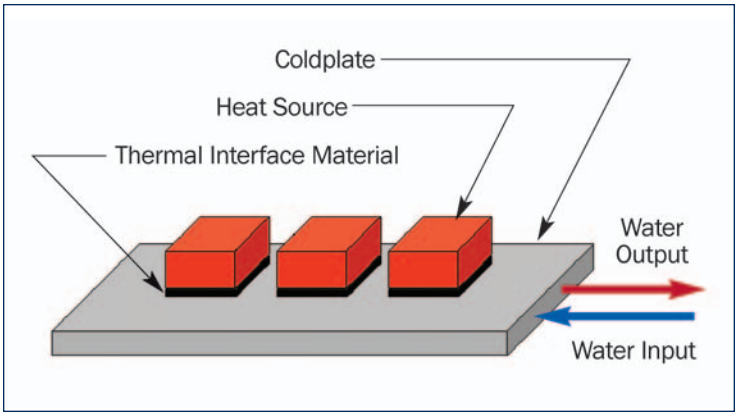

Figure 4-1: Test Vehicle Design

Fourier's Law states that the flow of heat is proportional to the temperature gradient and the cross sectional area normal to the heat flow direction. For a one dimensional heat flow at steady state, this can be expressed as:

$$Q = (k\,A\,\Delta\,T) / L$$

where: Q = Heat flow (Watts)

A = Effective area of heat transfer (m^2)

k = Thermal conductivity (W/m°C)

ΔT = Temp difference between heat source (T1) and heat sink (T2) = T1 - T2 (°C)

L = Length of heat transfer path (m)

The thermal conductivity (k) is an intrinsic property of how the bulk material internally conducts heat. It is not dependent on the size or shape of the material and more importantly, does not include any effects from the thermal interface.

Thermal resistance (R) is not an intrinsic material property and should be determined for each configuration according to this equation:

$$R = \Delta T/Q\ (°C/W)$$

Thermal resistance more accurately predicts thermal performance than thermal conductivity since the affects at the thermal interface are not ignored.

When two surfaces are mated under pressure, the contact is not perfect, even for highly polished flat surfaces. Surface irregularities prevent intimate contact of large areas between the mating surfaces. Solid contacts only occur between the high points of the two mating surfaces leaving a large number of voids between the low lying areas. Most of the heat transfer takes place via these solid contact points, but is restricted since the contact areas are very small. Heat transfer also occurs through the air entrapped in the irregular voids, but is extremely low since the thermal conductivity of air is very low compared to the metals that are in direct contact. In order to eliminate the air gaps and improve thermal transfer, a thermally conductive material is used. This material conforms to the surface peaks and valleys and displaces the air, providing more area for heat to flow and reducing the thermal resistance of the interface.

The thermal resistance at the interface is usually much greater than the overall bulk resistance of the two mating bodies and therefore provides the biggest barrier to increasing the heat transfer rates. This thermal resistance between two heat conducting surfaces depends on several factors such as:

- Geometry/flatness
- Surface finish of mating surfaces
- Hardness
- Modulus of elasticity
- Contact pressure
- Thermal conductivity
- Length of heat conducting path

There are four primary parameters that can be changed to enhance the conducted heat flow rate of any system (k, A, ΔT, and L). Once a suitable material with high thermal conductivity is selected, the other three parameters can be improved to enhance the heat removal rate.

To increase the effective area of heat transfer (A), the voids created by the imperfect surfaces must be filled with suitable highly conductive thermal interface materials. Many different approaches have been adopted by the industry to fill in these voids. Thermal greases, soft metal films, soft metal plating, better machining, and surface finishing techniques are some of the commonly adopted approaches.

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Manufacturer's Corner: Equipment Advisory Board

Part of the mission of the EMPF is the continual demonstration of advanced technology in electronics manufacturing. This is accomplished in several ways, but none more effectively than through the strategic partnerships which enable the EMPF to showcase manufacturing equipment from some of the world's most advanced manufacturers (Figure 5-1). This partnership arrangement is referred to as the Equipment Advisory Board or EAB.

The EAB has been a cornerstone of the EMPF almost from its inception. Not only does it enable the EMPF to highlight different aspects of manufacturing technology to over one thousand visitors each year, but through upgrades and expanding capabilities, it represents different levels of technology and methods.

The EAB is an evolving membership board that shares the mission to continually bring advanced methods of manufacturing technology to all who interact with the EMPF. Member companies have provided equipment for X-ray analysis, microscopy, automated optical inspection (AOI), rework, cleaning, selective soldering, wave soldering, conformal coating, wire bonding, adhesive dispensing, two lines of surface mount technology (SMT) production, and other analytical tools.

Figure 5-1: The demonstration factory at the EMPF showcases some of the world's most advanced equipment from leading-edge manufacturers.

The EMPF is the perfect venue to see the industry's most advanced, cutting-edge electronics manufacturing machinery and processes in action.

This community of technology partners is not exclusively for the use of the EMPF, but for demonstrations, workshops, trials, and ways to improve processes and line development. The EAB partners consist of Samsung, BTU, DAGE, YesTech, SPEA, RPS Automation, PACE, Vision Engineering, Technical Devices, Aqueous Technologies, Asymtek, Metcal, Tamura, Focal Spot, ORAFEC, and so many more.

The EMPF is the perfect venue to see the industry's most advanced, cutting-edge machinery and processes in action.

These partners have generously provided their equipment to the industry, knowing that readers of the *Empfasis*, visitors to our facility, and viewers of our website will have exposure to their unique apparatus. Not only do EAB partners demonstrate the complete, specialized capabilities of their equipment during pre-scheduled tours and meetings, but also at free, monthly workshops. These open house style events allow different manufacturing technologies to be discussed in detail. The "lunch and learn" format is sponsored by our EAB partners with the goal of sharing their expertise in their given field. Questions regarding the capability of a piece of equipment can be answered using your own board at the EMPF.

For more information or to schedule a demonstration of any piece of equipment from any of the EAB partners, contact the EAB Coordinator, Ken Friedman, at 610.362.1200, extension 279 or via email at kfriedman@aciusa.org.

Ken Friedman | EAB Coordinator

J-STD-001 Recertification and Challenge Test

The EMPF, an authorized training provider, offers IPC certification to our J-STD-001 customers. Recertification and Challenge Testing are time-saving classes developed by the IPC for students with a previous certification, or a high level of comprehension of the standard. Technical trainers, process engineers, manufacturing supervisors, and lead technicians who have been previously certified, are eligible for recertification.

Both recertification and challenge testing are abbreviated versions of the initial certification. The Certified IPC Specialist (CIS) recertification modules one through five (both lectures and workmanship) are covered in half the time. Inspection criteria for the three production classes are reviewed by the instructor. Guidelines for tools, equipment, surface mount device (SMD) placement, plated through-hole (PTH) component mounting and process compatibility are reviewed. CIS classes are taught by either a Certified IPC Trainer (CIT) or a Master IPC Trainer (MIT). CIT recertification classes run for two days and are taught by an MIT. The course reviews the assembly processes, soldering processes, coating and encapsulation, rework and repair, defects and process control, and other technical requirements of the J-STD-001. Like the initial certification, all IPC recertifications are good for two years and are valid through the last day of the month, no matter what day the certification was granted.

Challenge testing is available to both CIS and CIT students. CIS challenge testing is performed on a module by module basis. Module one covers general requirements, materials, components, cleanliness, assembly and soldering processes and is a prerequisite for modules two through five. Module two tests include wrapping, soldering, and inspection of connections to terminals. Module three tests knowledge pertaining to installation, soldering, and inspection of components in plated through holes. Module four tests include mounting, soldering, and inspection requirements for surface mount components. Module five tests knowledge of the J-STD-001 inspection criteria. Challenge testing for CIS students is also available for the workmanship and inspection portion. CIS students must earn an average passing grade of 70% on an open and closed book test for module one. Every other module has an open book test where 70% is passing as well.

Challenge testing for CIT students involves one day of testing with no review from an instructor. An average grade of 80% must be earned to pass the written test after which the workmanship and inspection test is given. Challenge tests for CITs must be proctored by a MIT. CITs may only challenge test for J-STD-001 if they are currently or previously certified as a CIT in J-STD-001.

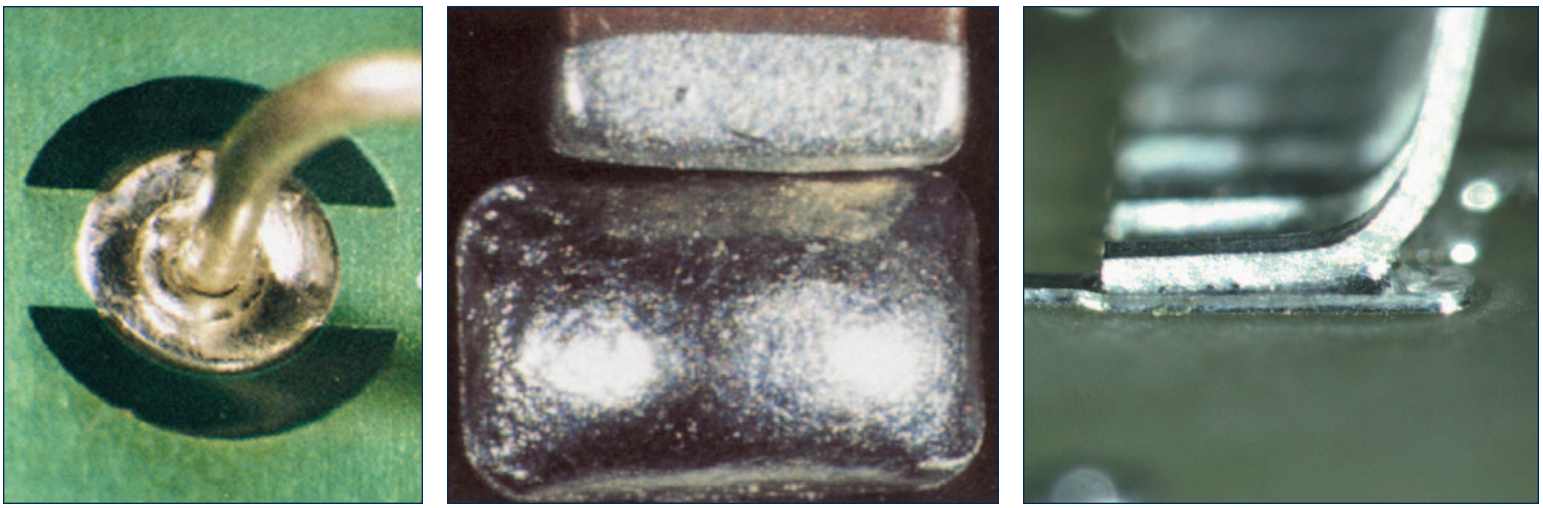

Figure 6-1: Examples of solder defects. Images courtesy of IPC.

Recertification classes can be scheduled up to 90 days before the certification is set to expire. The new certification will still expire two years from the old expiration date, not from the day you take the test. If scheduling problems delay a timely recertification, a CIT may grant a CIS a ninety day extension without having to report this to the IPC. If a CIT has a delay, the IPC may grant an extension of up to ninety days. The new certification's expiration date will reflect the original recertification date if extensions are granted.

The EMPF offers IPC certification courses, electronics manufacturing skill-based classes, lead free manufacturing and customized curriculum. Call the Registrar at 610.362.1295 or visit www.aciusa.org/courses for more details.

Ken Wolfson | Technician/Instructor

Atomic Layer Deposition

(continued from page 1)

Figure 1-1 shows a typical ALD cycle for deposition of Alumina (Al_2O_3) ceramic on an aluminum starting surface. The five-step cycle shown is continuously repeated once for each "atomic layer" of Al_2O_3. Tri-methyl aluminum is the first reactant gas introduced and water vapor is the second, resulting in one "atomic layer" of Al_2O_3 per cycle.

The ALD process is so attractive due to its ability to uniformly coat drastically non-uniform surface geometries. By introducing only one reactant at a time, the ALD process is self-limiting, allowing the reaction to create only one layer of deposited film material by using all the reactive sites on the starting surface. No further reaction can take place because there are no reactive sites left and only one reactant gas is present. Once the reaction chamber is flushed clean of the first reactant, the second reactant is introduced into the chamber, and in turn reacts with the surface until all reactive sites are used. This process cycle is then repeated, depositing one layer of reaction film product per cycle. Because of its inability to deposit any more or less than one molecular layer of reaction product per cycle, ALD cannot deposit excess or insufficient film product at non-uniformities (corners, edges, or holes) in the geometry of the object being coated.

For instance, it is very difficult to electroplate a uniform thickness of copper in the middle of a plated through-hole with an aspect ratio of 10:1 (printed wiring board thickness to hole diameter). Because of its self-limiting effect, aspect ratios of 1000:1 can be ALD coated with precise film uniformity. This is especially useful in coating complex geometries on Integrated Circuit (IC) chips, such as "air bridge" structures on Monolithic Microwave Integrated Circuits (MMIC) for Radio Frequency (RF) applications.

The unique ability of ALD to provide a uniform coat of very thin ceramic, organic, or metal films onto very non-uniform geometries is put to good use in many critical applications. The excessive build-up of reactant product at edges, steps, and other surface discontinuities common for many other liquid dip, spray, chemical vapor deposition, or electroplated deposition techniques, can be avoided by using ALD as the coating process. This is especially important in RF applications where excess coating can degrade RF electrical performance. The more uniform ALD coating can provide a better electrical performance.

Typically, ALD coatings will be deposited in several hundreds or thousands of cycles, one reactant gas in the chamber at a time, and one layer of reaction product per cycle. A common application might deposit 1000 monolayers of a compound in 45 minutes and 1000 cycles.

Since ALD coatings are often ceramic materials, the possibility exists to obtain a truly hermetic seal on coated electronic assemblies. Formerly, this hermetic seal could only be obtained by enclosing the electronics in a heavy, bulky, glass-and-metal lidded hermetic cavity enclosure. ALD coating may provide an equivalent hermetic seal with a lighter and less costly process.

Finally, a ceramic ALD coating could mitigate tin whisker growth when applied to lead (Pb)-free electronic assemblies having pure tin plated components. The EMPF is currently engaged in a Small Business Innovative Research (SBIR) project to investigate this new coating alternative.

Fred Verdi | Senior Manufacturing Engineer

Upcoming Courses

IPC J-STD-001

February 1-5 | Certification

This course provides an in-depth study and hands-on application of the national standard for soldering as well as all materials necessary to conduct operator training.

IPC A-610

February 8-11 | Certification

Achieve the highest quality and most cost-effective productivity by knowing how to correctly apply the IPC A-610 acceptability criteria.

CONTACT THE REGISTRAR VIA:

phone at **610.362.1295**, email at **registrar@empf.org** or online at **www.aciusa.org/courses**

Ask the EMPF Helpline!

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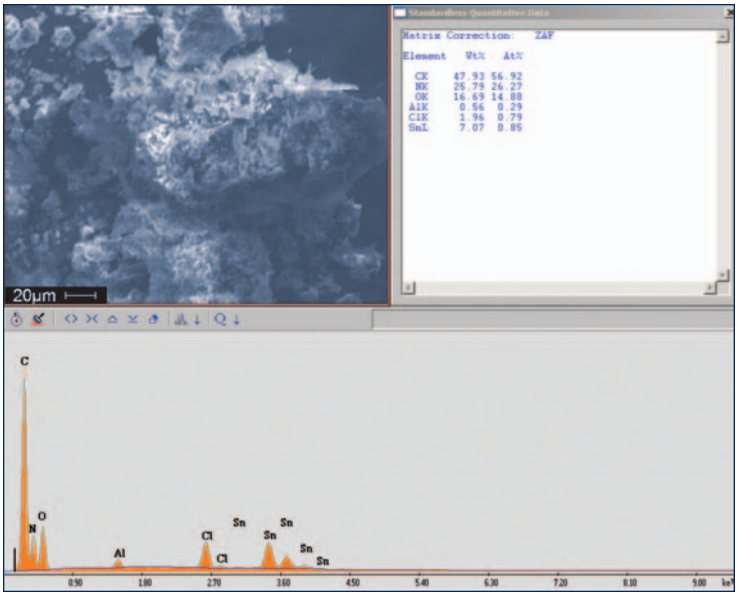

Figure 2-3: SEM image of white residue removed from assemblies. EDS confirmed the presence of tin and chlorine suggesting a tin chloride residue. The carbon, nitrogen, and oxygen are typical for the organic components in flux.

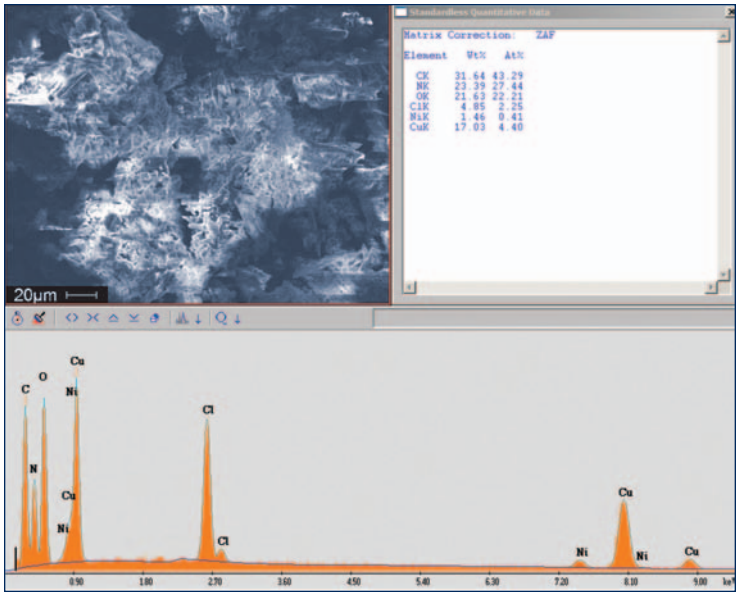

Figure 2-4: SEM image of green residue removed from the assembly. EDS confirmed the presence of copper and chlorine suggesting a copper chloride residue. The carbon, nitrogen, and oxygen are typical for the organic components in flux.

Chloride remaining on the assemblies after exposure to H1 fluxes is common. When combined with moisture and electrical bias, the presence of these chlorides is instrumental in corrosion. An assembly properly cleaned and rinsed after reflow can effectively eliminate the remaining halide fluxes, removing any ionic species necessary for corrosion. Manufacturing processes must also be thoroughly reviewed. This ensures that non-approved materials which may lead to reliability issues such as the corrosion residues observed on these assemblies are not applied.

The EMPF offers a variety of analytical instrumentation and techniques to aid in failure analysis and identification of corrosion residues. The EMPF can further assist with cleaning processes and cleanliness testing for ionic residues, as well as failure analysis, inspection, and engineering services. Ion chromatography, ionograph testing, Fourier Transform Infrared (FT-IR), and SEM/EDS capabilities are all on hand to aid in the determination of possible contamination issues and their root causes.

Ron Sauro | Chemist

Call the EMPF Helpline!

A direct connection to electronic manufacturing support.

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hydroxides or hydroxyl chlorides in the presence of high humidity and chlorides. An example of a copper dendrite is shown in Figure 3-4. Electrolytic metal migration can be mitigated by removing or preventing ionic residues and moisture.

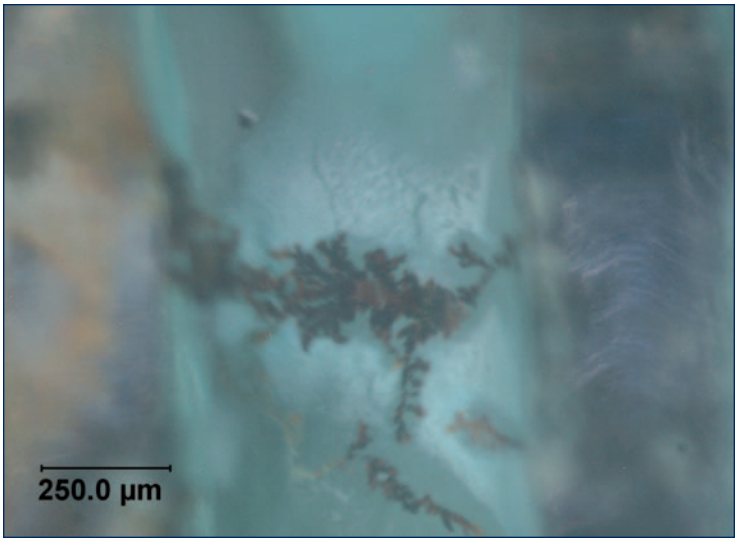

Figure 3-4: Dendrite that grew between two pins and surrounded by salt residue.

Galvanic Corrosion

Galvanic corrosion occurs when two dissimilar metals come in contact with one another or are connected through a conductive medium such as an electrolyte. A soldered joint is a composite system where many different materials are connected. Within the joint or between joints and other conductive circuitry, dc circuits can be established that will corrode the most anodic material.[4] When ionic species are present, such as flux residues and moisture, an electrolyte can form. The corrosion at the metal forming the anode will accelerate, while the corrosion at the cathode will slow down or stop. In a poorly deposited ENIG surface finish, a porous immersion gold layer exposes the underlying electroless nickel. The large difference in electrochemical potential between the nickel and gold causes corrosion of the nickel layer, while the gold acts as a powerful cathode. As the corrosion proceeds, pitting of the nickel can extend into the underlying copper and cause further corrosion. If there is no porosity in the gold layer, but instead, a gap between the metallic component and the resist edge, the metallic layers can be exposed to solution allowing galvanic corrosion.[5]

Table 3-1 is a listing of metals in order of their relative activity in sea water (the Galvanic Table from MIL-STD-889, Dissimilar Metals). The listing displays metals from more active (anodic) to less active (cathodic). Generally, the closer the metals are to one another in the listing, the more compatible. However, in any combination of dissimilar metals, the more anodic metal will preferentially corrode. To prevent galvanic corrosion, careful selection of adjacent materials must occur in the design phase. To mitigate galvanic corrosion from occurring in the field, an electrolyte must be prevented from depositing on any connection of dissimilar metals.

Summary

Corrosion can be mitigated by preventing electrolytes from forming. This is accomplished by ensuring that any ionic residues are removed after the component, bare board, and assembly manufacturing, as well as preventing salts from depositing on the assembly from extreme environmental conditions. Moisture can be prevented on electronics assemblies by using a conformal coating or hermetic package. Also, materials selection in the design phase is important so that metals with dissimilar electrochemical potentials are not directly connected. If dissimilar metals must be used, such as when using specific surface finishes, like ENIG, then ensuring good bare board construction is a critical step in reliable, corrosion free electronics.

More Active (Anodic)		
1. Magnesium	8. Copper (plated, cast, or wrought)	15. Molybdenum, commercial pure
2. Zinc (hot-dip, die cast, or plated)	9. Nickel (plated)	16. Titanium
3. Beryllium (hot pressed)	10 Chromium (Plated)	17. Silver
4. Cadmium (plated)	11. Tantalum	18. Gold
5. Aluminum	12. Tungsten	19. Platinum
6. Tin (plated)	13. Bronze 220	20. Palladium
7. Lead	14. Copper 110	21. Graphite
		Less Active (Cathodic, Noble)

Table 3-1: Material examples from the Galvanic Table.

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Cleanliness/Corrosion Mitigation

(continued from page 9)

References

[1] Bob Stump National Defense Authorization Act for Fiscal Year 2003. Pub. L.107-314. 2 Dec. 2002. Stat. 116.2658.

[2] Craig, B. D.; R. A. Lane, and D. H. Rose. Corrosion Prevention and Control: A Program Management Guide for Selecting Materials. AMMTIAC, 2006: 61. <http://www.corrdefense.org/Key%20Documents/Corrosion%20Prevention%20and%20Control--A%20Program%20Management%20Guide%20for%20Selecting%20Materials.pdf>

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[5] Ambat, Rajan. A Review of Corrosion and Environmental Effects on Electronics. Celcorr - Center for Electronic Corrosion, Technical University of Denmark. <http://www.celcorr.com/paper-DMS.pdf>

Sean Clancy, Ph.D. | Research Associate/Chemist

Upcoming Courses

Design for Manufacturability

February 8-9

The greatest opportunity to influence the cost of new product is early in its lifecycle. See the benefits and consequences of decisions made at the design level while assembling and processing a demonstration printed wire assembly. Through lecture and factory experience, develop effective DfM programs for your own facility.

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March 15-17

This course features both lecture and lab sessions. Learn the latest analytical methods to troubleshoot from manufacturing and laboratory perspectives. Content includes the latest information on lead-free solder, x-ray fluorescence, RF plasma etching and micro-probing of integrated circuits.

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February 22-23

Electronic manufacturers must consider new processes, materials and techniques to remove lead from electronic assemblies. This course introduces participants to the technical challenges of developing and implementing lead free soldering into an electronics manufacturing production environment and provides application specific solutions to address issues.

CONTACT THE REGISTRAR VIA:

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Tech Tips: Thermal Interface Materials Testing

(continued from page 4)

An experimental setup was created based on a coldplate's thermal management performance in cooling a simulated semiconductor device.

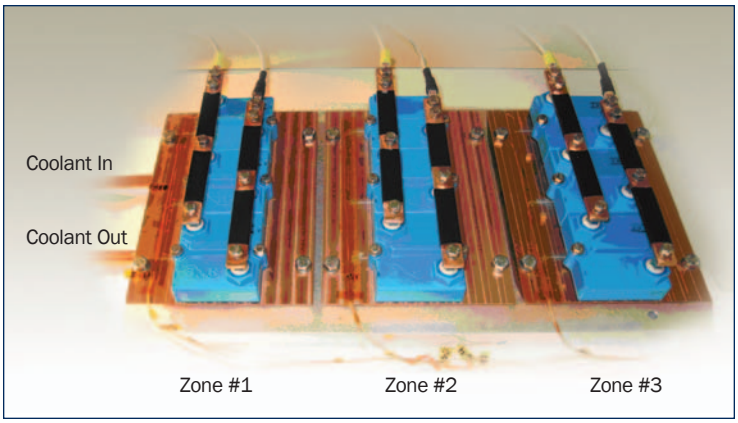

Figure 4-2: Copper tube coldplate with three heating zones.

Instead of using the actual semiconductor device which produces heat during operation, three planar 600 W, 3 Ω resistors were used to simulate the actual power levels predicted (Figure 4-2).

Several thermal interface materials were tested to determine their effectiveness.

- Thermal Greases (2)
- Soft Metal Foil
- Phase Change Metal Alloy (PCMA)
- Thermal Pad
- No TIM

Figure 4-3 shows the temperatures obtained when the best of the TIM materials were tested at the same flow rate, input water temp, and power input. Each TIM has a bar triplet that indicates the temperature at the center of zones 1, 2, and 3 (purple, red, and green, respectively). Under these conditions, the two thermal greases provided similar results, but the testing was sensitive enough to always discriminate one from the other. The soft metal foil TIM was almost as good. This material was developed as a compressible metallic shim for thermal applications under power devices. Rather than being flat, it has an embossed pattern that provides contact with both sides of an interface, even though surface irregularities exist. At the time of these experiments, samples were only available in a two inch width, much narrower than the heat spreader. While placed at the hottest portion of the zone, improved results would be expected if the foil covered the full width of the heat spreader. Also shown in this graph, is the higher temperatures obtained when no TIM was used.

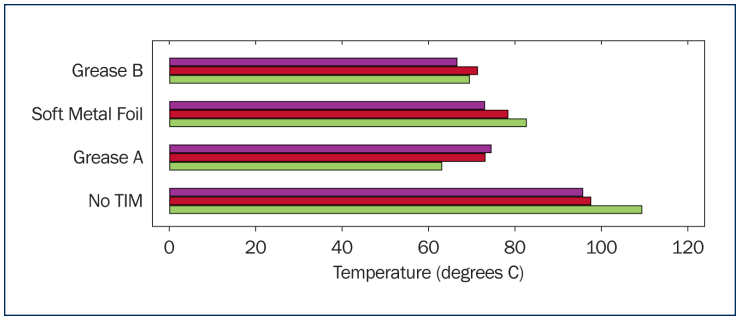

Figure 4-3: Resulting steady state temperatures (at 3000 W, 1.5 gpm coolant flow, 40ºC coolant input) obtained for different TIMs. Temperatures at zones 1, 2, and 3 are indicated by colors purple, red, and green, respectively.

The phase change metal alloy provided a temperature performance similar to the soft metal foil, however, regions of melting and flow occurred that allowed some of the material to move out of the interface. To properly test this material, the experimental design would need modifications to keep the TIM in place.

The thermal pad material produced the highest temperatures, but was the only TIM that was not maintained at a 0.004 inch bondline. Since it is constructed with three 0.002 inch layers (thermal grease/aluminum/thermal grease), the resulting bondline was greater than the other TIMs. The higher heat transfer path length resulted in a lower heat flow.

Fine differences in performances of thermal interface materials can be experimentally determined if the test vehicle is matched to the actual application. This study indicated that while a standard thermal grease may perform well in a particular application, other TIMs should also be considered. The soft metal foil provided similar thermal control without the careful application processes needed to apply thermal grease. To achieve a uniform coating and repeatable bondline control with thermal grease, an investment in fixturing tools and maintenance is required. The foil offers a more manufacturable, easier to apply, easier to rework, repeatable method for achieving cooling in high power devices.

The EMPF can perform thermal interface materials testing. For more information contact Ken Friedman, at 610.362.1200, extension 279 or via email at kfriedman@aciusa.org.

Paul Bratt | Senior Packaging Engineer

ACI Technologies, Inc.

2010 Class Schedule

National Electronics Manufacturing Technology Center of Excellence

Electronics Manufacturing

Boot Camp A
March 1-5
May 3-7
September 13-17
November 1-5

Boot Camp B
March 8-12
May 10-14
September 20-24
November 8-12

CIS/Operator

IPC J-STD-001
Call for Availability

IPC A-610
Call for Availability

IPC 7711/7721
Call for Availability

IPC/WHMA-A-620A
CIS Certification
February 16-18
April 19-21
June 28-30
September 27-29
December 20-22

High Reliability Addendum

IPC J-STD-001 DS
CIT Certification
January 15
February 19
April 23
May 28
August 20
October 8

IPC CIT Challenge Test

January 29
February 26
April 16
June 18
July 16
August 27
October 15
November 19
December 17
Call for Additional Availabilities

IPC Certifications CIT/Instructor

IPC J-STD-001
CIT Certification
January 4-8
February 1-5
March 15-19
April 26-30
June 7-11
July 19-23
August 30 - September 3
October 18-22
December 6-10

IPC J-STD-001
CIT Recertification
January 13-14
February 24-25
April 14-15
May 26-27
July 14-15
August 25-26
October 6-7
November 17-18
December 15-16

IPC A-610
CIT Certification
January 4-7
February 8-11
April 19-22
June 14-17
August 16-19
October 11-14
December 6-9

IPC A-610
CIT Recertification
January 11-12
February 22-23
April 12-13
May 24-25
July 12-13
August 23-24
October 4-5
November 15-16
December 13-14

IPC A-600
CIT Certification
January 26-28
March 22-24
June 21-23
September 7-9
November 29 - December 1

IPC 7711/7721
CIT Certification
January 25-29
March 22-26
July 26-30
October 25-29

IPC 7711/7721
CIT Recertification
March 8-9
May 17-18
June 14-15
September 13-14

Skills

BGA Manufacturing, Inspection, Rework
January 19-20
April 5-6
June 28-29
October 11-12

Chip Scale Manufacturing
February 16-18
May 26-28
August 11-13
December 13-15

Continuing Professional Advancement in Electronics Manufacturing

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February 8-9
May 24-25
August 9-10
November 22-23

Failure Analysis and Reliability Testing
March 15-17
May 17-19
September 27-29
November 15-17

Lead Free Manufacturing
February 22-23
June 7-8
October 4-5
December 20-21

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