IONIC PCB CONTAMINATION

A NEW VISION ACCORDING TO IPC STANDARDS

In the electronic equipment market, the problem of ionic contamination of the boards themselves (PCBA), even before the printed circuits (PCB) that they support are contaminated, is certainly not unknown, but with the latest revision of the J-STANDARD 001 norm, the technical commissions of the Association Connecting Electronics Industries (IPC) have suggested a new point of view for evaluating the quality of these devices.
But let's take things one step a time.
About 15% of the anomalies on electronic boards occur due to the contamination by processing residues present on the boards themselves. The contamination value represents the set of pollutants present on an electronic system left over from the production processes. When this is an ionic type of residue, it is made up of atoms or molecules /particles, which can dissolve in a water/alcohol solution and become conductive (under certain environmental conditions and/or from using the boards), and therefore likely to create defects in the reliability in future system operations if present in excess.

In terms of electronic device reliability this means that greater attention has been paid to the residual ionic content of the PCBA and the PCBs integrated into them than to other residues.
The ionic compounds that may be present during the production of PCBs and PCBAs include:

- **Generic salts**
- **Organic and inorganic acids**
- **Ethanolamines**
- **Flux activators**
- **Chemical agents derived from metal plating processes (for pcb only)**
- **Human sweat**

Based on the quantity, each of these components induces specific, more or less serious, and non-general contraindications.

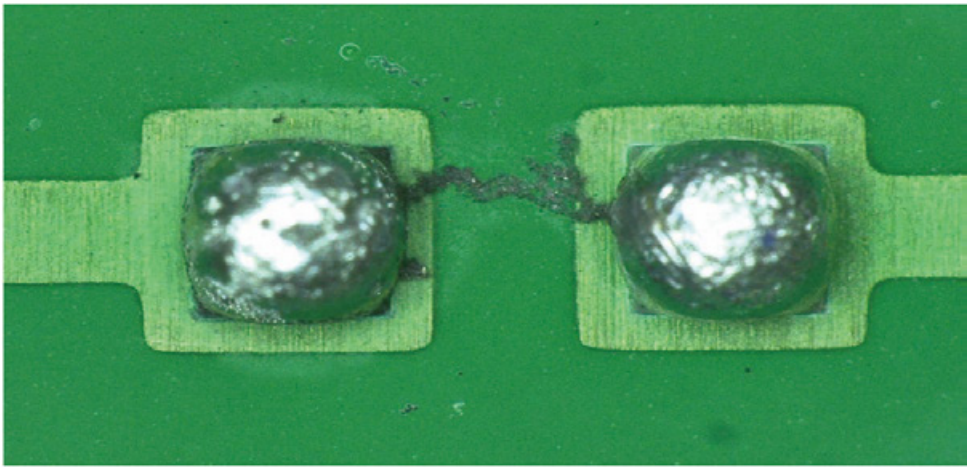
Ionic Contamination on pcba (photo by TechSpray)

When PCB/PCBA manufacturers are unable to remove excess ionic residues (and this occurs for a number of reasons not only related to improper production of the object but also to its design, like the well-identified standards of the IPC 2200 series), the following problems may occur:

Corrosion: corrosion is an electrolysis phenomenon that occurs in the presence of ionic residues and humidity, which are transformed into an electrolyte where the ions are more or less mobile according to their nature, the degree of humidity, and the electronic field to which they are subjected. The mobility of these ions induces an electric current under the effect of these fields, generating an electrolytic reaction that consumes/transforms the metals present. It is also possible to observe a spontaneous reaction, without the presence of electric fields, if two different metals come into contact with the aforementioned electrolyte: in this case it establishes an electrochemical cell which functions as a battery that generates the corrosion of the metals.
In both cases, part of the metal conductors on the board will be extremely weakened, in terms of conductivity, in less time than normal due to the presence of these residues which, in contact with the humidity in the environment, "flake off" on the metal parts (but not only). This generates corrosion, and, in the medium-to-short term, the consequent interruption of operation (due to lack or discontinuity of electrical conductivity). For example, the presence of dry acid residues from PCB processing can trigger the corrosion of the copper which makes up the conductive sections of the PCB itself.

Conductor corrosion on PCB (photo by EDN)

Dendritic growth: when ions are present between the metal conductors (those even partially exposed to the environment) and in certain electric field situations, dendritic growth occurs. In practice, conductive metal flakes are generated by the polarization of the ions themselves, which can lead to short circuiting the conductors of the apparatus themselves (electric bridge). The effect of the electric fields between the conductors themselves affects the position of the residues, creating lightning-like constructions. These deposits then function as conductive saline bridges which facilitate current leakages and therefore corrosion, and insulation loss between the metal parts involved.
For example, dendrites can appear more quickly when the residues of the fluxes used in soldering are excessive, or when their alkaline agents are not completely deactivated.

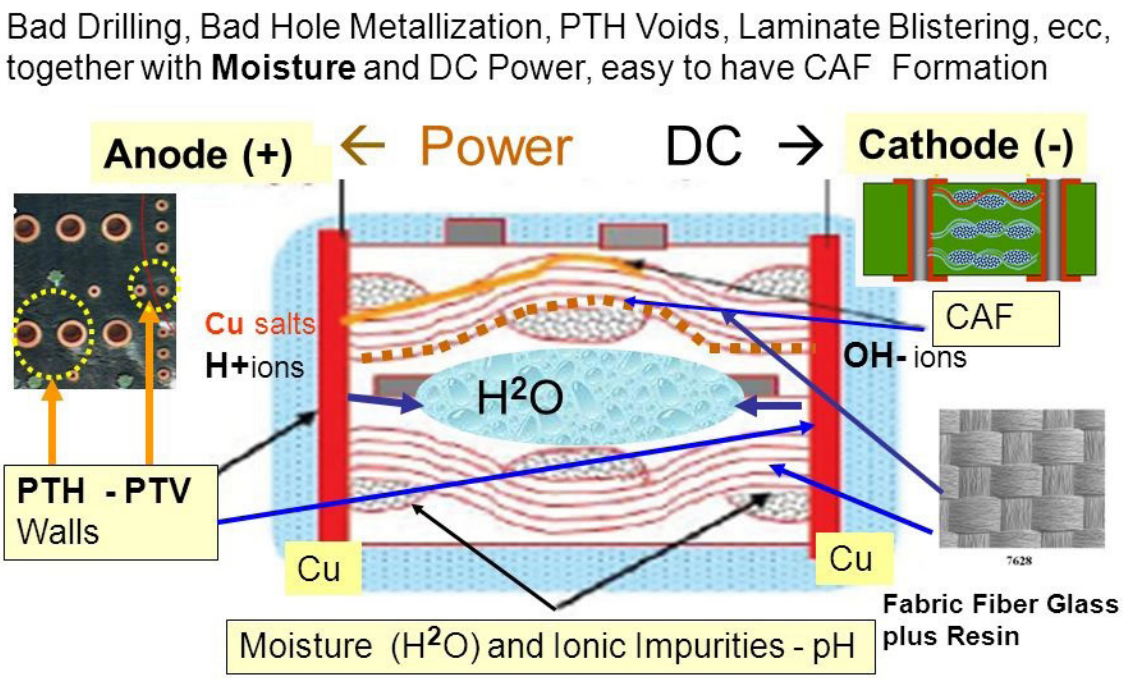


Dendritic growth on pcba (photo by Tamura Corporation)

Loss of insulation/Residual conductivity: the presence of surface ionic residues between the conductors may not only lead to dendritic growth, but also allow an albeit limited electrical conductivity between metal parts, the which must be perfectly isolated (infinite electrical resistance) to work properly. Such losses of insulation, or sources of low electrical conductivity if you prefer, will not necessarily be easily detected or easily assessed flaws in the functioning of the systems, but they will certainly lead to electrical dispersions during operations which can only be easily explained by measuring the ionic contamination, or, less easily, by measuring the surface insulation resistance.

Electrochemical migration: electrochemical migration like dendritic growth, is a source of intermittent failures or short circuits. Unlike dendrites (which are superficial), electrochemical migration leads to the development of ionic conductors even through dielectric material. In practice, since dendrites are formed by conductive ions, they can direct the currents in the opposite direction of the PCB design, thus generating an electrochemical migration (think of the CAF anomalies). Dendritic growth and electrochemical migration are closely related to each other and tend to occur at the same time.

Conductive Anodic Filament **CAF**



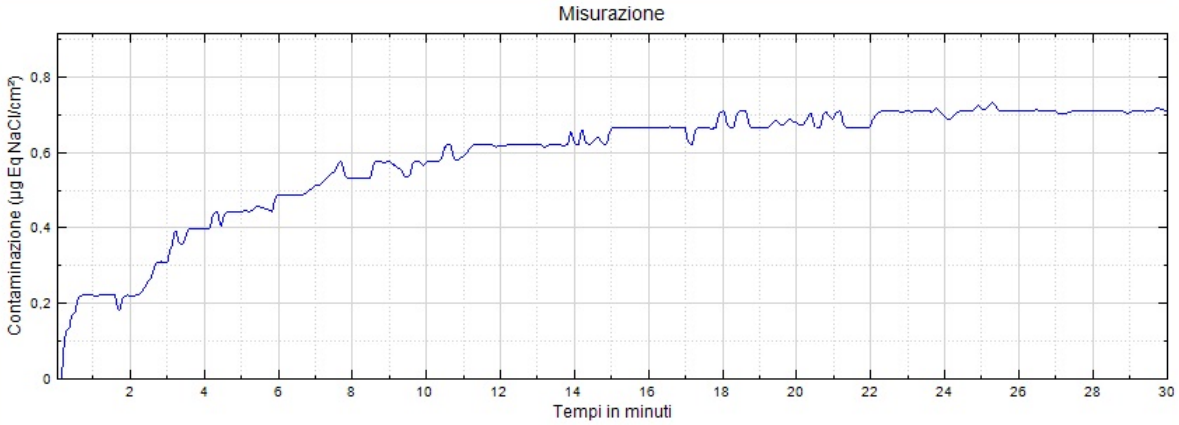
CAF formation

To ensure that the ionic residues do not reduce the life of the PCB or compromise its assembly/soldering, it is typical for printed circuit board companies to use cleaning processes (specifically dedicated washes) as standard steps in the production process. It is not so usual, however, to run eventual evaluation tests for residual ionic contamination after such washes, but when they are implemented they allow manufacturers to determine if they are using adequate cleaning techniques, or if the pcb has been designed and manufactured with a customer specification that take these aspects into account, and what the state of the pcb is at the time of shipment (at least in quantitative, though rarely qualitative terms).

In **Alba PCB Group** there is a specific procedure that provides for these tests both in terms of checking processes on standard patterns and for checking the lots produced, even for those PCBs coming from non-EEC regions.

The so-called ROSE (resistivity of solvent extract) is quite common among these tests. In practice the product to be evaluated is immersed in a "solvent" liquid (75% solution of pure isopropyl alcohol and 25% demineralized water with max 18 Mohm- nominal resistivity) at a temperature of 25 ° C for 60 minutes; in this way the PCB releases its ionic pollutants into the solution, increasing the electrical conductivity. This is then measured by suitable instrumentation identifying an ionic contamination in terms of content in micrograms of equivalent salts. By re-proportioning the measured value with respect to the size of the object being tested, the contamination value is found in terms of NaCl equivalent on cm^2. This test is typically performed by means of a single apparatus called Dynamic Ionograph and regulated by the IPC TM650 standard 2.3.26.

The Alba PCB Group uses an ionograph of the latest generation, which allows evaluation in less time. The apparatus adopts a system of forced movement for the solution which does not allow the solution to reconvert during the length of time it is being measured (limit of the classic dynamic system which then needs to integrate the results). This allows the concentration of the saline solution in less time (suggested 15min).



Ion contamination control graph using a 30-minute dynamic Ionograph adopted by Alba

The same thing has been indicated as mandatory by PCBA standards, for which washing, although possible, has been gradually abandoned with a view to using No Clean soldering products.
In the past, IPC technical teams indicated in the J-STD 001 that the ROSE test applied to electronic boards with a maximum limit of 1.56 µg /NaCl equivalence/cm^2 was qualified for a process aimed at obtaining an apparatus of adequate reliability, without evaluating the type and quantity of the individual contaminants present. Nothing was indicated for PCBs without components except for the same value, but verified before the drafting of the solder resist (see IPC 6012 3.9.1), reduced to 0.75 µg/NaCl equivalence/cm^2 in the case of products for the automotive market.
Reliability experts say that about 15 percent of PCBA failures are due to contamination of the bare PCB board and that only an estimated 2 percent of contaminated PCBs that are sent back to the manufacturer for cleaning. This is largely due to a basic misunderstanding about the correlation between PCB contaminants, PCBA and product failures. For this reason, for its PCBs ,the Alba Elettronica Group generally adopts the value of 1.0 max per finished product in the absence of a different customer specification, although on average, the measurement is much lower in value. These surveys are performed weekly on the internal production process to better monitor any drifts in the PCB washing and cleaning systems that have been adopted.

Let's get to the point (the new legislation under discussion)
With the release of the new revision of the J-STD 001G this point of view becomes outdated. Certainly the measurement of the overall residual ionic content is still a good indicator of the level of cleanliness of the PCB and PCBA (for this reason the Alba Elettronica Group will continue to regularly carry out this type of testing on its PCBs with Dynamic Ionographs), but this is no longer the value that unequivocally attests that this is, or may or may not be, a problem.

On the other hand, an **ion chromatography** test could give more indications about the components and their potential anomalies, but given the costs it is difficult to apply, except in cases of serious anomalies already present (when perhaps it is already too late for interventions). In practice, the above test uses extraction methods in a medium temperature solution similar to the ROSE test, except that it subjects the extracted solution to a chromatographic (and not conductivity) verification which provides information on the specific spectrum of each substance present in the solution, thereby allowing partial identification.
This matter is undergoing a great deal of discussion by the various commissions of the IPC and there will certainly be important implications in the near future: Alba's technical staff is at your disposal for any clarification you may need.