Ormet Circuits, Inc.

Ionic Contamination of Ormet Materials

<u>Task Summary:</u> This task is to determine the levels of ionic contamination in sintered conductive compounds and analyze the contributions from raw materials, processing and various environments. Standard testing is to be used while evaluating whether the materials posses a corrosion risk in electric applications.

<u>Background:</u> Corrosion of electronic devices remains a failure mode worthy of careful attention and action. Everyday corrosion works its slow destruction on water heaters, bridges, cargo ships, jewelry, batteries, power plants and microelectronic devices. Methods and tools for prevention and slowing this destruction are in high demand. One of these methods used extensively in the microelectronics industry is the determination of corrosion ions introduced through electronic materials of all types. This introduction to the electronic assembly can be through the original materials and/or through the process prior to final completion of the assembly. Various well-developed methods are employed to determine the levels of these corrosive ions in electronic materials and products. These methods vary with the particular materials to be evaluated but fundamentally all determine levels of mobile ions ready to corrode and make defectives in electronic devices.

The test methods all extract the mobile ions from the electronic material into pure water and then evaluate the levels of various ions in the solution as compared against carefully prepared standard solution, thereby determining the ion concentrations for the electronic materials. Various methods existed for extracting the mobile ions depending of the materials, process and sensitivity of the electronic devices.

These methods vary with the particular electronic device to be protected from ionic contamination. A corrosion attack by the same concentration of ions on a large electrical devices may function flawlessly for years but would render an integrated inoperative in few minutes. Integrated circuits have small metal lines susceptible to rapid destruction by corrosion. These tiny electronic devices demand very "clean" environments, free from mobile ions.

Ion Chromatography (IC) is the method of choice for anionic contaminate evaluations for electronic materials, components and assemblies. This method is widely applied for printed circuit boards, passive and active components, silicon wafers and electronic materials, including pastes, adhesive, thermal transfer films, desiccants and encapsulating compounds. Contamination levels measured in parts-per-billion are possible, with parts-per-million practical and routine.

Purpose: The purpose of this task is to determine the ionic levels of the Ormet conductive compounds with common test methods appropriate to the applications.

Scope: Ionic levels for fluorine, chloride, potassium and sodium were measured for fully reacted Ormet materials numbers 7001, 700, 500 and 800. The laboratory regularly performs mobile ion evaluations for electronic materials used with integrated circuits; specifically, die attach materials. This type of tested was selected because Ormet is being used in cavity board applications where integrated circuits are also install.

Activities: Samples of four Ormet products were fully reacted and submitted for evaluations at a laboratory specializing in the evaluations of materials used with integrated circuits. Testing for extractable ionic contaminants was preformed with routine and standardized methods. The following procedural highlights:

Ormet materials fine milled in a Wiley Mill
Pure water dilution factor by weight—10:1
Parr bomb temperature—100C
Parr bomb time—16 hours
Inductively Coupled Argon Plasma (ICAP) element analysis
Ion Chromatography with Dionex IC for element analysis
Methods per MIL-STD-883G, Method 5001, para. 3.8.7

Results:

Table 1 Extractable ionic Contaminants for Ormet Products

Product No.	**7001**	**700**	**500**	**800**
Ionic Level (PPM)				
Sodium	2	<1	<1	<1
Potassium	<1	<1	<1	<1
Chloride	10.7	4.7	6.4	5.6
Fluoride	<1	<1	<1	<1

No industry-wide ionic level limits are established for conductive interconnect materials; however, typical limits die attach compounds for integrated circuits are 20 PPM MAX for Sodium, Potassium, Chloride and Fluoride. Die attach materials require very low mobile ionic contaminates. All measurements shown in Table 1 are low compared to this low requirement with chloride readings higher than all others but well below the 20 PPM MAX limit.

Conclusion: The ionic measurements shown in Table 1 shows low levels and therefore predict little probability of corrosion within Ormet materials or with other materials adjacent with Ormet materials including integrated circuits. To achieve these low ionic levels with other electronic materials and especially polymers, it would typically be necessary to formulate with raw materials containing low ionic levels. Raw materials used in Ormet products—both the organic and metal components—are not selected, screened or processed to remove ionic contamination. Some other explanation for the low levels of the fully-reacted materials is needed.

The alloying process seems the most probably explanation. Ormet is formulated with a low-melting alloy which melts and forms a continuous metal matrix throughout the material. This metallurgical process enables the metals to react with both the anionic and cationic components rendering them alloyed with the metals or reacted with metals during the normal reaction process and consequently leaving little remaining mobile or "free" ionic contaminants. This is a "gettering" process, converting all mobile ionic contaminates to immobile and therefore none available for measurement or corrosion.

Another explanation is possible and understood by the findings during early development of Ormet materials. The early versions for these compounds were formulated with a separate "flux" that was not part of the resin system and the reacted Ormet products were found to have an unacceptable susceptibility to corrosion. Current formulation include "flux" that is chemically linked with the resin leaving little ionic contaminates after the metallurgical reaction is complete. How much of the low ionic content of the reacted material can be assigned to the current organic "flux" or to the metallurgical reaction is not known at this time. Both explanations could be contributing to the low ionic levels.

Corrosion processes generally requires moisture to accelerate to destructive levels. The applications where Ormet materials are fully encapsulated in multilayer structures generally blocks the intrusion of moisture and thereby provides further protecting the internal structures of these electronic devices. Ormet applications where the conductive compounds are external and exposed to the environment would not have the moisture barrier protection of the typical multilayer structure.