MOISTURE GETTERS

INTRODUCTION TO GETTERS

When engineering microelectronics, every factor that can affect component performance, regardless of how minor its basic details may initially seem, needs to be taken carefully into account. This holds particularly true for micro-optic electromechanical systems. Within the packages that house critical MOEMS components - as well as elsewhere in the other, larger elements of such systems, like the telemetry of a satellite - delicate but critically important optical signals must always maintain their integrity.

External factors that can adversely affect MOEMS operations on a large or small scale (or somewhere in between) show up with regularity in the environments where the technologies powered by sensitive microelectronics operate. These may include everything from atmospheric pressure and extreme temperature to hostile interference (in the case of reconnaissance systems or other defense-related tools).

However, the presence of moisture represents a factor that can crop up in all applications found for MOEMS components, and as such it's critical to provide the most thorough protective methods to safeguard against this hazard. As a longtime industry leader in the design and manufacture of microelectronic packages reliable enough for use across numerous industries, AMETEK ECP has many years of experience with moisture getters and all other hermetic products essential for upholding vital seals at key points of connection.

ESSENTIAL TENETS OF HERMETICITY

At its most basic, a hermetic seal is one that is completely airtight. No gas, air or other substances of any kind should be able to penetrate, not even in the most minuscule amounts measurable only in micrograms or fractional parts per million. Within the context of electronics, maintaining hermeticity ensures that the circuits, microchips, wiring, connectors and other components inside a hermetically sealed package will be impervious to any naturally occurring outside elements, regardless of what environment the larger technological system containing that package must operate in.

Figure 1 – Tube Getters

Based on the stipulations within TM 1014 of MIL-STD-883E, codified by the Department of the Defense and used all over the world by countless other commercial and military organizations, the level of air leakage in a hermetic seal cannot exceed a certain number of atmosphere cubic centimeters depending on its internal cavity volume: for example, no more than 5 x 10^-8 atm. cc per second for 0.01 cc or less of

internal space. The specific numbers involved will change with differences in volume per the standards detailed in the Howl-Mann equation, according to Oneida Research Services.

Glass-to-metal and ceramic-to-metal seals are the two most common varieties of hermetic sealing seen in commercial and industrial settings. For anyone in need of a memory refreshment, their distinctions are as follows:

- **Glass-to-metal seals** are likely far more familiar to the layperson than their ceramic counterpart, due to their application in consumer lighting products like halogen and neon bulbs. As their name implies, glass and metal are bonded together either with similar thermal expansion coefficients (in matched seals) or via a connection in which metal forms around a glass in the induction process because of how their thermal coefficients differ (in compression seals). The latter is preferable in many applications because it makes for a stronger bond.
- **Ceramic-to-metal seals** involve the use of much higher pressures and induction temperatures. Manufacturers opt for this hermetic seal type when the points of

  connection themselves are going to be under considerable stress on a regular basis, like the extreme heat present in numerous commercial and military aerospace settings. Ceramic seals arguably represent the best available method of protection for the electronic packages or devices that employ them, though the manufacturing simplicity and lower cost often makes glass-to-metal a better choice.

Epoxy resin-based seals represent a third type of hermetic bonding and sealing method, but their considerable limitations regarding temperature variation - namely, the inability to stand up to either great heat or deep cold - and their less than perfect sealing characteristics mean that their uses in the field of electronics are limited. As explained by Ambrell Induction Heating Solutions, you would most likely only encounter epoxy resin hermetic seals in electronic systems or devices that used significant amounts of copper or brass.

INHERENT HAZARD OF MOISTURE IN ELECTRONIC COMPONENTS

The presence of moisture in any delicate microelectronic package immediately signals bad news - not just for the immediate types of malfunction that moisture may cause, but also because it's typically indicative of a bigger problem. If air that's turning into moisture via the natural process of condensation is making its way into a supposedly hermetically sealed environment, the likely reason for this is the intrusion of a foreign gas, which itself is likely the result of external pressures that could ultimately bring about a significant or even total failure.

Philipp wh Schuessler, an innovator in the field of microelectronics and hermeticity assessment as well as the author of the volume Moisture in Microelectronics: Physics and Chemistry of Volatile Species in Hermetic Electronic Devices, noted that a high concentration of hydrogen is one of the biggest adverse issues that can affect electronic components. This issue first gained attention in the 1960s - along with the general problem of supposedly hermetic environments becoming compromised - as something that was occurring primarily within the context of microwave devices and systems. Yet soon enough (within a matter of months, in fact)

experts in the field began to realize that unnatural levels of hydrogen were a major hazard for all hermetically sealed environments.

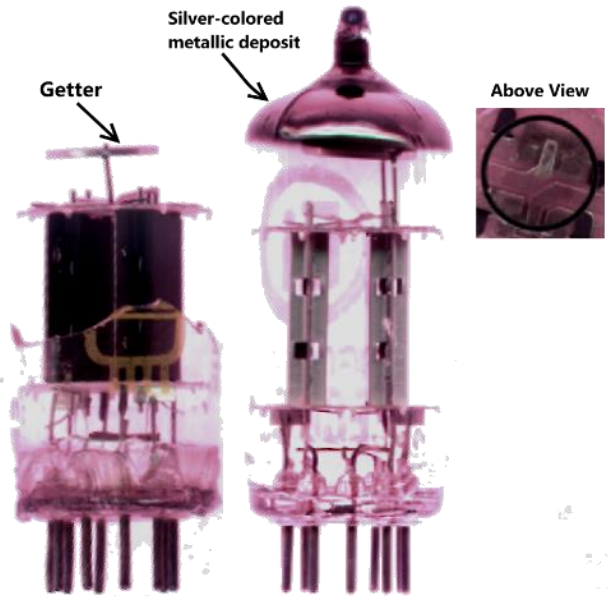
PROPERLY DETERMINING MOISTURE LEVELS IN MOEMS AND OTHER ELECTRONIC PACKAGES

Measuring moisture levels appropriately requires the conduction of internal gas analysis and residual gas analysis (IGA and RGA) tests. Per MIL-STD-883E, a mass spectrometer and a moisture dew point analyzer that conforms to National Institute of Standards and Technology calibration guidelines (and, in the latter device's case, is also recalibrated annually by NIST personnel) are the proper tools for these assessments. Any moisture content in an electronic package or component greater than 1,000 parts per million in volume is problematic, and anything above 5,000 ppmv is unacceptable. (That being said, the devices used for this testing must be capable of measuring even smaller volumes of moisture buildup: specifically, as little as 300 ppmv with a 50 ppmv margin of error.)

As pointed out by the consultancy firm TJ Green Associates LLC in a review of Schuessler's book, high moisture levels do not occur quite as commonly as they once did in the context of many modern industries that employ delicate microelectronic components. This is due in no small part to rigid quality control methods like those described in the paragraph above. Nevertheless, it remains absolutely vital for manufacturers to regularly carry out such assessments of moisture encroachment even if the risk of such a hazard's development is minor. Additionally, moisture getter solutions for microelectronics such as cover assemblies and related components developed by AMETEK ECP and fabricated in-house at our manufacturing facilities are crucial elements in maintaining extended life operating performance within electronic packages, as well as the larger technologies for which they provide the most critical operational support.

THE IMPORTANCE OF MAINTAINING ABSOLUTE HERMETICITY

In recent years, there have occasionally been some arguments against the idea that the seals protecting essential points of connection in electronic packages and devices need to be 100 percent hermetic. The driving factor behind such seemingly contrarian impulses, not surprisingly, is cost: It's more expensive to opt for fully hermetic seals (which employ highly engineered metals, glass and ceramics in their construction) than it is to choose "near-hermetic" or "non-hermetic" alternatives, often constructed of inexpensive organic materials. Seals, cover assemblies and other package components that fall into either of those latter categories are typically made out of various hybrid plastics: liquid crystal polymer, parylene-C, polyetheretherketone and other polymeric materials. The U.S. Army, in fact, uses these components in certain applications for the encasement of integrated circuits and other electronic components.



From Wikipedia : A vacuum tube with a "flashed getter" coating on the inner surface of the top of the tube. (left) The inside of a similar tube, showing the reservoir that holds the material that is evaporated to create the getter coating. During manufacture, after the tube is evacuated and sealed, an induction heater evaporates the material, which condenses on the glass.

To be fair, quite a few of the most advanced polymers used in near-hermetic products will probably conform to the minimum requirements outlined in TM 1014 of MIL-STD-883E, according to a whitepaper from TJ Green. However, the firm also noted that these plastic-molded assemblies will not be adequate for use in the most high-pressure environments that the technologies supported by hermetically sealed packages for MOEMS applications often will be used, such as interstellar orbit and other common settings of the aerospace sector. The Defense Department hermeticity standards were developed with glass, metal and ceramics in mind, because of how insignificant their moisture permeability levels are. Polymer materials can prevent most moisture buildup, but "most" is simply not good enough in use cases where lives may quite literally depend on the proper function of electronic packages.

AMETEK-ECP has been in the business of creating high-quality hermetic components including hermetic headers, moisture getter cover assemblies, ceramic feedthroughs and much more for multiple industries for decades. We are a global leader in the development of solutions that help mitigate the threat of moisture in delicate environments and guarantee the quality that company leaders need.