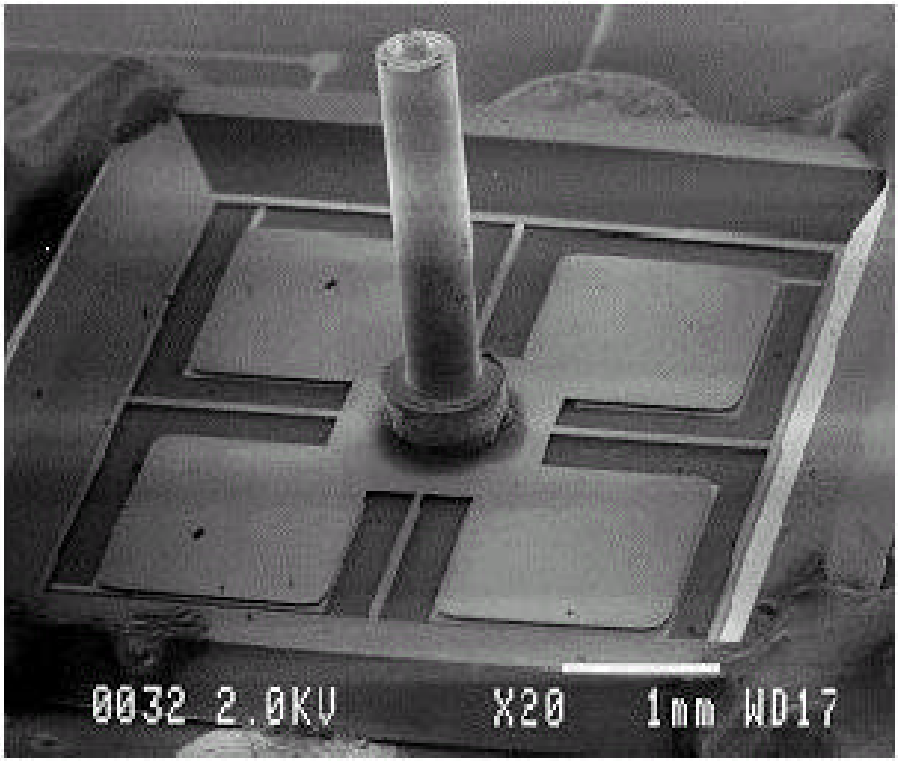
NASA ELECTRONIC PARTS & PACKAGING (NEPP) PROGRAM

EEE Links

March 2000, Vol. 6 No. 1

In this issue:



Getters for Reliable Hermetic Packages

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Executive Summary

A variety of sealed-off devices such as cathode ray tubes (CRT's), electron tubes, plasma displays, particle accelerators and colliders, vacuum thermal insulation, ultra-high vacuum (UHV), extreme high vacuum (XHV) systems for semiconductor processing, X-ray tubes, lamps, field-emission displays (FEDs), flat panel displays (FPDs), some microelectromechanical systems (MEMS) and science instruments for space applications nuclear systems require a vacuum for their successful operation. Maintaining vacuum in extremely small to large volume electronics hermetic packages and vacuum systems depends on the true surface area of the materials exposed to that volume as this is the source of species to be outgassed and it is this outgassing that will finally destroy the vacuum. Destroying the vacuum by outgassing from various materials used may lead to poor performance of the device (e.g., vibratory microgyroscope MEMS device). Getters are routinely used in small and large static systems and similarly getters will be needed if the desired system lifetimes of many years are to be obtained in MEMS and other packages for space applications.

JPL has been working on various types of microelectromechanical systems (MEMS) for space applications. Many high sensitivity microelectromechanical systems such as microgyros and some pressure sensors need to operate in hermetically sealed vacuum electronic packages to realize their full performance characteristics. This vacuum is destroyed by out-gassing of various species such as water vapor, hydrogen, deuterium, tritium, methane, carbon monoxide, nitrogen, oxygen, methane, argon, nitrogen and carbon dioxide from the package surfaces and microleaking or permeation through the package body. The loss of vacuum is particularly serious if organic materials are used in isolated MEMS packaging device. A getter material is needed to eliminate this problem and to achieve successful MEMS device operation for long duration space applications. term "getter" refers to materials, which chemically sorb active gases in a vacuum environment. A solution is proposed using a nonevaporable high porosity getter material family such as the type of zirconium-aluminum- iron manufactured by SAES Getters Inc., to solve the hermetic sealing problem associated with the microgyro, other similar MEMS devices and other vacuum systems where hermetic sealing is required. The getter consists of a highly porous and mechani-cally stable packaging component installed inside the MEMS vacuum packaging chamber and subsequently activated.

The activation of the getter is a key step, which should be performed using a suitable combination of temperature and time. This removes the layer of surface oxides, nitrides, and carbides, by their diffusion into the bulk of the getter and provides a clean metallic surface ready to react with the impinging gaseous molecules in a vacuum environment. Depending on the diffusion constants for the elements (such as H_2, CO, CO_2, H_2O, etc.,) into the getter materials, one can have a more or less effective cleaning of the surface during the activation process. The diffusion rate of various gaseous species present in the package in-creases upon raising the temperature of the getter material. The activation of the getter must be done when it is exposed for the first time or whenever ex-posed to air.

The solid-state getters may be either planar or three-dimensional and exhibit good mechanical strength. They must be particle free under the stringent opera-tional conditions in space and on the ground, and they should have a high active surface area that can easily be activated at low temperatures. This mini-mizes problems such as high ambient temperature that may be detrimental to MEMS devices and other packages during the activation of getter. High porosity combined with a large active surface area of the nonevaporable getter will assure excellent sorption performances at room temperature. There should not be any loss of getter particles before, during, or after activation of the getter in a packaged MEMS device as

this may cause failure of the MEMS device. It is critical to maintain the getter's mechanical structure during shocks and vibrations at the time of spacecraft launch and during operation of the MEMS device. The presence of an activated getter material inside the MEMS package will allow achievement of a better vacuum in the hermetically sealed vacuum package. The presence of a getter material inside a MEMS package is needed to avoid a pressure increase above the operational limit of the MEMS device. Sorption of outgassed species by getters permits a greater anticipated lifetime for MEMS devices in hermetically sealed packages.
I have provided an overview on various aspects such as gas sources in the electronics packaging, possible solutions, thermal treatment of packages, package materials, type of getters, applications of getters, preparation, characterization, and activation of get-ters,leak testing, and advantages and disadvantages of the various types of getters in various applications.

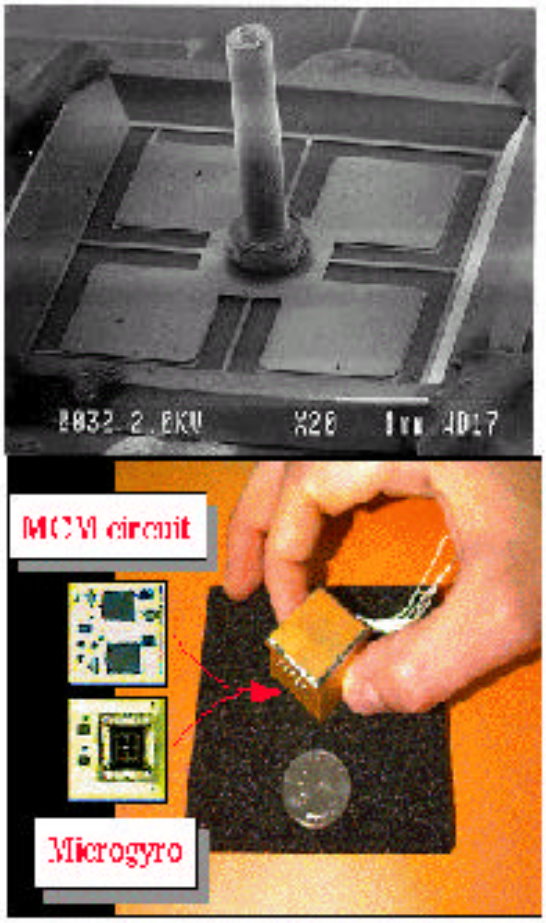

Figure 1. Packaging and Interconnect Development of JPL developed MEMS devices for Space Applications (Courtesy: Tony Tang, MDL/JPL)

This document will guide the researchers to select an appropriate getter for their respective application. The author of this document encourages the user to search for the latest information on this getter technology prior to implementing the concept of a getter to solve the problem in their specific application. (Total number of pages in the document: 88)

Acknowledgements: The document was put together at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, under the contract with the National Aeronautics and Space Administration (NASA). It was primarily funded by the NASA Code Q under Research Technology Objectives and Plans (RTOP) and the Center Program Plan, UPN 100336-60.1 through Jet Propulsion Laboratory's AssuranceTechnology Program Office of Engineering Mission Assurance Division.