Manufacturing & Prototyping

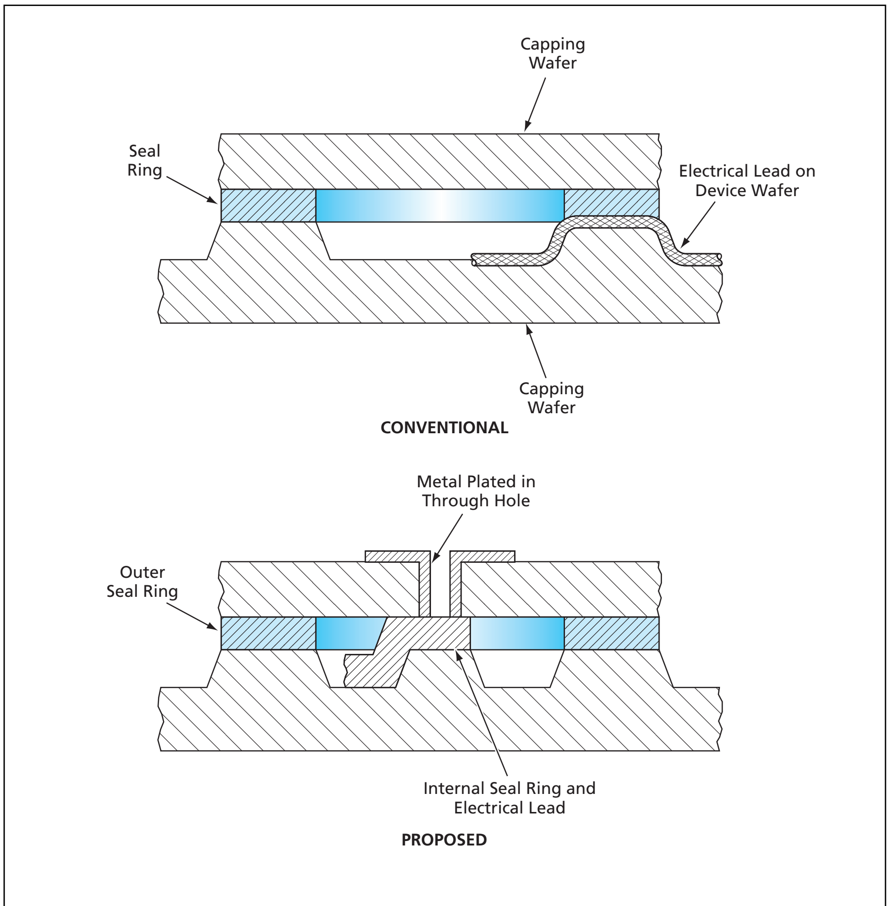
Vacuum Packaging of MEMS With Multiple Internal Seal Rings

Each internal seal ring would be part of an electrical feed-through.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed method of design and fabrication of vacuum-packaged microelectromechanical systems (MEMS) and of individual microelectromechanical devices involves the use of multiple internal seal rings (MISRs) in conjunction with vias (through holes plated with metal for electrical contacts). The proposed method is compatible with mass production in a wafer-level fabrication process, in which the dozens of MEMS or individual microelectromechanical devices on a typical wafer are simultaneously vacuum packaged by bonding a capping wafer before the devices are singulated (cut apart by use of a dicing saw). In addition to being compatible with mass production, the proposed method would eliminate the need for some complex and expensive production steps and would yield more reliable vacuum seals.

Conventionally, each MEMS or individual microelectromechanical device is fabricated as one of many identical units on a device wafer. Vacuum packaging is accomplished by bonding the device wafer to a capping wafer with metal seal rings (one ring surrounding each unit) that have been formed on the capping wafer. The electrical leads of each unit are laid out on what would otherwise be a flat surface of the device wafer, against which the seal ring is to be pressed for sealing. The resulting pattern of metal lines and their insulating oxide coverings presents a very rough and uneven surface, upon which it is difficult to pattern the sealing metal. Consequently, the seal is prone to leakage unless additional costly and complex planarization steps are performed before patterning the seal ring and bonding the wafers.



These **Cross Sections of Pertinent Parts** of one of many identical devices fabricated on a wafer are greatly simplified in order to illustrate salient differences between the proposed method and the conventional method.

In the proposed method, unlike in the conventional method, the electrical leads would not be laid out on the flat sealing surface of the device wafer (see figure). There would be a seal ring surrounding each MEMS or device as in the conventional method, but in addition, there would be smaller internal seal rings (the aforementioned MISRs) within the outer seal ring. Each internal seal ring would be formed integrally with one of the electrical leads of the MEMS or device.

In addition to the conventional processing of the capping wafer, holes concentric with the internal seal rings would be etched through the capping layer. The seal rings would be aligned with the sealing surfaces and the wafers bonded together in a vacuum, as in the conventional method. Then by a combination of electroless plating and electroplating, the through holes would be plated with metal to form electrical feed-throughs that would terminate in the internal seal rings. Hence, each internal seal ring would serve as both (1) part of an electrical feed-through and (2) the vacuum seal for that feed-through.

This work was done by Ken Hayworth, Karl Yee, Kirill Shcheglov, Youngsam Bae, Dean Wiberg, and Chris Peay of Caltech and Anthony Challoner of The Boeing Co. for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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Innovative Technology Assets Management
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov

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