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Titanium-Based Getter Solution for Wafer-Level MEMS Vacuum Packaging

VIVEK CHIDAMBARAM,[1,2] XIE LING,[1] and CHEN BANGTAO[1]

1.—Institute of Microelectronics, A*STAR (Agency for Science, Technology and Research), 11 Science Park Road, Science Park II, Singapore 117685, Singapore. 2.—e-mail: nachiappanvc@ime.a-star.edu.sg

Ultrahigh-vacuum conditions can be achieved by employing porous absorbent materials such as Ti, Zr, Ta, and Yt. Commercial getters are primarily Zr-based, since Zr possesses the best adsorption characteristics. Titanium is not considered as a candidate, since adsorption of gases by Ti is significantly reduced due to oxidation and other contamination. In the present work, it is demonstrated that the adsorption property of Ti can be substantially enhanced and benchmarked against other Zr-based commercial getters by employing a sacrificial layer such as Ni over Ti, and also by using other surface engineering techniques. It has been confirmed that, in addition to the activation temperature, the vacuum level during getter activation also plays a pivotal role in influencing the adsorption characteristics of Ti. It has been determined that the getter life could be significantly improved by the reversible adsorption characteristic of H_2 gas, facilitating regeneration cycles.

Key words: Vacuum packaging, getter, sacrificial layer, activation, outgassing, regeneration cycles

INTRODUCTION

Vacuum packaging protects microelectromechanical systems (MEMS) devices from external environments. Pressure level is a key parameter that significantly influences the functioning of MEMS devices. The pressure deterioration within a microcavity is strongly related to the leakage of the packaging structure and the outgassing phenomenon.[1] Ultrahigh-vacuum condition for MEMS packaging can be achieved and sustained using getter technology. This technology adsorbs residual gases trapped inside the device and thereby maintains the pressure at a very low level for the required lifetime of the device. Wafer-level MEMS vacuum packaging is gaining momentum, since the yield and the volume are very high, providing a practical route for cost reduction.[2,3]

The sources of gases inside the MEMS package could be due to outgassing from the walls of the vacuum chamber, leaks, and the permeability of materials used in its construction. The type of pumping mechanism used will also produce a residual atmosphere bearing no relation to the composition of the normal atmosphere.[4] The constituents of the normal atmosphere are mainly N_2 and O_2 at ratio of 80% to 20%, respectively, together with small traces of rare gases and CO_2, and a variable quantity of water vapor depending upon the ambient temperature and humidity conditions. In addition, gases such as Ar could be introduced during the getter deposition processes. Vacuum range requirements for MEMS devices vary depending on the type of MEMS device and its applications. The vacuum range requirement of various MEMS devices are listed in Table I. Thus, most MEMS devices require vacuum packaging. The presence of getter material inside a MEMS package is indispensable for MEMS structures with moving or suspended parts, since interior pressure could dampen the movement of such components.[2] Getter material either adsorbs or chemically reacts with active gases such as H_2, CO, CO_2, N_2, O_2, and H_2O. Unlike these active gases, hydrocarbons such

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