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DVS Application Note 31

Measurement of Moisture Ingress in Microelectronics Device Packaging

Surface Measurement Systems Ltd.

In this paper DVS ET(Elevated Temperature) is used to study the moisture sorption of a standard 16 pin DIL IC package under precisely controlled temperature and humidity conditions to demonstrate the capacity of the instrument to overcome the challenges of measuring very small weight changes in samples over a long period of time under highly aggressive conditions such as 85% RH and 85°C .

Introduction

The microelectronics industry of the 21st century is under relentlessly increasing pressure to produce devices that are smaller, more powerful, more reliable and cheaper to manufacture. One key feature of many devices is the packaging system used to protect the device from physical damage and from environmental degradation of performance. Whereas hermetically sealed packages are the preferred solution for high-cost, high reliability applications such as avionics and defence, a more cost effective solution is required for consumer and industrial applications. The most common packaging solution used today is to encapsulate the device and the interconnection system in a thermosettable polymer resin. One problem with the epoxy resins most commonly employed to encapsulate microelectronic devices is that they absorb moisture from the atmosphere they are exposed to during storage. In the worst case this can lead to an effect known as 'popcorning' during the wave soldering process, whereby the absorbed moisture is suddenly exposed to temperatures in excess of 220°C leading to violent release of vaporised water from the plastic device package (see Figure 1).

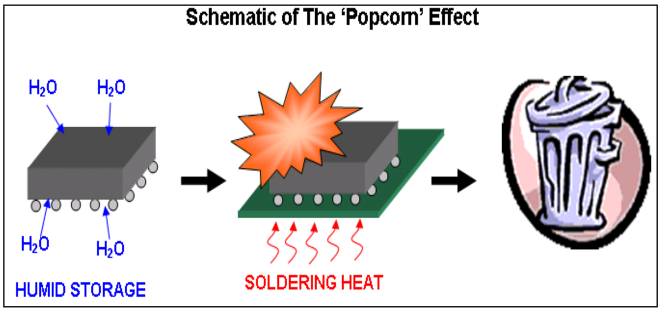

Figure 1. Schematic of the 'popcorn' effect.

This and other related moisture absorption issues has created the need for accelerated testing of microelectronic packaging systems to prevent significant problems during manufacture or during service of the device. One of the most commonly used conditions is 85% RH and 85°C originally adopted from US military standards but now widely accepted within the industry. However nearly all the existing test protocols are semi-empirical in basis, measuring the functionality of the device as the pass or fail criteria. A deeper understanding of the fundamental moisture interaction with the packing materials is clearly needed, in order to develop a better understanding of the effect of moisture over the entire lifecycle of a microelectronic device.

Surface Measurement Systems, has recently developed a dedicated gravimetric moisture sorption apparatus DVS ET (DVS Elevated Temperature), specifically designed to study the moisture sorption of real microelectronics packaging devices under precisely controlled temperature and humidity conditions. Key features of this instrument are high sensitivity (1μg) and high capacity (10g), combined with extremely good long-term stability of both the measured mass and the generated %RH.

Method

The device package used was a standard 16 pin DIL IC package with through-hole interconnects weighing approximately 1g total weight. The sample was suspended from a sample holder in the DVS ET apparatus and subjected to 0% RH at 85°C in order to dry the sample. After a fixed period of time the humidity was then increased in a single step to 85% RH. The resulting change in mass of the sample due to loss and gain of moisture from the packing device was recorded at 1-minute intervals throughout the whole experiment.

Results

The kinetics of drying under 0% RH and 85°C are shown in Figure 2. Over the duration of the drying step, the loss in mass corresponding to diffusion of moisture out of the device package is in this case approximately linear. A least squares regression analysis of the data shows that the rate of moisture loss from the device package is approximately 0.7 □g per minute. In this case the sample was only dried briefly due to time limitations, however one would expect the rate of drying to follow asymptotic behaviour as the moisture content decreases. The rate of moisture loss will be determined by a number of factors including the package material properties, initial moisture content, the package dimensions and any heterogeneous features such as the interface between the packaging resin and the device interconnects (leadframe).

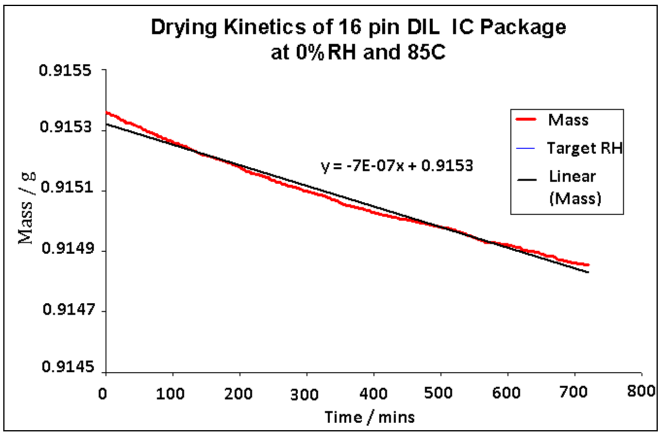

Figure 2. Drying Kinetics of 16 pin DIL IC Package.

Figure 3 shows the moisture sorption kinetics for the 16 pin DIL IC after being exposed to a constant humidity condition of 85% RH and 85°C as well as the previously shown drying data. The blue line indicates the %RH and the red line indicates the change in mass as a function of time. In this case as the humidity is stepped up to 85% RH, mass increases rapidly at first and then in an asymptotic fashion as the sample begins to approach equilibrium. After the initial uptake, the rate of mass increase becomes almost pseudo steady state, since the diffusion into the bulk of the package is relatively slow. Taking the last 1500 mins (~ 1 day) of data, a linear regression analysis shows that the device package is taking up moisture at a rate of approximately 0.2 □g per minute.

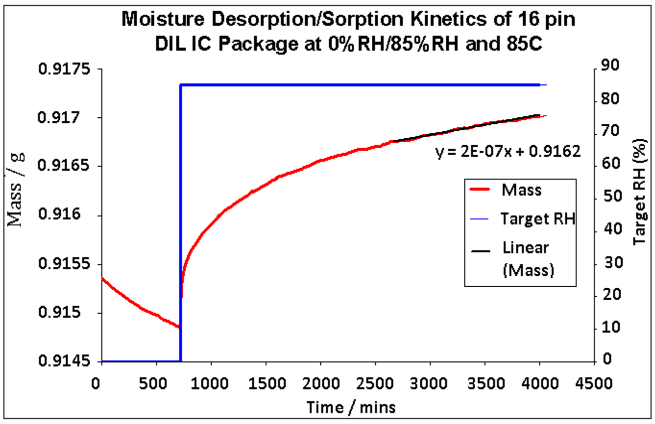

Figure 3. Kinetics of Moisture Sorption of 16 pin DIL Package at 85%RH and 85°C.

It should be noted that although a single humidity step of 85% RH was chosen for this study, the DVS ET can be programmed to generate humidities between 0% RH and 90% RH at 85C with a repeatability better than 1% RH. Indeed equilibrium measurements at several different humidities may be made to construct adsorption and desorption isotherms.

Conclusion

This short study demonstrates the sensitivity and accuracy of the DVS ET gravimetric moisture sorption system, specifically designed for use at 85% RH and 85°C. Although the total moisture uptake over the duration of this experiment is no more than 0.25% of the total weight of the device, it is thought that even moisture contents as low as 0.1% can have significant impact in terms of ‘popcorning’ and other device failures. Therefore the sensitivity of the DVS ET allows accurate determination of moisture absorption in microelectronics device packages. This will enable product development engineers and materials scientists to relate such data to both production specific issues and accelerated device testing protocols currently being used.

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Head Office:
Surface Measurement Systems, Ltd
5 Wharfside, Rosemont Road
LondonHA0 4PE, UK
Tel: +44 (0)20 8795 9400
Fax: +44 (0)20 8795 9401
Email: science@surfacemeasurementsystems.com

United States Office:
Surface Measurement Systems, Ltd, NA
2125 28th Street SW, Suite I
Allentown PA, 18103, USA
Tel: +1 610 798 8299
Fax: +1 610 798 0334