technology topics

Determination of Pre-Seal Vacuum Bake Conditions by Using Al_2O_3 In-Situ Moisture Sensor Chips

Loyd A. Searle
Panametrics, Inc
221 Crescent Street
Waltham, MA 02154

M. R.Stahler
General Electric Co.
Space Division
Philadelphia, PA 19406

It is well documented that excessive moisture trapped within sealed microelectronic packages can contribute significantly to device failure.[1] Design and process changes can complicate moisture control by causing a significant change in the ability of the product to absorb moisture and thus should be accompanied by corresponding adjustments in vacuum bake conditions. Proper bakeout is necessary for efficient manufacture of a dry package and work done by M. R. Stahler demonstrates clearly that the Al_2O_3 moisture sensor chip is a useful tool for determining vacuum bake conditions.

When microelectronic devices start failing, one of the first concerns is moisture content. Excessive moisture sealed inside of microelectronic packages has been shown to contribute to gold and silver migration, and ionic effects on devices can occur, producing leakage or inversion. [1,4] Most major moisture related failures occur long after testing and acceptance. In most cases neither the manufacturer nor the user is aware of the latent danger. [1]

Often moisture control is complicated by changes in manufacturing processes, especially for the hybrid industry. Prior to assembly, microelectronic devices undergo a pre-seal vacuum bakeout to drive off absorbed moisture resting in components, die attach, hermetic sealing or package style may lead to a significant change in the ability of the total package to absorb moisture. Significant changes in product design and assembly should be accompanied by adjustments of vacuum bakeout conditions.

Proper pre-seal vacuum bakeout conditions are absolutely necessary to insure efficient manufacture of a dry microelectronic device. While inadequate vacuum, temperature or time may lead to potentially dangerous levels of moisture, selecting excessive bakeout will increase production time. The Al2O3 moisture sensor chip can be used to accurately determine proper vacuum bakeout conditions for individual manufacturing processes without adding unnecessary production costs. [5]

The aluminum oxide sensor will permit manufacturers to certify moisture levels for almost any package configuration or manufacturing process by testing the effectiveness of moisture controls, including vacuum bake, hermeticity, and sealing environment. The chip monitors controls after installation within the package. Internal moisture content and hermeticity can then be determined nondestructively at any time during the shelf and operating life of the product.

The aluminum oxide moisture sensor chips are easy to use. Operator error is minimized and only six basic steps are necessary:

1. Assemble package / die and wire bond sensor. Vary vacuum bake conditions, seal.
2. Document measurements shortly after sealing.
3. Simulate burn-in and vary conditions.
4. Remove from oven and allow to cool in room ambient.
5. Document measurements after burn-in.
6. Determine proper bakeout conditions from measurement of desorbed moisture.

Standard assembly procedures are used for die attach, wire bonding and hermetic sealing.3 A typical procedure5 uses just enough locktite adhesive for die attach to achieve a bond and then allows room ambient curing for ten minutes minimal. Wire bonding between the Al2O3 sensor chip's bonding pads and two case pins is done with an ultrasonic bonder and .0015 diameter gold wire. The sealing process consists of a vacuum bake, transfer to the dry box and sealing. Vacuum bake temperatures and times are varied (Table 1) The device is taken directly from the vacuum bake and placed into the inert dry nitrogen chamber of the resistance weld sealing system and the package is sealed using the following parameters and values:

Moisture level — <100 ppm
Pulse amplitude — 600 amps
Pulse width — 2- m sec
Pulse repetition rate — 60 m sec
Table feed rate — 0.1 μsec

After sealing, the moisture trapped within the package is measured with the hygrometer**. Bakeout conditions necessary for low moisture levels before and after burn-in are readily available (Table 1)

*Panametrics Mini-Mod-A
**Panametrics Model 771

No.	Hybrid Type	Vacuum Bake Cond. Temp. (°C)	Vacuum Bake Cond. Time (Hrs.)	Initial	Measured (ppm_v) Desorbed After Exposure to: 150°C/24 hrs.	150°C/48 hrs.	150°C/72 hrs.	125°C/ 168 hr.
1	1	100	4	1200		Not Re-exposed		
2	2	100	16	250	7,200			
3	2	100	24	1800	10,500			
4	2	150	4	200	4,200			
5	2	150	24	50		10,000		
6	1	150	24	60		2,400		
7	2	150	64	<10			6,000	
8	2	150	72	15				25
9	2	150	72	15				20
10	2	150	72	15				15
11	2	150	72	<10				10
12	2	150	88	<10			175	

Table 1 — Results of desorbed moisture measurement in hermetically sealed microcircuit packages, vacuum baked at 100°C to varying time periods, then re-exposed at elevated temperatures (simulated burn-in) for various periods.

The typical procedure mentioned earlier produce initial low moisture levels (<100 to 1200 ppm.) after only four hours of vacuum bake at 100°C and 150°C temperatures. These initial moisture levels increased dramatically after burn-in was simulated.

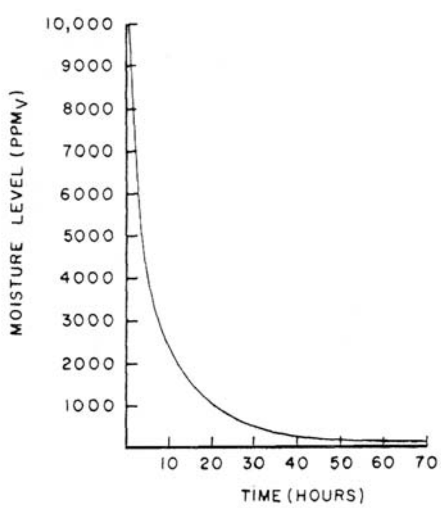

Fig. 1—Typical recovery curve shows re-absorption of desorbed moisture at room temperature.

Exposure to 150°C for 24 hours increased the initial low moisture level from less than 100 ppm, to more than 4000 ppm. Moisture levels repeatedly remained low (<100 ppm,) throughout 168 hour of burn-in at 125°C when the vacuum bake at 150°C for 72 hour was employed prior to sealing. After burn-in, readings dropped to within 10-20% of initial moisture measurements within 72 hours at room temperature (Fig. 1).

Changes in manufacturing processes can contribute to change in absorption properties of microelectronic devices. Corresponding adjustments of pre-seal vacuum bakeout conditions are therefore necessary for assurance that the resulting process will be moisture-safe and efficient. A practical method for determining proper bakeout conditions has been established utilizing the Al2O3 moisture sensor chip. Implementation of the Al2O3 method on production lines will give manufacturers assurance that their process is efficient and that their products are safe from the deleterious effects of moisture.

References

1. R. W. Thomas, Moisture, Myths and Microcircuits, IEEE Trans PH P-12, No. 3, Sept. 1976
2. Michael G. Kovac, David Chleck, Philip, A New Moisture Sensor for In-Situ Monitoring of Sealed Packages, Reliability Physics Proceedings, April 1977.
3. Michael G. Kovac, Performance Characteristics of Al2O3 Moisture Sensor Inside Hybrid Packages, ISHM Proceedings, Oct. 1977.
4. Doug R. Fancher and Richard G. Horner, Hybrid Package Hermeticity and Moisture Level monitoring, ISHM Proceedings, Sept. 1978.
5. M. R. Stahler, Moisture Control and Verification Within Hermetic Microcircuit Enclosures, ISHM, Keystone Chap., Nov 1, 1978