

METHOD AND DEVICE FOR DETECTING WATER VAPOR INTRUSION PATH OF
POLYMER ENCAPSULATED DEVICES

5 The present patent application claims priority from an earlier Chinese invention patent application number 2022 1 0164278.7 (published as CN114216954B) that is filed with CNIPA on 22 February 2022 and has the same title. Content and/or relevant subject matter of the priority application is hereby incorporated entirely and/or wherever appropriate by reference.

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The present invention relates to the technical field of semiconductor performance testing, and in particular to a method and device for detecting the water vapor intrusion path of a package device (e.g., integrated semi-conductor chip).

15 Electronic packaging is the process of connecting and fixing a package to a substrate or frame to form a complete system or electronic device. Epoxy moulding compound (EMC) is the most widely used electronic packaging material. Epoxy encapsulated packaging is an unhermetic (e.g., penetrated, pervious, injured, compromised, defective, leaking, pierced, not airtight) package, and water vapor can invade into the
20 chip along the path of the packaging material, plastic sealant, interface of the structural frame or substrate, causing failure such as corrosion and short circuit of the chip. Therefore, the encapsulation device needs to be tested for encapsulation performance.

In the prior art, the following two methods are used to test the packaging performance
25 of packaged devices.

The first method is the gravimetric method. The gravimetric method immerses the polymer encapsulated device in water and calculates the water absorption rate of the device by the weight change before and after immersion. The problem is that the water absorption rate of the device can only be calculated by the weighing method, and the path and speed of water vapor intrusion in the sample cannot be obtained, which cannot fundamentally solve the problem of poor moisture-proof reliability of the product.

The second method is Water Vapor Transmission Rate (WVTR), which uses an electrolytic humidity sensor, by setting a humidified nitrogen gas with a certain marked ambient relative humidity to flow on one side of the sample to be measured, and a dry nitrogen gas to flow at a specific flow rate on the other side of the sample to be measured, due to the existence of a humidity gradient. Water vapor diffuses from the high humidity side through the film to the low humidity side; on the low humidity side, the water vapor transmitted is carried to the sensor by the flowing dry nitrogen gas, and the water vapor transmission rate of the sample to be measured is calculated through the analysis of the electrical signal of the sensor. The problem is that the water vapor permeation analysis method is only applicable to thin film, sheet or plate samples, and the shape of the sample to be measured has specific requirements, and this method can only yield the water vapor transmission rate of water vapor in the sample to be measured, and cannot obtain the path and speed of water vapor invasion in the sample, which cannot fundamentally solve the problem of poor moisture-proof reliability of the product.

The present invention provides a method and device for detecting the water vapor intrusion path of polymer encapsulated devices, which effectively realizes the detection of water vapor intrusion path and intrusion speed of polymer encapsulated devices and helps to improve the moisture-proof reliability of polymer encapsulated devices.

According to an aspect of the present invention, there is provided a method for detecting a water vapor intrusion path of an polymer encapsulated device, comprising the steps of: conducting a water vapor tracer marker based on a predetermined tracer for the polymer encapsulated device to be tested, obtaining a tracer marker sample; conducting a secondary ion mass spectrometry analysis of said tracer marker sample to obtain the tracer intensity of said tracer marker sample; and determining the path and rate of water vapor intrusion based on said tracer intensity.

Optionally, said water vapor tracer tagging based on a predetermined tracer to be tested packaging device, to obtain a tracer tagging sample, comprising: establishing a predetermined tracer tagging environment; tagging a water vapor intrusion path of said packaging device to be tested based on said predetermined tracer tagging environment; determining said tracer tagging sample based on the path tagging result.

Optionally, the predetermined tracer tagging environment includes: tagging environment temperature, tagging environment relative humidity, and tagging duration.

Optionally, said determining the path and rate of water vapor intrusion based on said tracer strength, comprising: obtaining a marker duration for which the water vapor

tracer marking process lasts; determining the path and rate of water vapor intrusion based on said tracer strength and said marker duration.

Optionally, said determining the path and speed of water vapor intrusion based on
5 said tracer strength and said marker duration, comprising: determining the tracer intrusion distance and intrusion path based on the tracer strength; establishing a target infiltration curve based on the tracer intrusion distance and marker duration; and determining the speed of water vapor intrusion based on the target infiltration curve.

Optionally, said secondary ion mass spectrometry analysis of said tracer marker
10 sample to obtain said tracer intensity of said tracer marker sample, comprising: obtaining at least one tracer detection signal of said tracer marker sample using secondary ion mass spectrometry; determining the location of water vapor intrusion and tracer intensity in said tracer marker sample based on said tracer detection signal; wherein said tracer detection signal corresponds one-to-one with said water vapor
15 intrusion location.

Optionally, prior to performing secondary ion mass spectrometry on said tracer marker sample, said detection method further comprises the step of: applying a surface conductive thin film coating to said tracer marker sample.

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Optionally, said pre-set tracer comprises deuterium or deuterium oxide.

According to another aspect of the present invention, there is provided an polymer encapsulated device water vapor intrusion path detection device, comprising: a
25 tagging module for water vapor tracer tagging the polymer encapsulated device to be

measured based on a predetermined tracer to obtain a tracer tagging sample; a mass spectrometry module for secondary ion mass spectrometry analysis of said tracer tagging sample to obtain the tracer intensity of said tracer tagging sample; and a data processing module for determining the path and speed of water vapor intrusion based
5 on said tracer intensity.

The technical solution of the embodiment of the present invention, through the pre-set tracer to be tested packaging device for water vapor tracer marker, to obtain the tracer marker sample; secondary ion mass spectrometry analysis of the tracer marker
10 sample, to obtain the tracer intensity of the tracer marker sample; according to the tracer intensity to determine the path and speed of water vapor intrusion, solve the existing semiconductor packaging test cannot identify the path and speed of water vapor intrusion, is conducive to It can improve the dynamic detection accuracy of water vapor intrusion, facilitate the study of the reliability failure mechanism of the package
15 device, monitor the product life, and constrain the chip use environment, and help to develop corresponding improvement measures to fundamentally enhance the moisture resistance reliability of the package device.

It should be understood that what is described in this section is not intended to identify
20 key or important features of embodiments of the present invention, nor is it intended to limit the scope of the present invention. Other features of the present invention will be readily understood by the following specification.

In order to more clearly illustrate the technical solutions in the embodiments of the
25 present invention, the following is a brief description of the accompanying drawings to

be used in the description of the embodiments, it is obvious that the following description of the accompanying drawings are only some embodiments of the present invention, for the person of ordinary skill in the art, without creative work, other drawings can be obtained according to these accompanying drawings.

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According to further aspect of the invention, the present application provides a method for detecting a water vapor intrusion path of a packaged device. The method comprises following steps:

- based on the pre-set tracer, the water vapor tracer mark is carried out on the
10 packaged device to be tested, and the tracer mark sample is obtained;
- performing secondary ion mass spectrometry analysis on the tracer-labelled sample to obtain the tracer intensity of the tracer-labelled sample;
- determine the path and speed of water vapor intrusion according to the tracer intensity;
- 15 ➤ the water vapor intrusion path can be determined according to the tracer intensity at different positions of the sample, and the water vapor intrusion speed can be determined according to the time required for the tracer to reach different positions of the sample;
- determine the water vapor intrusion path according to the tracer intensity at
20 different positions of the sample, including: obtaining the tracer detection signal of any target point of the tracer-marked sample, and determining the indication of the target point according to the numerical value of the tracer detection signal.
if the tracer intensity of any marking time and any target point exceeds the pre-set concentration threshold, it is determined that the tracer penetrates into the
25 point after the current marking time, and the target point is determined as the

sample passes through the water vapor intrusion position corresponding to the current marked duration.

Particularly, the water vapor trace marking is preferably carried out on the packaged device to be tested based on the pre-set tracer. The trace mark sample is obtained by following steps, comprising:

- establishing a default tracer marking environment;
- marking the water vapor intrusion path of the packaged device under test based on the pre-set trace marking environment;
- 10 ➤ determining the tracer-marked samples according to the path-marker results.

The pre-set trace marking environment preferably comprises steps of marking environment temperature, marking environment relative humidity, marking duration, and/or a combination of any of these steps in any plausible sequence.

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The determining the path and speed of water vapor intrusion according to the intensity of the tracer comprises step of:

- obtaining the marking duration of the water vapor tracer marking process; and/or
- 20 ➤ determining the path and speed of water vapor intrusion according to the intensity of the tracer and the duration of the marking.

The determining the path and speed of water vapor intrusion according to the tracer intensity and the marking duration preferably includes:

- determining the tracer invasion distance and invasion path according to the tracer intensity;
- establishing a target penetration curve according to the tracer invasion distance and the marking duration;
- 5 ➤ determining the water vapor intrusion velocity according to the target infiltration curve.

The carrying out secondary ion mass spectrometry analysis on the tracer-labelled sample to obtain the tracer intensity of said tracer-labelled sample comprises steps of:

- 10 ➤ obtaining at least one tracer detection signal of the tracer-labelled sample by secondary ion mass spectrometry; and/or
- determining the water vapor intrusion location and tracer intensity in the tracer-marked sample according to the tracer detection signal.

The tracer detection signal is in one-to-one correspondence with the water vapor
15 intrusion location.

Before performing secondary ion mass spectrometry analysis on the tracer labelled sample, the following step(s) are also preferably included:

- carrying out the surface conductive thin film coating treatment on the tracer
20 mark sample.

The pre-set tracer preferably includes deuterium or deuterium oxide.

According to an additional aspect, the present application provides a water vapour intrusion path detection device for a packaged device. The water vapor intrusion path detection device includes or comprises:

- the marking module being used to perform water vapor trace marking on the packaged device to be tested based on a pre-set tracer, and obtain trace mark samples;
- a mass spectrometry module, configured to perform secondary ion mass spectrometry analysis on the tracer-labelled sample, to obtain the tracer intensity of the tracer-labelled sample;
- a data processing module, configured to determine the path and speed of water vapor intrusion according to the intensity of the tracer;
- the water vapor intrusion path configured to be determined according to the tracer intensity at different positions of the sample, and the water vapor intrusion speed can be determined according to the time required for the tracer to reach different positions of the sample;
- determine the water vapor intrusion path according to the tracer intensity at different positions of the sample, including:
 - ❖ obtaining the tracer detection signal of any target point of the tracer-marked sample, and
 - ❖ determining the indication of the target point according to the numerical value of the tracer detection signal.

If the tracer intensity of any marking time and any target point exceeds the pre-set concentration threshold, it is determined that the tracer penetrates into the point after the current marking time, and the target point is determined as the sample passes

through the water vapor intrusion position corresponding to the current marked duration.

The pre-set tracer in the marking module is preferably gaseous or liquid.

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FIG. 1 is a flowchart of a method for detecting the water vapor intrusion path of an polymer encapsulated device provided in Example 1 of the present invention;

FIG. 2 is a flowchart of another method for detecting water vapor intrusion paths in polymer encapsulated devices provided in Example 1 of the present invention;

10 FIG. 3 is a flowchart of yet another method for detecting water vapor intrusion paths in polymer encapsulated devices provided in Example I of the present invention;

FIG. 4 is a schematic diagram of a target penetration curve provided in Example 1 of the present invention;

15 FIG. 5 is a schematic diagram of an alternative target penetration profile provided by Example I of the present invention;

FIG. 6 is a flowchart of yet another method for detecting water vapor intrusion paths in polymer encapsulated devices provided in Example I of the present invention;

FIG. 7 is a flow chart of a method for detecting water vapor intrusion paths in a polymer encapsulated device provided in Example II of the present invention;

20 FIG. 8 is a schematic diagram of the structure of a polymer encapsulated device water vapor intrusion path detection device provided in Example III of the present invention;
and

FIG. 9 is a schematic diagram of the structure of another polymer encapsulated device water vapor intrusion path detection device provided in Example III of the present
25 invention.

In order to enable those in the art to better understand the embodiments of the present invention, the technical solutions in the embodiments of the present invention will be clearly and completely described below in conjunction with the accompanying
5 drawings in the embodiments of the present invention, and it is clear that the embodiments described are only some of the embodiments of the present invention, and not all of them. Based on the embodiments in the present invention, all other embodiments obtained by a person of ordinary skill in the art without making creative labour shall fall within the scope of protection of the present invention.

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It is noted that the terms “include”, “comprise” and “has/have” and any variations thereof in the specification and claims of the present invention and the accompanying drawings above are intended to cover non-exclusive inclusion. For example, a process, method, system, product or apparatus comprising a series of steps or units need not
15 be limited to those steps or units clearly listed, but may include other steps or units not clearly listed or inherent to those processes, methods, products or apparatus.

Example I

FIG. 1 shows a flow diagram of a method for detecting a water vapor intrusion path of
20 an polymer encapsulated device provided in Example 1 of the present invention, which may be applicable to an application scenario where the path and speed of water vapor intrusion of an polymer encapsulated device is dynamically detected, the method may be performed by a detection device, which may be implemented in the form of hardware and/or software, the detection device may be configured in one or more
25 detection devices and/or control modules.

As shown in FIG. 1, the method for detecting the water vapor intrusion path of the polymer encapsulated device, specifically comprising the following steps.

- 5 Step S1: tracer marking the water vapor based on a predetermined tracer for the polymer encapsulated device to be tested, and obtaining a tracer marking sample.

Wherein, the package device to be tested may be a display, a display application film, a moulded device, or an integrated package chip; and the tracer marker sample is a package device to be tested with a tracer after being marked.

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Optionally, the predetermined tracer can be deuterium or deuterium oxide.

- In this embodiment, heavy water may be used as a carrier for the preset tracer, and deuterium atoms in heavy water are used as tracer atoms, and the polymer encapsulated device to be tested is placed in a marking device containing heavy water, and the environment of the polymer encapsulated device to be tested is simulated by the marking device so that heavy water vapor enters the polymer encapsulated device to be tested through a water vapor intrusion path, and deuterium atoms in heavy water are introduced into the polymer encapsulated device to be tested to obtain a tracer marker sample with tracer.
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Step S2: Secondary ion mass spectroscopy (SIMS) is performed on the tracer-labelled sample to obtain the tracer intensity of the tracer-labelled sample.

Among them, secondary ion mass spectrometry uses electro-optical methods to accelerate and focus primary ions such as noble gases into a fine high-energy ion beam to bombard the sample surface to excite and sputter secondary ions, and collect the secondary ions separated by mass spectrometry, which can obtain the elemental composition and distribution on the sample surface and ontology to achieve sample composition analysis.

In this step, the tracer intensity of the tracer labelled sample may be the intensity of deuterium atoms in the sample, and a secondary ion mass spectrometer may be used to detect the intensity of deuterium atoms at different locations of the tracer labelled sample, and the detection sensitivity of the secondary ion mass spectrometer may reach the ppm or ppb level, and if heavy water enters the sample, the secondary ion mass spectrometer may detect the specific location and tracer intensity of heavy water intrusion into the sample by the deuterium atom signal.

Step S3: Determine the path and rate of water vapor intrusion based on the tracer intensity.

where the water vapor intrusion path can be determined based on the tracer strength at different locations of the sample, and the water vapor intrusion rate can be determined based on the time required for the tracer to reach different locations of the sample.

Specifically, for water vapor intrusion path detection of the package device to be tested, deuterium atoms or deuterium oxide in heavy water is used as a predetermined tracer,

and the package device to be tested is left in a vapor or liquid environment of heavy water to allow heavy water to enter the package device to be tested along the water vapor intrusion path. After a period of standing, the tracer labelled sample with the tracer is removed. The intensity of deuterium atoms at different locations of the tracer
5 marker sample is measured by a secondary ion mass spectrometer, and the path and rate of water vapor intrusion in the polymer encapsulated device to be tested are determined based on the intensity of deuterium atoms at different locations and the time the sample is left in the heavy water environment.

10 The technical solution of the embodiment of the present invention, by using heavy water tracing method combined with secondary ion mass spectrometry analysis to determine the path and speed of water vapor intrusion in the packaging device, solves the problem that the existing semiconductor packaging test cannot identify the path and speed of water vapor intrusion, helps to improve the dynamic detection accuracy
15 of water vapor intrusion, facilitates the study of the reliability failure mechanism of the packaging device, monitors the product life, constrains the chip use It can be widely used in industrial fields such as original packaging material suppliers, packaging factories, display suppliers, chip suppliers and product terminal integrators.

20 Optionally, FIG. 2 is a flow diagram of another method of detecting water vapor intrusion paths in polymer encapsulated devices provided in Example 1 of the present invention, exemplarily showing a specific implementation of a tracer marker on the basis of FIG. 1, rather than a specific limitation of step S1 above.

25 As shown in FIG. 2, step S1 above, specifically comprises the following steps.

Step S101: Establishing a pre-set tracer marker environment.

5 Optionally, the predetermined tracer marking environment comprises: a marking environment temperature, a marking environment relative humidity, and a marking duration.

10 In this step, a marking device containing heavy water may be used to tracer mark the package device to be tested, wherein the marking environment temperature is the temperature in the chamber of the marking device, the marking environment relative humidity is the relative humidity in the chamber of the marking device, and the marking time is the total time consumed by the package device to be tested from resting in the marking device until the sample is removed.

15 Step S102: Marking the water vapor intrusion path of the package device to be tested based on a predetermined tracer marking environment.

In this step, the heavy water vapor may be in gaseous or liquid state, without limitation.

20 Step S103: Determine the tracer marker sample based on the path marking results.

Exemplarily, the marker ambient temperature may be any value greater than or equal to 25°C and less than or equal to 120°C; and the marker ambient relative humidity may be any value greater than or equal to 70% and less than or equal to 100%.

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Specifically, in the marking process, the specific values of the temperature, the relative humidity of the marking environment and the marking time in the cavity of the marking device containing heavy water vapor are first set to simulate the actual application environment of the packaging device to be tested, and the packaging device to be tested is placed in the heavy water vapor environment so that the heavy water vapor enters the packaging device to be tested through the water vapor intrusion path. When the resting time reaches the length of the marker, the sample is removed, at which time, the heavy water vapor has entered the water vapor intrusion path, and the tracer marker sample is obtained. By setting the tracer mark environment with adjustable parameters, the actual application environment of the polymer encapsulated device is simulated, and the water vapor intrusion path and speed of the sample are detected in different places under the same application environment, which facilitates the study of the reliability failure mechanism of the polymer encapsulated device and helps to develop corresponding improvement measures to fundamentally improve the moisture-proof reliability of the polymer encapsulated device.

It should be noted that the value of the pre-set tracer mark environment can be set according to the actual application conditions of the package device to be tested, and there is no restriction on its specific value.

Optionally, FIG. 3 is a flow diagram of yet another method of detecting a water vapor intrusion path of a polymer encapsulated device provided in Example 1 of the present invention, and on the basis of FIG. 1, FIG. 3 exemplarily illustrates a specific implementation of water vapor intrusion detection, rather than a specific limitation of step S3 above.

As shown in FIG. 3, the method for detecting the water vapor intrusion path of the polymer encapsulated device, specifically comprising the following steps.

5 Step S1: tracer marking the water vapor based on a predetermined tracer for the e polymer encapsulated device to be tested, and obtaining a tracer marking sample.

Step S2: Secondary ion mass spectrometry is performed on the tracer-labelled sample to obtain the tracer intensity of the tracer-labelled sample.

10 Step S301: Obtain the tagging duration for which the water vapor tracer tagging process lasts. wherein the marker duration is the total duration of time the polymer encapsulated device to be tested is sitting in the heavy water vapor.

Step S302: Determining the path and rate of water vapor intrusion based on the tracer strength and the marker duration.

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Specifically, steps S301 to S302 above document a method for determining the path and rate of water vapor intrusion based on tracer intensity.

20 Optionally, the path and speed of water vapor intrusion is determined based on the tracer strength and marker duration, including: determining the tracer intrusion distance and intrusion path based on the tracer strength, wherein the tracer intrusion distance may be along the length of lateral penetration of the polymer encapsulated device package or along the depth of longitudinal penetration perpendicular to the polymer encapsulated device package, and the tracer intrusion path may include
25 intrusion into the chip along the plastic seal or along the interface; establishing a target

penetration curve based on the tracer intrusion distance and marker duration; and determining the speed of water vapor intrusion based on the target penetration curve.

The target infiltration curve is a curve characterizing the correspondence between the tracer invasion distance D and the marker duration t . For example, the target penetration curve can be established from the detected data by using the marker duration t as the horizontal coordinate of the target penetration curve and the tracer invasion distance D as the vertical coordinate of the target penetration curve.

FIG. 4 shows a schematic diagram of a target penetration curve provided in Example 1 of the present invention. In the embodiment shown in FIG. 4, the package device to be tested is a plastic sealed device, and FIG. 4 exemplarily illustrates a schematic diagram of the curve of water vapor intrusion into the chip along the plastic seal material.

In combination with Figure 4, when establishing the target penetration curve, the tagging environment temperature T is set to 75°C , the tagging environment relative humidity is 95% RH, the tracer intensity of the tracer tagging sample is obtained once per pre-set sampling interval time Δt , and the specific location of the tracer invasion is determined by the detected tracer intensity. For example, the pre-set sampling interval Δt can be 6 hours, at the first marker duration $t_1=0$, the tracer intrusion distance D determined by deuterium signal detection is 0; at the second marker duration $t_2=6$, the tracer intrusion distance D is $100\text{ }\mu\text{m}$; at the third marker duration $t_3=12$, the tracer intrusion distance D determined by deuterium signal detection is $200\text{ }\mu\text{m}$; at the fourth marker duration $t_4=24$ At the fourth marker time $t_4=24$, the tracer intrusion distance D

determined by deuterium signal detection is $400\mu\text{m}$, according to which, curve 1 is plotted as the target penetration curve of water vapor invasion along the plastic seal to the chip.

5 FIG. 5 shows a schematic diagram of another target permeation profile provided in embodiment one of the present inventions, in the embodiment shown in FIG. 5, the package device to be tested is a plastic sealed device, and FIG. 5 exemplarily illustrates a schematic diagram of a profile of water vapor intrusion into the chip along the interface.

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Combined with Figure 5, the tagging environment temperature T is set to 75°C , the tagging environment relative humidity is 95% RH, the tracer intensity of the tracer tagging sample is obtained once per pre-set sampling interval time Δt , and the specific location of the tracer invasion is determined by the detected tracer intensity. For
 15 example, the pre-set sampling interval Δt can be 3 hours, and the tracer intrusion distance D determined by deuterium signal detection is 0 at the first marker duration $t_1' = 0$, $600\mu\text{m}$ at the second marker duration $t_2' = 3$, $600\mu\text{m}$ at the third marker duration $t_3' = 6$, $600\mu\text{m}$ at the fourth marker duration $t_4' = 12$, the tracer intrusion distance D determined by deuterium signal detection is $600\mu\text{m}$, and at the fifth marker
 20 time $t_5' = 24$, the tracer intrusion distance D determined by deuterium signal detection is $600\mu\text{m}$, according to which, curve 2 is plotted as the target penetration curve of water vapor invasion along the interface to the chip.

Optionally, FIG. 6 is a flow diagram of yet another method of detecting water vapor
 25 intrusion paths in polymer encapsulated devices provided in Example 1 of the present

invention, and on the basis of FIG. 1, FIG. 6 exemplarily illustrates a specific embodiment of secondary ion mass spectrometry analysis, rather than a specific limitation of step S2 above.

- 5 The method for detecting the water vapor intrusion path of the polymer encapsulated device, as shown in FIG. 6, specifically comprising the steps of:

Step S1: Tracer mark the water vapor based on the predetermined tracer for the package device to be tested and obtain a tracer mark sample.

- 10 Step S201: The secondary ion mass spectrometry is used to acquire at least one tracer detection signal of the tracer labelled sample.

Step S202: Determine the water vapor intrusion location and tracer intensity in the tracer marker sample based on the tracer detection signal. Wherein, the tracer detection signal corresponds to the water vapor intrusion location one by one.

- 15 Step S3: Determine the path and rate of water vapor intrusion based on the tracer intensity.

Specifically, steps S201 to S202 above document a method for performing secondary ion mass spectrometry analysis of a tracer-labelled sample. In the secondary ion mass spectrometry detection process, the tracer-labelled samples obtained after different labelling durations are acquired separately, and the tracer detection signal (i.e., deuterium signal) is acquired at any target site of the tracer-labelled samples using the secondary ion mass spectrometer, and the tracer intensity (i.e., deuterium atomic intensity) at the target site is determined based on the numerical magnitude of the tracer detection signal, and if the tracer intensity at any labelling duration and any

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target site. If the intensity of the tracer at any target site exceeds the pre-set concentration threshold, it is determined that after the current marker duration, the tracer penetrates into the site, and the target site is determined as the location of water vapor intrusion corresponding to the sample after the current marker duration, and the intensity of the tracer at the current location is recorded. The secondary ion mass spectrometry analysis combined with heavy water tracer method can pinpoint the specific location of water vapor intrusion and facilitate the study of water vapor intrusion path and rate.

10 Example Two

Optionally, FIG. 7 shows a flow chart of a method for detecting water vapor intrusion paths in an polymer encapsulated device provided by Example II of the present invention, which improves detection accuracy by coating the examined sample for secondary ion mass spectrometry analysis as compared to Example I.

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As shown in FIG. 7, the detection method also includes: treating the tracer marker sample with a surface conductive thin film coating prior to performing secondary ion mass spectrometry on the tracer marker sample. The polymer encapsulated device water vapor intrusion path detection method specifically includes the following steps.

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Step S1: Tracer mark the water vapor based on the predetermined tracer for the package device to be tested and obtain a tracer mark sample.

Step S4: The tracer-labelled sample is treated with a surface conductive thin film coating, and the coated sample is used as the examined sample for the secondary ion mass spectrometry analysis.

- 5 Step S2: secondary ion mass spectrometry analysis of the tracer labelled sample after coating treatment to obtain the tracer intensity of the tracer labelled sample.

Step S3: Determine the path and rate of water vapor intrusion based on the tracer intensity.

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Specifically, in the process of secondary ion mass spectrometry detection, there is electron accumulation phenomenon, and optimizing the examined sample for secondary ion mass spectrometry analysis by surface conductive thin film coating treatment of the tracer-labelled sample can effectively reduce the charge effect
15 generated by electron accumulation on the sample surface and avoid the deuterium signal analysis data error caused by the charge problem, which is conducive to improving the detection accuracy.

Example Three

- 20 FIG. 8 is a schematic diagram of the structure of an polymer encapsulated device water vapor intrusion path detection device provided in Example III of the present invention, wherein the detection device in this Example is used to perform the polymer encapsulated device water vapor intrusion path detection method provided in any of the above Embodiments, with the corresponding functional modules and beneficial
25 effects of performing the method.

As shown in FIG. 8, the detection device 00 includes: a tagging module 101, a mass spectrometry module 102, and a data processing module 103, wherein the tagging module 101 is used to obtain a tracer tag sample based on a predetermined tracer
5 tracer marker for the package device to be measured; a mass spectrometry module 102 is used to perform secondary ion mass spectrometry analysis of the tracer tag sample to obtain the tracer intensity of the tracer tag sample; and a data processing module 103 is used to determine the path and speed of water vapor intrusion based on the tracer intensity. The data processing module 103 is used to determine the path
10 and speed of water vapor intrusion based on the tracer intensity.

Optionally, the marker module 101 is used to hold a predetermined tracer, establish a predetermined tracer marker environment, and mark the water vapor intrusion path of the package device to be tested based on the predetermined tracer marker
15 environment and the predetermined tracer to obtain a tracer marker sample.

Optionally, the pre-set tracer in the tagging module 101 may be in a gaseous or liquid state.

20 Optionally, the pre-set tracer tagging environment includes: tagging ambient temperature, tagging ambient relative humidity, and tagging duration.

Optionally, the data processing module 103 is used to obtain the mark duration for which the water vapor tracer marking process lasts and to determine the path and rate
25 of water vapor intrusion based on the tracer intensity versus the mark duration.

Optionally, determining the path and rate of water vapor intrusion based on the tracer strength and marker duration, including: determining the tracer intrusion distance and intrusion path based on the tracer strength; establishing a target infiltration curve based on the tracer intrusion distance and marker duration; and determining the rate of water vapor intrusion based on the target infiltration curve.

Optionally, the tracer marker sample is analysed by secondary ion mass spectrometry to obtain a tracer intensity of the tracer marker sample, comprising: obtaining at least one tracer detection signal of the tracer marker sample using secondary ion mass spectrometry; determining a water vapor intrusion location and a tracer intensity in the tracer marker sample based on the tracer detection signal; wherein the tracer detection signal corresponds one-to-one with the water vapor intrusion location.

Optionally, FIG. 9 shows a schematic diagram of the structure of another polymer encapsulated device water vapor intrusion path detection device provided in Example III of the present invention, with the addition of a module for coating the inspected sample on the basis of FIG. 8, which is conducive to improving detection accuracy.

As shown in FIG. 9, the detection device 00 further comprises: a sample preparation module 104, the sample preparation module 104 being used to treat the tracer marker sample with a surface conductive thin film coating, and using the coated sample as a sample subject to secondary ion mass spectrometry analysis.

Optionally, the pre-set tracer comprises deuterium or deuterium oxide.

In summary, the present invention provides a water vapor intrusion path detection device for packaging devices, which determines the path and speed of water vapor intrusion in packaging devices by using heavy water tracer method combined with
5 secondary ion mass spectrometry analysis, solves the problem that existing packaging tests cannot identify the path and speed of water vapor intrusion, facilitates the improvement of dynamic detection accuracy of water vapor intrusion, facilitates the study of the failure mechanism of packaging chip reliability, monitors It can be widely used in industrial fields such as original packaging material suppliers,
10 packaging factories, display suppliers, chip suppliers and product terminal integrators.

It should be understood that the steps can be reordered, added or deleted using various forms of the process shown above. For example, the steps documented in the present invention may be performed in parallel or sequentially or in a different order,
15 as long as the desired results of the technical solutions of the present invention are achieved, and are not limited herein.

The above specific embodiments do not constitute a limitation on the scope of protection of the present invention. It should be understood by those skilled in the art
20 that various modifications, combinations, sub-combinations and substitutions can be made depending on the design requirements and other factors. Any modifications, equivalent substitutions and improvements, etc. made within the spirit and principles of the present invention shall be included in the scope of protection of the present invention.

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Claims

1. A method for detecting a water vapor intrusion path of a packaged device, comprising following steps:

- 5 ➤ with a predetermined tracer, a water vapor tracer mark is carried out on the packaged device to be tested, and the tracer mark sample is obtained;
- performing secondary ion mass spectrometry analysis on the tracer mark labelled sample to obtain the tracer intensity of the tracer marker labelled sample;
- 10 ➤ determining the path and speed of water vapor intrusion according to the tracer intensity;
- the water vapor intrusion path is determined according to the tracer intensity at different positions of the sample, and the water vapor intrusion speed is determined according to the time required for the tracer to reach different
- 15 positions of the sample;
- determining the water vapor intrusion path according to the tracer intensity at different positions of the sample, comprising: obtaining the tracer detection signal of any target point of the tracer-marked sample, and determining the indication of the target point according to the numerical
- 20 value of the tracer detection signal; if the tracer intensity of any marking time and any target point exceeds the predetermined concentration threshold, it is determined that the tracer penetrates into the point after the current marking time, and the target point is determined as the sample passes through the water vapor intrusion position corresponding to the current
- 25 marked duration.

2. The method according to claim 1, wherein the water vapor trace marking is carried out on the packaged device to be tested based on the predetermined tracer, and the trace mark sample is obtained, comprising:
- establishing a default tracer marking environment;
 - 5 ➤ marking the water vapor intrusion path of the packaged device under test based on the predetermined trace marking environment;
 - the tracer-marked samples are determined according to the path-marker results.
- 10 3. The method according to claim 2, wherein the predetermined trace marking environment comprises: marking environment temperature, marking environment relative humidity and marking duration.
4. The method according to claim 1, wherein said determining the path and speed of
15 water vapor intrusion according to the intensity of said tracer comprises:
obtaining the marking duration of the water vapor tracer marking process;
wherein the path and speed of water vapor intrusion are determined according to the intensity of the tracer and the duration of the marking.
- 20 5. The method according to claim 4, wherein the determining the path and speed of water vapor intrusion according to the tracer intensity and the marking duration comprises:
- determining the tracer invasion distance and invasion path according to the tracer intensity;
 - 25 ➤ establishing a target penetration curve according to the tracer invasion distance and the marking duration;

- the water vapor intrusion velocity is determined according to the target infiltration curve.

6. The method according to claim 1, wherein said carrying out secondary ion mass spectrometry analysis on said tracer-labelled sample to obtain the tracer intensity of said tracer-labelled sample comprises:

- obtaining at least one tracer detection signal of the tracer-labelled sample by secondary ion mass spectrometry;
 - determining the water vapor intrusion location and tracer intensity in the tracer-marked sample according to the tracer detection signal;
- wherein, the tracer detection signal is in one-to-one correspondence with the water vapor intrusion location.

7. The method according to any one of claims 1~6, characterized in that, before performing secondary ion mass spectrometry analysis on the tracer labelled sample, the method further comprises carrying out the surface conductive thin film coating treatment on the tracer mark sample.

8. The method according to any one of claims 1~6, wherein the predetermined tracer comprises deuterium or deuterium oxide.

9. A water vapor intrusion path detection device for a packaged device, characterized in that the device comprises:

- a marking module is used to perform water vapor trace marking on the packaged device to be tested based on a predetermined tracer, and obtain trace mark samples;

- a mass spectrometry module, configured to perform secondary ion mass spectrometry analysis on the tracer-labelled sample, to obtain the tracer intensity of the tracer-labelled sample;
 - a data processing module, configured to determine the path and speed of water vapor intrusion according to the intensity of the tracer;
 - the water vapor intrusion path is determined according to the tracer intensity at different positions of the sample, and the water vapor intrusion speed is determined according to the time required for the tracer to reach different positions of the sample;
 - determining the water vapor intrusion path according to the tracer intensity at different positions of the sample, comprising: obtaining the tracer detection signal of any target point of the tracer-marked sample, and determining the indication of the target point according to the numerical value of the tracer detection signal; if the tracer intensity of any marking time and any target point exceeds the predetermined concentration threshold, it is determined that the tracer penetrates into the point after the current marking time, and the target point is determined as the sample passes through the water vapor intrusion position corresponding to the current marked duration.
10. The detection device according to claim 9, characterized in that, the pre-defined tracer in the marking module is gaseous or liquid.