TITLE

BUILT-IN MACHINERY TO CARRY OUT TEMPERATURE-DEPENDENT TESTS ON ELECTRONIC COMPONENTS SUCH AS CHIPS

Technical field

The present invention relates to the technical field of machineries for carrying out temperature-dependent tests on electronic components in general, such as chips.

In particular, the invention relates to an innovative built-in machinery capable of enabling to carry out a temperature-dependent test on electronic components such as chips, printed circuit boards etc. remarkably saving energy and resulting in a particularly functional and simple machinery.

Brief outline of the prior art

It is known that all electronic components such as chips, printed circuit boards, sensors, etc. must be electronically tested in order to check the correct working thereof.

Depending on the operation that the electronic component must perform, a suitable test is provided which simulates a normal operating condition in order to check the correct working thereof.

The component under test is generally indicated with the English acronym DUT, “Device Under Test”.

Tests are often carried out at predetermined temperatures, that is temperatures which may vary for example from -50°C to 180°C.

Depending on the electronic component and the device in which it is installed, it might consequently be subject

to extreme thermal operating conditions and, for this reason, it is necessary to test it in these conditions.

At the state of the art, temperature-dependent tests require the use of testing machineries fitted with a testing chamber where components are moved through mechanical arms and within which is arranged the device under test. The whole machinery is insulated from the external environment to be brought to extreme thermal testing temperatures.

This kind of solution proved to be particularly complex for various reasons.

First of all, since the whole machinery is brought to testing temperature, all the mechanical and electronic parts constituting the machinery itself must be engineered to resist to high rises/falls in temperature. This fact not only complicates remarkably the planning and production thereof, but also increases the costs of production and maintenance thereof.

In particular, if handling robotic arms are provided, they may be operating in an environment in which extreme temperature variations occurs, causing high mechanical stress conditions to them.

Moreover, the environment to "heat" or "cool" is wide, since it basically surrounds the whole machinery and this requires more powerful and therefore more expensive air conditioning systems.

Summary of the invention

Therefore, the aim of the present invention is to provide an innovative testing machinery and relative testing method, which resolves said technical disadvantages.

In particular, the aim of the present invention is to provide an innovative machinery capable of carry out

temperature-dependent tests on electronic components, such as electronic chips, so as to enable a remarkable decrease in consumptions and so that this solution maintains at the most the componentry of the machinery itself.

These and other aims are therefore achieved with the present machinery to test at a predetermined controlled temperature (**T**), one or more electronic components (**DUT**), according to claim 1.

This machinery (1) comprises:

- A surface (4);
- At least a test recess (25) obtained in a part of said surface (4) and in which the component under test can be arranged;
- Means (27, 28a, 28b, 200) for generating a predetermined thermal condition within said test recess (25);
- Said test recess (25) being configured for being substantially thermally insulated from the surrounding environment.

In this manner, all the said technical drawbacks are readily solved.

In particular, the temperature-dependent area is limited to the recess only, which is thermally insulated from the rest of the machinery and from the rest of the surface 4 where it is obtained. In this manner, all the components of the machinery are protected from sudden temperature changes, thus being better preserved and then more long-lasting.

Therefore, the robotic arms of the machinery can operate outside the recess for the test 25 thus being preserved from sudden temperature changes.

Advantageously, a pre-conditioning recess (20) can be obtained onto said surface (4) configured for keeping a

predetermined temperature condition suitable for conditioning the components under test.

More specifically, advantageously, said recess for the test (25) is obtained on the base of the pre-conditioning recess (20).

In this manner, a pre-conditioning area is created, where to arrange all the components under test and then to move them one by one to the testing area obtained within the pre-conditioning recess itself.

Advantageously, said means for generating a predetermined temperature condition within the test recess (25) comprise at least a duct (27) arranged within the wall (30, 31) delimiting this recess for the test and suitable for enabling the circulation of a fluid at a predetermined temperature.

In this manner, the recess is readily brought to temperature.

Advantageously, a device (200) can be provided suitable for heating and/or cooling said fluid at the required temperature and piping it along said duct, preferably a liquid.

Advantageously, said means for generating a predetermined temperature condition within the recess for the test (25) comprise, in addition or alternative to the above solution, a gas flow (f2), preferably air, at a predetermined temperature and injected within said chamber by means of one or more injecting nozzles (29a, 29b) protruding from the walls delimiting the test recess (25).

Advantageously, said test recess (25) is made of a thermally insulating material.

Advantageously, the test recess is open above.

In particular, advantageously, said test recess (25) is delimited by lateral walls, by an upper opening, through which the component under test can be inserted

within it and by a base equipped with an arrangement area (26) on which the component under test can be arranged.

Advantageously, the machinery (1) further comprises a housing (11) for a testing device (100), said housing being arranged in such a way that, as soon as said testing device (100) is housed within said housing (11), a part thereof (101) provided with electric contacts for carrying out the test is arranged on said arrangement area (26).

In this manner, by arranging the DUT in the area 26, it is in electric contact with the ATE arranged below.

Advantageously, said test recess (25) is open above for enabling the insertion of the component under test and a barrier element is comprised adapted to prevent and/or reduce the thermal dispersion through said upper opening.

The barrier element is obviously arranged above the component under test so as to cover the opening delimiting a test volume which contains the component under test.

The publication WO2009/118855 is known which does not describe a barrier element arranged on the component under test and therefore, according to this solution, a remarkable thermal leakage occurs upwards.

In a possible solution, advantageously, this barrier element can be in the form of a laminar gaseous flow (f1), preferably air.

It can be advantageously at a predetermined temperature, for example room temperature.

Therefore, the laminar gaseous flow f1 is arranged above the component under test thus creating this barrier element. Figure 4 depicts schematically the laminar flow f1 arranged for closing the upper opening above the component under test.

The laminar flow, as depicted in figure 4 and as well known in the state of the art, is in form of a thin plane

(for example, with a thickness under 1 mm) and formed by parallel planes of flows parallelly sliding between each other, unlike a turbulent flow in which fluids have vortical motion and then they radiate in irregular manner in the whole area.

The said laminar gaseous flow is advantageously generated through suitable nozzles (20a, 28b) which expels the flow so as to generate said barrier element and obviously with these nozzles arranged above the component under test, so that, as described above, the laminar gaseous flow is above the component under test thus creating a closing cover.

In the known publication WO2009/118855 the discussed flow is not laminar and therefore does not form a barrier arranged above the component under test. Moreover, it is injected below and on the base of the component under test, therefore with a diametrically opposed solution with respect to the solution of the present invention.

Alternatively, a real cover can be used, preferably sliding, fold-out or a combination of both the cover and the laminar flow.

Advantageously, handling means (5) are arranged on said surface (4), for example at least a robotic arm (5) for moving the electronic components under test and/or a storage area (7) for the pieces under test, said movement means and/or said storage area being arranged outside the recess for the test (25).

Advantageously, a cover (3) of removable type can be provided, suitable for covering said surface (4).

It is also described here a method for carrying out a temperature-dependent test on one or more electronic components under test, the method comprising the following steps:

- Arrangement of at least a test recess (25) obtained,

preferably dug, in a part of a surface (4) and within which the component under test can be arranged;

- Arrangement of means (27, 28a, 28b, 200) for generating a predetermined thermal condition in said test recess (25) and with said test recess (25) configured for being thermally insulated from the surrounding environment;

- The method providing the generation of a predetermined thermal condition within said recess and the arrangement of the component under test within the recess.

Advantageously, handling means (5) are provided suitable for handling said electronic components under test between a storage area (7, 7') and said recess (25) and vice versa.

Advantageously, these movement means are arranged outside the recess (25);

A particularly preferred and advantageous embodiment of the present invention is the that providing a barrier to the thermal leakage through the upper opening, for example through a laminar flow arranged to cover the opening above the component under test.

Therefore, the following embodiment is held to be advantageous:

A machinery (1) for testing one or more electronic components (**DUT**) at a predetermined controlled temperature (**T**), the machinery comprising:

- A surface (4);

- At least a test recess (25) obtained in a part of said surface (4) and in which the component under test can be arranged;

- Means (27, 28a, 28b, 200) for generating a predetermined thermal condition within said test recess (25);

- Said test recess (25) being thermally insulated from

the surrounding environment;

- And wherein said recess is open above for enabling the insertion of the component under test and wherein a barrier element is comprised suitable for preventing and/or reducing the thermal dispersion through said upper opening and being arrangeable so as to be positioned above the component under test.

In this manner, the thermal leakage is limited and the area for the test is insulated from the rest of the machinery.

In a particularly advantageous embodiment, said barrier element is in form of a laminar gaseous flow (f1) at a predetermined temperature which is arranged above the electronic component to be tested.

In this manner, by activating the laminar flow, a cover strongly limiting the leakage is generated through a simple solution which does not interrupt the operativeness, since the robotic arm can pass through the flow while operating the placement/removal of the piece without necessarily interrupting the flow.

The laminar gaseous flow can be activated/deactivated thus creating a cover which can be passed through by mechanical arms when they operate the arrangement and the removal of the pieces under test.

This flow is generated through suitable nozzles arranged at suitable height in the lateral walls.

Advantageously, it is also described here a method for carrying out a temperature-dependent test on one or more electronic components under test, the method comprising the following steps:

- Arrangement of at least a test recess (25) obtained in a part of a surface (4) and in which it is arranged the component under test;

- Arrangement of means (27, 28a, 28b, 200) for

generating a predetermined thermal condition in said test recess (25) and with said test recess (25) thermally insulated from the surrounding space;

- The method providing:

- The arrangement of the component under test within the recess and the generation of a predetermined thermal condition within said recess and wherein it is further provided the phase of arrangement of a barrier element arranged above the component under test and which covers above the opening of the recess for the test.

Advantageously, said arrangement of the barrier element comprises the generation of a laminar gaseous flow arranged above the component under test so as to form a barrier element which shuts above the chamber for the test (25) thus thermally insulating it.

Brief description of the drawings

Additional features and advantages according to the invention will become apparent from the following description of preferred embodiments thereof, given only by way of non-limiting example, with reference to the attached drawings, wherein:

- Both figure 1 and figure 2 depict in axonometric view a schematization of the machinery for temperature-dependent tests according to the invention;

- Figure 3 depicts, in a broken-out section view, the area of the machinery in which the temperature-dependent test is carried out;

- Figure 4 depicts, in a section, the single cell in which the temperature-dependent test occurs and the components which cooperates with it.

Description of some preferred embodiments

Both figure 1 and figure 2 depict in axonometric

view a schematization of the machinery for carrying out predetermined temperature-dependent tests on electronic components, according to the invention.

The machinery is preferably built-in, as it comprises all the components for the test, including handling systems to handle the components under test.

The machinery, according to figure 1 and figure 2, comprises a bedplate 2 which forms a working plane 4 onto which one or more robotic arms 5 can be installed. To simplify, figure 1 and figure 2 depict an arm only but, obviously, the machinery can include even two or any number of arms.

The robotic arm works for moving the component under test from a point to another point within the working plane 4.

Any known robotic arm could be used and it is not the specific subject of the present invention.

By way of not limiting example only and therefore in a not limiting way, figure 1 depicts a robotic arm 5 rotatable around an axis having a tool 6 (for example a sort of mechanical pliers or sucker system) which works for collecting and releasing components under test. This tool 6 can be slidingly mounted, so as to lower or raise it.

Other types of robotic arms with different kinematic motions can obviously be used.

As described above, the robotic arm and the equipment thereof for collecting and releasing objects are well known over the state of the art and they are not the specific subject of the present invention.

Always with reference to figure 1, a storage area 7 for components under test is provided on the working plane 4.

The storage area 7 can provide a series of cavities

7' in which, the component undergone to the temperature-dependent test is arranged in each of them, waiting to be tested, as explained thereinafter.

Then a cover 3 is provided which can be removable, for example made of transparent material such as plastic or similar materials.

Figure 1 depicts this cover 3 separated from the rest of the machinery while figure 2 depicts the cover 3 applied so as to insulate the testing environment in order to avoid contaminations.

Obviously, the cover is preferably transparent so as to enable operators to inspect the whole area relative to the working plane 4 and visually supervise the course of the test.

According to the invention, the working plane 4 provides a first recess 20 obtained in said working plane and a second recess 25 is present on the base thereof, as described thereinafter.

The first recess 20 delimits an area for thermally conditioning the components under test while the second recess 25 is the recess where the test on the component occurs effectively at the testing temperature.

In this manner, unlike prior art and as described thereinafter, the whole volume of the machinery delimited by the cover 3 and by the surface 4 remains at room temperature while the extreme test conditions are created and kept within the recesses 20 and 25 only.

Therefore, it is evident that, according to this solution, a remarkable energy saving is obtained by simplifying further the whole machinery.

In fact, the robotic arm 5 operates within an environment at a predetermined ordinary temperature of the laboratory and then it is not subjected to thermal shocks.

Moreover, the test volume is extremely reduced with

respect to traditional machineries and then it implies a remarkable energy saving.

Therefore, by describing the invention in greater detail, always figure 1 depicts that a housing is obtained in the bedplate, for example openable and closable through a suitable wicket 12.

The housing 11 serves for inserting and removing the device which is generally in use to test the electronic component, while, as said, the recess 20 and the recess 25 are the environment in which the prearranged temperature conditions are created.

The device which is generally used for tests is well known in itself and it is not the subject of the invention. It is known with the acronym ATE, *"Automatic Test Equipment"*.

It is schematized in figure 3 with the number 100 and it is provided with a cradle 101 on which the component under test is arranged and it is fitted with electronic contacts to send signals for the test. Therefore, through the cradle, the ATE generates all the signals for the test.

When the ATE is inserted into the housing 11, when cradle 101 is arranged exactly below the recess 25 so that the robotic arm can position the electronic component under test, for example a board, above the cradle and with the electronic component under test which faces entirely within the recess 25.

Therefore, for this purpose, the recess 25 is fitted with a passage opening on the base thereof, i.e. the opening 26 of figure 3, which enables the cradle 101 to position itself for closing it.

Anyway, the opening 26 could be equivalently be closed by an electrically conductive component which transmits the signal from the underlying ATE to the

component under test.

Obviously, an electric communication occurs in both cases.

Therefore, the operator can readily insert the ATE manually into the housing 11 when he must carry out a series of tests and then remove it at the end of the test.

Figure 4 schematically depicts the second recess for the test 25 according to the invention and represented, only for descriptive purposes, in isolated way from the plane 4 and from the first tank 20.

This recess 25, as clearly inferable from figure 4 and from figures 1 and 2, is delimited by lateral walls 30 and by a base 31 so as to delimit a test volume 25' which represents the volume brought to the required temperature for the test.

Obviously, the recess 25 is open above for the insertion of the component under test.

This recess is generally shaped with a rectangular or squared plan but any shape can be realized.

As depicted in figure 3 and as described above, the recess has preferably on the base 30 an opening 26 for enabling to apply the component under test on the underlying ATE.

Only for descriptive straightforwardness, figure 4 does not depict this opening which is in figure 3 instead.

Figure 1 schematizes, in a not limiting example, a component (DUT) under test and arranged within the said chamber 25, in particular within the volume 25' of the chamber arranged at the required thermal condition, so as to be exposed to the temperature of the test.

The walls of the chamber are made of a thermally insulating material or they can be covered by insulating panels so as to be insulated better with respect to the external environment.

In this manner, the thermal condition created within the chamber is kept for enough time to carry out the test, thus reducing dissipations at a minimum.

Any insulating material useful for the purpose of thermal insulation can be used, without exceeding the scope of the present inventive concept.

Going further with the structural description of the invention, means for thermal regulation 27 are provided configured for enabling to create a predetermined temperature within the test volume 25'.

Preferably, the operative temperature obtainable within this volume 25' can vary from -60°C to approximately 180°C, and even more preferably from -50°C to 175°C.

It is immediately evident that the operating temperature range for carrying out the test is particularly wide and with particularly extreme peaks. Therefore, it is evident that the present solution enables the whole machine to be preserved enormously, since other components of the same machine, such as the robotic arm and electronic components are not forced to stand up to temperatures that can easily exceed one hundred degrees or fall far below zero degrees.

In the preferred embodiment of the invention, these means of thermal regulation 27 are in the form of a circulation system for a fluid, preferably a liquid.

In particular, as shown schematically in figure 2, a suitable device 200 can be provided which is able to heat or cool the fluid, preferably a liquid, used to create the temperature for the test. The device 200 heats or cools the fluid and injects it into the pipe/s 27 which run inside the walls of the recess 25, preferably but not necessarily on the base 31.

As described above, depending on the tests to be

carried out, operative conditions vary from -50°C to 180°C approximately.

Machineries suitable to heat and/or cool a fluid to the said temperature are known per se and available on the market and they are not the specific subject of the present invention.

In addition, the liquid used to be injected into the pipes 27 can be freely selected depending on the cases, so that is for example equipped with additives or with intrinsic physical properties such as not to freeze up to -50°C or not to evaporate up to 180°C.

Always in the first preferred embodiment of the invention and as schematically depicted in figure 4, the volume 25' which is brought to the temperature for the test is covered above through a first laminar flow (f1) at room temperature, for example at temperatures of the order of 25°C.

In this manner, the laminar flow (a gas such as air) creates a cover that insulated the internal volume 25', thus limiting thermal leakages through the opening above.

The flow must be preferably laminar, so as to form a sort of thin plane and must be preferably at room temperature (room temperatures mean temperatures fluctuating from 22 to 27 degrees, preferably 25 degrees) so as to obtain a greater insulating effect.

Figure 4 depicts also a second flow f2 arranged below the flow f1.

Even if it is depicted as laminar in figure 4, it is not necessarily laminar and it is an air flow which is brought to the same temperature of the fluid circulating in the pipes so as to create the required thermal condition within the volume 25' in faster and more efficient manner.

Therefore, this flow f2 is preferably turbulent and

anyway directed in such a way as to spread into the environment of the recess delimited by the upper laminar flow and the walls.

The same device 200 of figure 2 can heat/cool the gas f2 or a separated device can be provided.

A said, the device 200 is connected to possible quick connections on the machinery for the test to inject the fluid into the pipes and/or generate the air flow f2.

Then figure 4 schematizes the nozzles (28a, 28b) which generates the laminar flow (**f1**) and the nozzles (29a, 29b) which generates the temperature-dependent air flow within the chamber 25 (in case, laminar as well).

The laminar flow is readily obtained through a suitable shape of the nozzle and a suitable pressure of the flow.

As inferable from figure 4, the nozzles of the laminar flow (28a, 28b) are obviously arranged at a predetermined height so that the laminar flow is at a certain height from the base, so as to be arranged above the component under test and acts as cover.

A control device in form of a switch or similar ones enables to control the activation and the deactivation of the laminar flow f1 depending on needs.

In a possible embodiment of the invention, provided what has been described heretofore, it is possible to provide a real cover for shutting tight the upper opening.

Obviously, it can be of thermally insulating material too.

Moreover, it is preferably of foldaway type so as to slide between a closing position and an opening position with an automated sliding system.

In order to achieve a better insulating condition, the first laminar flow f1 can be maintained despite the presence of the cover.

Alternatively, an embodiment with the cover only and without laminar flow f1 could be provided.

The flow f2 in combination with the pipes 27 where the liquid flows act together, in synergistic way, to reach better and earlier, the environmental condition within the chamber. Nevertheless, in all the embodiment described, the use of only one solution or the other solution could be provided.

Going further with the description of the invention, for all the embodiments described, it is preferable to provide also a conditioning recess depicted in figure 2 with number 20 (see also figure 1 and 2).

The conditioning recess, as inferable, is a chamber where the testing environment conditions or similar conditions are created.

Therefore, the conditioning recess 20 is as well dug in the surface 4 and it is shaped by lateral walls, a base in which the recess 25 is further dug and it is open above.

On the base of the conditioning recess, the tank 25 depicted in figure 4 is therefore dug.

The conditioning recess will be of insulating material as well and it is brought to the temperature for the test through a pipe system in which the fluid circulates exactly as the recess 25 and possibly taking advantage of the same device 200.

In this conditioning recess, the presence of the laminar flow at room temperature is not necessary (even if not excluded) for insulating the thermal leakage from the upper opening thereof.

Therefore, this recess 20 is not for testing but only for conditioning, hence the temperature value does not need to be precisely maintained as in the recess 25. The conditioning recess has a greater surface for enabling

to put more components under test within it and each component is brought and tested one by one within the recess 25.

Through the presence of the preconditioning recess, the testing times are reduced in their whole, as many components which are arranged contextually in the preconditioning recess 20 reach the optimal temperature and when they are arranged in the recess for the test 25, they can be tested immediately without waiting further.

Substantially, therefore, through the present invention and in particular through the preconditioning chamber 20, a remarkable reduction of the conditioning time (soak time) occurs, since it is split between all the DUTs which are preconditioned.

Therefore, in use, the operation of the machinery of figure 1 and 2 is as follows.

On the storage area 7, within the dedicated recesses 7', the electronic components under test (the so-called DUT "Device under test") are positioned, which may be printed circuit boards or chips.

At this point, the ATE is arranged in the housing 11, taking care that the cradle 101 thereof faces toward the testing volume 25' within the tank 25 through the area 26 of the latter on the base.

Then the plane 4 is closed through the cover 3.

At this point, the robotic arm 5 (one robotic arm or more than one arm depending on the types of the built machinery), collects a certain number of components (DUT) in the storage area to position them within the recess 20 which represents the conditioning chamber (or preconditioning chamber, in other words).

When the cover has been applied, it is possible to crate the testing conditions by activating the device or the devices 200 which serve for making the fluid circulate

into the pipes and/or injecting the air flow (f2) at the required temperature.

In the same way, a similar environmental condition is created in the conditioning area 20 while the rest of the volume under the cover 3 is in fact at room temperature.

At this point, the robot 5, after waiting the necessary time to condition the components, collects the first component arranged in the recess and puts it into the recess 25 in position on the cradle 101 so that the planned test is carried out for the necessary time. At the end of the test the arm removes the component and arranges it in the storage area and then it collects from the storage area a new component which replaces the former one in the recess 25.

By means of the barrier element, the recess for the test 25 is thermally insulated and no thermal leakage occurs.

Just as in form of a flow, despite the use of a cover, it is passed through the handling arm, with no need to open and close continuously as in the event of use of a physical barrier such as a surface of material.

The proceeding goes on until all the planned components are tested.

As explained in the description, it is inferable that, according to this solution, the volume of an environment brought to the testing temperature is limited to the preconditioning recess and the recess for the test only, while all the components of the machinery, including the robotized arms, are arranged outwards at room temperature.

The conditioning chamber is important to preliminarily condition the component before the test and then to reduce the overall time of the operation.

Nevertheless, it is not necessary for the operation and for the scopes set by the present invention.

The preconditioning chamber as well could have a laminar flow f1 similar to that of chamber 25.