

## Through-type furnace and a die bonder with a through-type furnace

### Field of the invention

The invention relates to a through-type furnace with a releasable cover, so that the interior of the furnace is accessible for maintenance work. A working gas is supplied to the interior of the furnace. The invention further relates to a mounting apparatus known as die bonder with such a through-type furnace, in which the working gas is a protective gas. Examples for “dies” are especially semiconductor chips, but also capacitors, metal platelets etc.

### Background of the invention

It is common practice in the mounting of semiconductor chips to connect the semiconductor chips, mainly power semiconductors, to the substrate by means of solder in order to ensure via the solder connection an effective dissipation of the heat loss from the semiconductor chip that occurs during operation. But other “dies” are also soldered onto the substrate. Metallic substrates, so-called lead frames, are mainly used as substrates.

A die bonder which is suitable for this process is marketed by the applicant under the name DB2009 SSI. This die bonder comprises a through-type furnace, through which the substrates are transported one after the other to a soldering station where the solder is applied and melts, to a distributing station where the solder is distributed on the substrate location, and then to a bonding station where a semiconductor chip is placed by a pick-and-place system on the liquid solder. The solder can also be applied to the respective substrate location and distributed over the substrate location in a single process station. The through-type furnace is formed as a channel or tunnel with the necessary process openings. A protective gas atmosphere prevails in the channel in order to prevent undesirable oxidation of the substrates. Hydrogen is usually added to the protective gas in order to achieve a reduction of already existing oxides. The lower the oxygen concentration in the interior space of the furnace, the more effective the substrate is protected from oxidation.

The through-type furnace is formed by a furnace body and a cover, which delimit the channel. Since the furnace needs to be opened for maintenance work, the cover is detachably connected to the furnace body. The cover is relatively heavy and is therefore often only placed on the furnace body, where it presses with its own weight on the furnace body. The cover can also be screwed together with the furnace body. The interfaces between the individual parts of the cover and also between the cover and the furnace body are formed as mutually opposite surfaces, which are designated as mating surfaces within the scope of this disclosure. The mating surfaces ideally touch each other over a large surface area and thus ensure that the interior space of the furnace is sealed at all interfaces against the ambient environment. Since unavoidable gaps remain between the mating surfaces even in the case of the most diligent production, through which ambient air can enter the interior space of the furnace, mating surfaces are principally

avoided to the highest possible extent and many other measures are taken in order to prevent the entry of ambient air into the channel flooded with a protective gas.

In the Swiss patent application No. 01938/13, a through-type furnace is described in which the front side wall of the channel is formed with an elongated slot, so that the substrates can be transported with clamps. The interior space of such through-type furnaces is hardly under significant overpressure despite the supply of protective gas because they belong to the type of semi-open through-type furnaces.

There are also through-type furnaces in which a different working gas is used instead of a protective gas.

#### Brief description of the invention

The invention relates to a through-type furnace of the kind mentioned above and further to a die bonder with such a through-type furnace. In a die bonder, the cover of the through-type furnace comprises for example a process opening for applying solder to the substrates transported through the furnace, a process opening for distributing the solder on the substrate locations, and at least one process opening for applying the semiconductor chips to the substrates. The cover comprises at least one lid and optionally additionally at least one plate which covers one of the process openings, and optionally further elements. The process openings for applying and distributing the solder are covered for example by a plate which is moved back and forth in operation for reasons that are not explained here in closer detail. The plate is used for sealing the respective process opening in order to prevent the entry of oxygen to the highest possible extent. In order to prevent the intrusion of ambient air into the channel through the gaps present between the individual parts of the cover and the furnace body, the interfaces between the individual parts of the cover and also between the parts of the cover and the furnace body are principally formed as mutually opposite mating surfaces. The mating surfaces can be, but need not be, flat surfaces.

Examinations of the inventors have shown that oxygen reaches the channel not only at the entrance, exit and process openings and optionally through the longitudinal slit in the front side wall, but also through the very thin, but unavoidable gaps between the mating surfaces. In order to avoid this the invention proposes that all interfaces are provided with a groove, i.e. to form a groove in at least one of the mutually opposite mating surfaces, and to connect the groove via one or several closed channels and/or conduits with a vacuum source, so that it can be supplied with a negative pressure in operation. The groove acts in principle like a vacuum chamber and separates the interior space of the furnace at the respective interface with respect to pressure from the ambient environment. The negative pressure prevailing in the groove ensures on the one hand that gases such as oxygen reaching the gap between the mating surfaces from the ambient environment through diffusion and/or due to pressure difference only reach the groove and are extracted there by suction as a result of the prevailing negative pressure and are discharged to the ambient environment again. The negative pressure prevailing in the groove also ensures on the other hand that working gas flows from the interior space of the furnace to the groove in the case

of a pressure gradient between the interior space of the furnace and the groove and is also extracted there by suction and is discharged to the ambient environment. This loss of working gas is low and acceptable.

In the through-type furnace in accordance with the invention, the interfaces between the individual parts of the through-type furnace, which are detachably connected to each other, are formed with mutually opposite mating surfaces. At least some, and preferably all, of the interfaces comprise a groove which can be subjected in operation to a vacuum. The air which inevitably enters through the gaps between the mating surfaces is extracted by suction via the groove and does not reach the interior space of the furnace.

The invention will be explained below in closer detail by reference to an embodiment and the drawings. The drawings are schematic and are not shown in true scale for reasons of clarity of the illustration.

#### Description of the drawings

- Fig. 1 shows a top view of parts of a through-type furnace in accordance with the invention;
- Fig. 2 shows a cross-sectional view of two mutually adjoining lids of the through-type furnace;
- Fig. 3 shows an interface of the through-type furnace;
- Fig. 4 shows a process opening of the through-type furnace which is covered by a plate, and
- Fig. 5 shows a pressure diagram.

#### Detailed description of the invention

Fig. 1 schematically shows a top view of parts of a through-type furnace 1 in accordance with the invention, which is especially designed for use in a die bonder. The through-type furnace 1 comprises a furnace body 2, having a base 3 and two side walls 4, 5, which are either integral or are connected to each other in a gas-tight manner, and a cover 6. The furnace body 2 and the cover 6 form a channel through which substrates can be conveyed in a direction indicated by the arrow 7. This channel forms the interior space of the furnace. The front side wall 5 can contain a longitudinal slot, so that the substrates can be conveyed through the channel by means of a clamping system.

The cover 6 comprises at least one lid, but several lids 8 and 9 in this embodiment. Each of the lids 8, 9 can comprise one or several process openings 10. The first lids 8 are designed to be removed rather rarely, i.e. especially for maintenance work. The second lids 9 are formed as rapidly exchangeable parts, so that adjustments to various processes, e.g. adjustments to the process openings, are possible within a short period of time. The base 3 and/or one or several of the lids 8, 9 contain a plurality of holes (not shown), which can be connected to a protective gas source so that a protective gas can be supplied to the interior space of the furnace during operation.

The first lids 8 and also the second lids 9 are releasably connected to the furnace body 2. In a first

embodiment, the first lids 8 only rest with their own weight on the furnace body 2 and are manually removed for maintenance work. In a second embodiment, the first lids 8 also rest with their own weight on the furnace body 2, but can be pressed additionally in a pneumatic or hydraulic manner against the furnace body 2 and can also be lifted pneumatically or hydraulically from the furnace body 2, for example for maintenance work. Both the first lid 8 and also the second lid 9 can be screwed together with the furnace body 2. The lids 8, 9 rest on each other and/or overlap each other.

The process openings 10, which are provided for the purpose that the semiconductor chips can be placed on the substrates conveyed through the channel, are usually permanently open. Other process openings 10, e.g. a process opening through which a solder wire can be inserted from the outside into the channel so that solder can be molten on the substrate, can be covered by a fixed plate or also one that is movable in operation.

The interfaces between the lids 8, 9 and the furnace body 2 as well as the interfaces between adjacent lids and also the interfaces between the plates and the associated lid are formed as mutually opposite mating surfaces.

In the through-type furnace there are consequently the following interfaces where there is an unavoidable gap through which oxygen can reach the interior space of the furnace:

- mating surfaces between the first lids 8 and the furnace body 2;
- mating surfaces between the second lids 9 and the furnace body 2;
- mating surfaces between adjoining lids 8, 9, and
- mating surfaces between a lid with a process opening and the plate covering the process opening.

In order to exclude the intrusion of ambient air through said gaps or at least to reduce said intrusion, all of these interfaces, but at least the most relevant thereof, are provided with a groove, and the groove is connected via respective channels and/or gas lines to a vacuum source, which ensures in normal operation of the through-type furnace that a vacuum prevails in the groove. The groove is respectively arranged in one of the mutually opposite mating surfaces of the respective interface. Such a groove forms a vacuum chamber, which is connected in gas communication through the unavoidable gap between the mating surfaces to the ambient environment on the one hand and to the interior space of the furnace on the other hand.

Some aspects of the invention will be explained below in closer detail.

In order to seal the interfaces between the two side walls 4 and 5 by means of vacuum, the mating surfaces 12 of the furnace body 2, which are formed on the face ends of the side walls 4 and 5, are each provided with a groove 13. The grooves 13 advantageously terminate at a certain distance from the entrance and exit of the channel, in order to avoid that ambient air incoming through the entrance or exit

of the channel is drawn in directly into the grooves 13. The grooves 13 can be subdivided by separating walls 14 into individual sections. In this case, the individual sections are connected to the vacuum source. Since the mating surfaces 11 and 12 rest on each other, the grooves 13 can be arranged alternatively in the mating surfaces 11 of the lids instead of the mating surfaces 12 of the furnace body 2.

In order to seal the interfaces between mutually adjoining lids 8, 9 by means of vacuum, a groove 15 is applied to one of the mutually opposite mating surfaces of the two lids 8, 9. In a first embodiment, the side surfaces of two mutually adjoining lids 8, 9 rest on each other as accurately as possible and the groove 15 is formed in one of the mutually adjoining side surfaces of the first lid 8 or the second lid 9. In a second embodiment, the first lid 8 is formed with a projection 18 (Fig. 2) which overlaps the second lid 9.

The groove 15 either opens into the groove 13, as shown in Fig. 1, or is alternatively connected via a separate gas line to the vacuum source.

Fig. 2 shows a cross-sectional view of a first lid 8 and a second lid 9, which are adjacent to each other and border each other, according to the second embodiment. For reasons of clarity of the illustration, the lid 8 is shown offset to the left in an upwardly oblique manner, so that the gaps, in which the exterior air on the one hand and the protective gas on the other hand reach the groove 15, is clearly visible. The projection 18 lies as flat as possible on the second lid 9. The groove 15 is either formed in one of the mutually adjoining side surfaces of the adjacent lids 8, 9 (as shown) or in the bottom side of the projection 18 of the first lid 8 which is opposite the second lid 9. The arrow 16 indicates that exterior air flows into the gap between the projection 18 and the lid 9; the arrow 17 indicates that protective gas flows from the interior space of the furnace into the gap which exists between the two adjoining side walls of the two lids 8 and 9.

Fig. 3 shows a cross-sectional view of a further possibility to extract the air which enters the gap between the two mating surfaces 11 and 12 by suction via a groove. This is enabled by means of an element 19 which is attached to the exterior side of the through-type furnace above the gap, so that it covers the gap, and which comprises a groove 20 on the side facing the gap which is connected to the vacuum source.

Fig. 4 shows a top view of a lid 9 having a process opening 10 which is covered by a plate 21. The plate 21 can be mounted in a fixed manner or it can be entrained by a writing head (not shown). The writing head is used for example to guide a solder wire in an arbitrary direction over the substrate in order to write a solder track on the substrate or in order to distribute the deposited solder on the substrate by means of a pin driven by ultrasonic sound. The plate 21 always lies on the lid 9 and slides back and forth. The bottom side of the plate 21 and the upper side of the lid 9 are formed as mating surfaces. A groove 22 surrounds the process opening 10 completely and is connected via a channel 23 to the vacuum source. The channel 23 is for example formed in such a way that it opens into the groove 22 on the bottom side

of the lid 9.

In addition to the lids 8, 9, the cover 6 can therefore comprise one or several elements 19 and one or several plates 21.

Since the interior space of the furnace is continually supplied with a protective gas in operation of the through-type furnace, the pressure in the interior space of the furnace is equal to atmospheric pressure or higher than atmospheric pressure, while the vacuum prevailing in the grooves 13, 15, 20 and 22 is lower than the atmospheric pressure. The level of the vacuum in the respective grooves 13, 15, 20 and 22 is selected in such a way that there is a slight gas flow from the interior space of the furnace to the grooves 13, 15, 20 and 22. In order to achieve and set the desired vacuum, a vacuum source 24 and a common or separate adjustable pressure-control valves 25 is/are used with which the grooves 13, 15, 20 and 22 are connected via the gas line(s) 26. Fig. 5 shows a pressure diagram for a through-type furnace which comprises grooves 13 and 15.

## CLAIMS

1. Through-type furnace, comprising a furnace body (2) and a cover (6) which surround a channel through which substrates can be conveyed and to which a working gas can be supplied, wherein the cover (6) comprises at least one process opening (10), and interfaces between the individual parts of the through-type furnace, which are detachably connected to each other, are formed as flat connections with mutually opposite mating surfaces (11, 12), **characterized in that** at least some of the interfaces comprise a groove (13, 15, 20, 22) which can be supplied in operation with a vacuum.
2. Die bonder with a through-type furnace according to claim 1.