

The invention relates to a process for measuring the oscillation amplitude on an energy transducer which, together with a suitably constructed bonding head device for the ultrasound-bonding wire connection of electrical circuits to metal system carriers, is delivered to the respective processing point and, in order to generate a mechanical longitudinal oscillation, is acted upon by an input first ultrasound value in order to generate an electrical voltage, the instantaneous amplitude of the longitudinal oscillation of the energy transducer being measured. The invention also relates to a device according to the preamble of Claim 7. A process of this type and a device of this type are disclosed in EP-A-275 877 for example.

In the production of semiconductor chips the wire is bonded by means of the thermosonic process which is known per se and in which the necessary ultrasound energy for bonding the wire, which energy is to be transmitted to the point of contact, is delivered to a capillary tube which is disposed at the front end of a transducer and guides the wire. Thus the transmission of the ultrasound energy is dependent on various influencing factors such as mechanical variations which occur in particular when the transducer is clamped. Further factors influencing the bonding process reside in the fact that, owing to wear, the capillary tube is to be secured replaceably on the mounting device and in that factors which influence the bonding process occur on assembly and as a result of slight, for example production-dependent, deviations of the capillary tube to be newly inserted.

The present invention is concerned with the problem of measuring the oscillation amplitude at the capillary tube tip of an energy transducer constructed for bonding electrical circuits, the invention being based on the

object of indicating a process and a device for performing the process by means of which the absolute delivery movement of the bonding head device and the absolute longitudinal oscillation which are both achieved by means of predetermined factors are measured accordingly and the measurement result is used for determining ultrasound energy corresponding to the respective requirements.

In accordance with the invention this object is achieved by the process having the features of the characterizing part of the first claim.

The device according to the invention for performing the process consists of a carrier component having a supporting plate for a metal system carrier and a bonding head device which, together with the energy transducer disposed thereon, can be delivered to the respective processing point of the system carrier for bonding electrical circuits, the device being characterized in that a correspondingly disposed measuring head which is operationally connected to a computer is provided with at least one optical/electrical sensor; and in that the sensor comprises an optical range of action by means of which both a distance for the delivery movement of the bonding head device and a measured variable for the longitudinal oscillation of the energy transducer can be detected and activated by the measured values of the computer.

Further features of the invention emerge from the following description in conjunction with the drawings and the further claims.

In the following the invention will be described with reference to the drawings, in which:

Figure 1 shows a device for the ultrasound-bonding wire connection of circuits to electronic components in schematic perspective view; and

Figure 2 shows a sequence control system for the device according to Figure 1 in the form of a block diagram.

In order to illustrate the invention and as a general overview of the system Figure 1 shows a device 100 of the semiconductor connecting technique in a schematic and perspective view. The device 100 is used for the ultrasound-bonding wire connection of circuits to electronic components and substantially comprises a bonding head device 50, a bonding member 20 with a correspondingly associated bonding wire clamping device 30 and a schematically illustrated bonding wire delivery device 40.

Figure 1 further shows a mounting plate 45 of a holding-down device (not illustrated) by means of which a metal system carrier 46 (leadframe strip) is held in a positionally stable manner on a supporting plate 47 such that it is aligned exactly with the respective processing point P. Associated with the bonding member 20 is a measuring head 55 which has a recess 51 and which is secured in a stationary manner by means of a screw connection or the like (not shown in further detail) to a carrier component 60 of the device 100.

Disposed between the two walls 51', 51" (Figure 2) of the recess 51 in the measuring head 55, which walls are disposed at a spacing from each other, is a capillary tube 27 of an energy transducer 25 which is operationally connected to the bonding member 20. The bonding member 20 can be pivoted, together with the energy transducer 25, about an axis Z in the sense of

the arrow Z' (Figure 1). In the following description the energy transducer 25 will be known as the transducer 25 for the sake of simplicity.

Furthermore a sensor, for example an optical/electronic sensor 52, generally designated 52 is disposed in the measuring head 55. The sensor 52 substantially comprises a transmitter part 52' and a receiver part 52" disposed in a manner corresponding thereto. The optical range of action or measuring range of the sensor 52 is dimensioned such that it detects both the distance of the delivery movement of the bonding head and a measured variable of the longitudinal oscillation of the transducer 25. In this respect the distance of the delivery movement corresponds to a multiple, for example ten times the size, of the ultrasound amplitude of the capillary tube 27. The relative movement (longitudinal oscillation) of the capillary tube 27 is measured by the measuring head 55 disposed in a stationary manner on the carrier component 60 in the form of a machine base.

In the following the individual components of the device 100 shown in Figure 1, which are operationally connected to one another, will be described:

the bonding head device 50 substantially comprises a housing-like carrier component 15. The carrier component 15 can be moved in the plane in the X-direction and/or in the Y-direction by means of suitably disposed drives (not illustrated) according to a system of coordinates designated K. The carrier component 15 is provided on one side facing a slide plate 16 with an air cushion bearing which is not shown in further detail and which can be pretensioned by vacuum, whereby the carrier component 15 is mounted on the sliding surface 17 of the slide plate 16 such that it can move in an approximately freely hovering manner. The carrier component 15 is used for accommodating and bearing the bonding member 20 and

an extension arm 35. Disposed on the front end of the extension arm 35 is a suitably constructed bonding wire guide member 37 and an optical scanning component 36 (sensor) which is aligned on the respective processing point P of the system carrier 46. The movement of the carrier component 15 oriented in the X-direction and/or in the Y-direction is brought about as a result of the drives (not illustrated) which are operationally connected to the carrier element 15 being suitably excited with direct current.

A preferred and suitably constructed embodiment of the above-mentioned bonding head device 50 is disclosed in EP-A 0 317 787.

The carrier component 15 described above is used for accommodating the bonding member which is generally designated 20. The bonding member 20 substantially comprises a carrier frame 22 which can be pivoted in the sense of the arrow Z' about the axis Z of an axial body 19 mounted in the carrier component 15. In the front region the carrier frame 22 is constructed for mounting the transducer which is generally designated 25 and the bonding wire clamping device 30 mounted thereon.

Provided at the front end of the transducer 25 is the capillary tube 27 which is replaceably held and secured on the transducer 25 by a suitably constructed screw connection 26. Provided at the other, rear end of the carrier frame 22 is an electromotive drive which is generally designated 21 and which comprises stator bodies and coil formers which are disposed at spacings from one another and are not described in further detail. Disposed in a gap 23' between the stator bodies and coil formers is a swordlike magnet body 23 which is secured on the carrier frame 22. A movement of the magnet body 23 relative to the stator bodies and thus the pivoting movement (Figure 1) of the components 20,

25 and 30 oriented in the sense of the arrow Z' is attained by suitably exciting the coil formers with direct current.

A preferred and suitably constructed embodiment of the above-mentioned bonding member generally designated 20 is disclosed in EP-A 0 340 506.

Figure 1 further shows the schematically illustrated bonding wire delivery device 40 which comprises a removal component (not shown in further detail) by means of which a bonding wire 42 which is scanned in a contactless manner by an electrical/optical sensor (not illustrated here) is drawn off a suitably mounted wire coil 41. In this respect the bonding wire 42 is guided through the guide member 37 provided on the extension arm 35 and is substantially drawn off the wire coil 41 and guided centrally in the capillary tube 27 by means of the clamping device 30.

A preferred and suitably constructed embodiment of the above-mentioned bonding wire delivery device 40 is disclosed in EP-A 0 342 358.

Figure 2 shows a sequence control system in the form of a block diagram and the schematically illustrated bonding head device 50 and the measuring head 55 of the device 100 can be seen as well as a computer which is generally designated 200. The computer 200 substantially comprises a control unit 201, a multiplier 202, a generator 203, an amplifier 204, a first processor 205 and a second processor 206.

The method of operation of the device 100 in conjunction with the computer 200 illustrated in Figure 2 for the sequence control system composed substantially of the measurement of the movement of the bonding head device

50 and of the measurement of the oscillation amplitude of the transducer 25 as well as of the calibration of the individual measured values will be described below:

- the control unit 201 delivers a corresponding signal 1 to the electromotive drive which is not illustrated and is operationally connected to the carrier component 15, whereby the bonding head device 50 with the transducer 25 moves a predetermined distance S_k in the direction of the arrow Y' , the fixed distance S_k being measured by the sensor 52;
a signal 5 corresponding to the fixed distance S_k is delivered to the amplifier 204 for conversion into a corresponding voltage U_k , the first voltage U_k determined in this manner either being read or stored in an appropriate manner;
- a preprogrammed, first ultrasound value is delivered by the control unit 201 as signal 2 to the multiplier 202 and receives a corresponding signal 3 from the generator 203 by means of the multiplier;
the signal 3 is converted by the generator 203 into a first electric voltage and is delivered as signal 4 to an oscillating member 25' operationally connected to the transducer 25, whereby a mechanical longitudinal oscillation which is oriented relative to the stationary measuring head 55 is generated at the capillary tube 27 of the transducer 25, is measured by the sensor 52 as the first measured variable S_m and is detected;
a signal 6 corresponding to the first measured variable S_m (longitudinal oscillation) is delivered to the amplifier 204 which converts it into a corresponding, second voltage U_m , it likewise being

possible for the second voltage U_m determined in this manner to be stored;

- the amplifier 204 delivers the first voltage U_k as signal 7 and the second voltage U_m as signal 8 to the first processor 205 and the processor 205 determines the instantaneous (actual) ultrasound amplitude designated S'_m according to the following equation:

$$S'_m = S_k \frac{U_m}{U_k}$$

and delivers it as signal 9 to the second processor 206;

- in the second processor 206 the instantaneous ultrasound amplitude S'_m delivered as signal 9 is converted as a corresponding correction factor K_f and is delivered as signal 10 to the multiplier 202;
- in the multiplier 202 the first ultrasound value delivered as signal 2 by the control unit 201 is multiplied by the correction factor K_f determined and is delivered as the correspondingly corrected signal 3' to the generator 203;
- the signal 3' now being converted into a corrected, second voltage in the generator 203 and delivered as signal 4' to the oscillating member 25' which is operationally connected to the transducer 25.

With the process according to the invention and device according to the invention for performing the process it is now possible to measure directly and exactly at the

tip of the capillary tube present the variation in the longitudinal oscillation caused by replacement or wear of the capillary tube and to calibrate the first ultrasound value accordingly with the calculated correction value.

A particular advantage is further seen in the fact that the calibrated ultrasound value can be reproduced without particular expenditure on another bonding device and the electric circuits can thus always be bonded with the same ultrasound values.



CLAIMS

1. Process for measuring the oscillation amplitude on an energy transducer (25) which, together with a suitably constructed bonding head device (50) for the ultrasound-bonding wire connection of electrical circuits to metal system carriers, is delivered to the respective processing point and, in order to generate a mechanical longitudinal oscillation, is acted upon by an input first ultrasound value in order to generate an electrical voltage, the instantaneous amplitude of the longitudinal oscillation of the energy transducer (25) being measured, characterized in that the predetermined delivery movement of the bonding head device (50) is measured, a correction factor (K_f) is determined from the measured variables determined in this manner and the first ultrasound value and thus the oscillation amplitude of the energy transducer (25) are calibrated with the correction factor (K_f).

2. Process according to Claim 1, characterized in that on the one hand the longitudinal oscillation of the energy transducer (25) and on the other the delivery movement of the bonding head device (50) are measured optically/electrically and a first electrical voltage U_k proportional to the delivery movement and a second electrical voltage U_m proportional to the longitudinal oscillation are generated from the measured variables.

3. Process according to Claims 1 and 2, characterized in that:

- a) the actual delivery movement of the bonding head device (50) is measured as a distance (S_k) which is converted into the first electrical voltage U_k and is stored;



- b) the instantaneous longitudinal oscillation amplitude of the energy transducer (25) is measured as the first measured variable (S_m) which is converted into the second electrical voltage (U_m) and is stored;
- c) the ultrasound amplitude (S'_m) is determined by computer according to the following equation:

$$S'_m = S_k \frac{U_m}{U_k}$$

and in that

- d) the ultrasound amplitude (S'_m) determined in this way is converted as a correction factor (K_f).
4. Process according to Claim 1, characterized in that the first ultrasound value is multiplied by the correction factor (K_f) determined by computer.
5. Process according to any one of Claims 1 to 4, characterized in that when the bonding process is interrupted and at given time intervals, preferably at regular time intervals, the ultrasound amplitude (S'_m) is determined by computer and converted into the correction factor (K_f), the first ultrasound value being multiplied by this correction factor (K_f).
6. Process according to Claim 3, characterized in that the bonding head device (50) is displaced by a distance corresponding to a multiple, preferably ten times the size, of the ultrasound amplitude; and in that this distance (S_k) is measured and converted into the first electrical voltage (U_k).



7. Device (100) for performing the process according to Claim 1, consisting of a carrier component (60) having a supporting plate (47) for a metal system carrier (46) and a bonding head device (50) which, together with the energy transducer (25) disposed thereon, can be delivered to the respective processing point (P) of the system carrier for bonding electrical circuits, characterized in that a correspondingly disposed measuring head (55) which is operationally connected to a computer (200) is provided with at least one optical/electrical sensor (52); and in that the sensor (52) comprises an optical range of action by means of which both a distance (S_k) for the delivery movement of the bonding head device (50) and a measured variable (S_m) for the longitudinal oscillation of the energy transducer (25) can be detected and activated by the measured values of the computer (200).

8. Device according to Claim 7, characterized in that the measuring head (55) is secured on the carrier component (60), which is constructed as the machine base, in a manner such that it is stationary relative to the bonding head device (50) which can be delivered.

9. Device according to Claim 7, characterized in that the measuring head (55) has a recess (51) with two walls (51', 51'') disposed at a spacing from each other for accommodating a transmitter part (52') and a receiver part (52'') of the sensor (52), the recess (51) being constructed and dimensioned for accommodating the capillary tube disposed on the correspondingly movable energy transducer (25).

10. Device according to Claim 7, characterized in that the computer (200):

- a) comprises a control unit (201), a multiplier (202) and a generator (203) for achieving the delivery



movement of the bonding head device (50) and for acting upon the energy transducer (25) with a first ultrasound value; and

- b) is provided with an amplifier (204) in which the distance (S_k) of the bonding head device (50) is converted into the first electrical voltage (U_k) and the measured variable (S_m) of the longitudinal oscillation amplitude is converted into the second electrical voltage (U_m); and
- c) comprises a first processor (205) with means for determining the instantaneous ultrasound amplitude (S'_m) by computer and a second processor (206) with means for converting the instantaneous ultrasound amplitude (S'_m) into a correction factor (K_f) by which correction factor (K_f) the first ultrasound value can be multiplied in the multiplier (202).