Method of making wire connections of predetermined shape

The invention relates to a method of making a wire connection of predetermined shape between a first connecting point located on a semiconductor chip and a second connecting point. During semiconductor assembly, the electrical connections between the semiconductor chip and the substrate which carries the semiconductor chip are produced by means of such wire connections. Such methods are known for example from the documents US 4 327 860, US 5 111 989, US 5 395 035, US 5 148 964, US 5 192 018, US 5 205 463 and EP 792 716.

The object of the invention is to propose a method for making a shaped wire connection which is suitable for wire connections for so-called CSPs (Chip Scale Package or Chip Size Package).

The invention consists of the features given in claim 1. Advantageous embodiments are described in the dependent claims.

An embodiment of the invention is explained in more detail hereinafter with reference to the drawings.

There is shown, in:

Fig. 1 a wire connection 1 of predetermined shape which connects a connecting point on a semiconductor chip with a connecting point on a substrate, and

Fig. 2 a trajectory moved through by a capillary to produce the wire connection.

Fig. 1 shows a wire connection 1 of predetermined shape which connects a first connecting point 2 on a semiconductor chip 3 with a second connecting point 4 on a substrate 5. The wire connection 1 has two kinks K_1 and K_2 to which the angles α_1 and α_2 are assigned. Angle α_1 amounts to almost 90°. Angle α_2 is somewhat larger than 90° and amounts typically to 100 - 120°. In special cases however, the angle α_2 can amount to up to 150°. The length L of the wire connection 1 amounts to $L = L_H + L_1 + L_2 - \delta_1 - \delta_2$. L_H denotes the loop height, L_1 the distance from the first kink K_1 up to the second kink K_2 and L_2 the distance of the second kink K_2 from the second connecting point 4. δ_1 and δ_2 denote two correction values as the wire connection 1 demonstrates a curved and not an angular development at the two kinks K_1 and K_2. For CSPs, it is required that the loop height L_H as well as the distance D between the two connecting points 2 and 4 are as short as possible. In addition, the loop height L_H must only disperse slightly from wire connection 1 to wire connection 1 and the wire connection 1 between the first kink K_1 and the second kink K_2 should run as parallel as possible to the surface of the substrate 5 so that, on the one hand, the distance between the wire connection 1 and the edge of the semiconductor chip 3 remains large enough to guarantee the electrical insulation and, on the other hand, the distance remains large enough between the wire connection 1 and the edge of the CSP housing which arises from the subsequent encapsulation.

Fig. 2 shows a predetermined trajectory 6 run through by a capillary which leads from the first connecting point 2 located on the semiconductor chip 3 to the second connecting point 4 lying on the substrate 5. For this, the horizontally and vertically movable capillary is guided by a drive mechanism. A wire 7 runs through the capillary. The capillary serves not only to attach the wire 7 to the two connecting points 2, 4 but also to guide the wire 7 along the trajectory 6.

After attaching the wire 7 to the first connecting point 2, the capillary is moved along the trajectory 6 up to a first point P_1 for preforming the kink K_2 and to pull out the wire 7 as far as the required total length L for the wire connection 1 (Fig. 1) to be produced. Optionally, kink K_1 is also preformed. Preforming of kink K_2 and, if necessary, kink K_1 takes place in a well known manner by means of one or two so-called reverse movements 8, 9 which are movements directed away from the second connecting point 4. On passing through the point P_1 the wire 7 is optionally secured by a wire clamp. Afterwards, the capillary is moved further from point P_1 along a circular arc 10 up to a second point P_2 at which the wire 7 is locked in the capillary. The radius R of the circular arc 10 is centred in the first connecting point 2 or in immediate vicinity of the first connecting point 2 and, as the wire 7 is not straight, is somewhat less than the total length L of the wire connection. The movement of the capillary along this circular arc 10 prevents the wire from being pushed back through the capillary in the direction of the wire reel. Pushing back of the wire through the capillary and the possible later unreeling would take place jerkily because of the transition from the higher static friction to the lower sliding friction and lead to an uncontrollable total length L of the wire connection 1 and possibly to undesirable abrasion marks. This could give rise to a lower constancy of the loop height L_H and a worse parallelism of the wire piece between the two kinks K_1 and K_2 and the surface of the substrate 5 or the edge of the CSP housing. As soon as the wire 7 is locked in the capillary (at point P_2), the capillary can move through any trajectory curve within certain limits without the wire being pushed back through the capillary. With the invention, an extremely low dispersion of the loop height L_H is established as well as only minor deviations of the parallelism of the said wire piece.

When the capillary is located at the second point P_2, then the kinks K_1 and K_2 are still not very pronounced, ie, the angles α_1' and α_2' are considerably larger than the sought for values of 90° or 100 - 120°. In order to already obtain a sharper pronouncement of the kinks K_1 and K_2 during production of the wire connection 1, the capillary is advantageously moved on the trajectory 6 between the point P_2 and the second connecting point 4 along a loop 11 directed against the first connecting point 2. As the wire 7 is securely locked while the capillary passes through the loop 11, no wire is pushed back through the capillary even when the distance between the trajectory 6 and the first connecting point 2 is less than the required length L of the wire connection 1. A good preforming of the kinks K_1 and K_2 already on passing through the trajectory 6 results in the constancy of the loop heigh L_H and the parallelism of the wire piece between the two kinks K_1 and K_2 to the surface of the substrate 5 being guaranteed within

tight tolerances.

The position of point P_2 on the trajectory 6, where the wire 7 is locked in the capillary depends on various factors such as the characteristics of the wire 7 and the capillary, the length L of the wire connection 1, etc. If the position of point P_2 is shifted, for example to point P_2', then a direct trajectory 6' drawn dotted can possibly be passed through instead of the loop 11.

Preferably, the trajectory 6 has a first and second reverse movement 8 and 9 to preform the two kinks K_1 and K_2. The second reverse movement 9 is preferably moved along a circular arc centred in the second connecting point 4 so that no wire is pulled out of the capillary during this movement phase. If the second reverse movement 9 does not take place along the arc trajectory, but linear, as drawn with a dotted line, parallel to the surface of the semiconductor chip 3, then, during this movement phase, the wire is pulled through the capillary as the distance of the trajectory 6 to the first connecting point 2 increases. As the result of friction between the wire and the capillary, undesirable abrasion marks occur on the wire on the one hand and, on the other hand, the pulled out length of wire is subject to certain variations.

The second kink K_2 is preformed by means of the second reverse movement 9. If the movement of the capillary to unreel the wire 7 as far as the required wire length L takes place purely vertically up to point P_1, then there is practically no friction between the wire 7 and the capillary so that the unreeled length of wire is definitely reproducible. However, to shorten the bond cycle, it is possible on unreeling the wire 7 to lead the capillary not only vertically but also already with a horizontal movement component to a point P_1' instead of to point P_1. The point P_1' can be passed through without a stop movement.

The parallelism of the wire piece between the two kinks K_1 and K_2 to the surface of the substrate 5 can be calibrated by means of altering the total length L of the wire 7 which is unreeled. Correspondingly, the distance of point P_1 from the first connecting point 2 is increased or decreased and thereby also the radius R of the circular arc 10. In order to be able to perfectly bond wire connections of varying lengths for a semiconductor chip 3, it is planned that a correction factor $\delta = \delta_1 + \delta_2$ is envisaged for determining the wire length L whose value changes, eg, linearly, depending on the lengths L_1 and/or L_2.

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CLAIMS

1. Method of making a wire connection (1) of predetermined shape between a first connecting point (2) located on a semiconductor chip (3) and a second connecting point (4) whereby a wire runs through a capillary which serves not only the attachment of the wire (7) to the two connecting points (2; 4) but also guides the wire (7) between the two connecting points (2; 4) whereby the capillary, after attaching the wire (7) to the first connecting point (2), is moved along a predetermined trajectory (6) up to a first point (P_1; P_1') for the preforming of one or two kinks (K_2; K_1, K_2) and for pulling the wire (7) out as far as the required total length (L) of the wire connection (1) **characterised in that** the capillary is moved from the first point (P_1; P_1') along a circular arc (10) up to a second point (P_2; P_2') at which the wire (7) is locked in the capillary whereby the circular arc (10) is centred in the first connecting point (2) or in the immediate vicinity of the first connecting point (4) and that the capillary is then moved to the second connecting point (4).

2. Method according to claim 1, **characterised in that** the capillary is moved from the second point (P_2; P_2') to the second connecting point (4) along a loop (11) directed against the first connecting point (2).

3. Method according to claim 1 or 2, **characterised in that** on passing through the first point (P_1; P_1') the wire (7) is secured by means of a wire clamp.