CLAIMS

1. A wire-bonding apparatus comprising:

a capillary through which a wire is inserted;

an annular wire projecting length detection ring disposed coaxially with the capillary; and

a projecting length determination unit configured to determine whether or not a projecting length of the wire projecting from a tip of the capillary is appropriate based on detection on whether or not power is conductive when a predetermined inspection voltage is applied between the wire and the wire projecting length detection ring.

2. The wire-bonding apparatus according to claim 1, wherein

a predetermined inspection high voltage is applied between the wire and the wire projecting length detection ring to detect a presence of a discharge spark, if the power has been detected to be non-conductive when the predetermined inspection voltage is applied between the wire and the wire projecting length detection ring.

3. The wire-bonding apparatus according to claim 1, wherein

the projecting length determination unit:

previously obtains a relation regarding detection among the projecting length of the wire, the inspection high voltage, and the presence of a spark;

sets the inspection high voltage according to a bonding condition for wire bonding; and

determines whether or not the projecting length of the wire is suitable for the bonding condition.

4. The wire-bonding apparatus according to claim 3, further comprising:

a disconnection determination unit configured to apply a predetermined electrical signal and to determine whether or not the wire is disconnected based on a response of the application of the predetermined electrical signal, the predetermined electrical signal being applied between a bonding target and the wire in a clamped state after an operation of disconnecting the wire from a second bonding point is performed by moving the capillary while the wire is in the clamped state after wire bonding at the second bonding point is performed subsequent to wire bonding at a first bonding point, wherein

when the disconnection determination unit has determined that the wire is disconnected, the projecting length determination unit determines whether or not the projecting length of the wire is appropriate, and when the projecting length of the wire has been determined to be inappropriate,

outputs an abnormal signal determining that bonding at the second bonding point has not been performed and that the wire has been disconnected between the first bonding point and the second bonding point.

5. The wire-bonding apparatus according to claim 4, further comprising:

a preliminary bonding unit configured to, when the projecting length of the wire has been determined to be inappropriate, make a disconnected tip portion of the wire be an appropriate projecting length using a previously determined preliminary bonding point.

6. The wire-bonding apparatus according to one of claims 4 and 5, wherein

the wire bonding at the first bonding point and the second bonding point is performed according to a wedge bonding method.

7. A method of manufacturing a semiconductor device, the method comprising:

a first wire bonding step of bonding a wire to a first bonding target at a first bonding point of wire bonding using a capillary through which the wire is inserted, the bonding being performed according to a wedge bonding method;

a second wire bonding step of feeding the wire by a predetermined wire length from the first bonding point after the wire bonding at the first bonding point, and bonding the wire to a second bonding target at a second bonding point of the wire bonding;

a movement step of, after the wire bonding at the second bonding point, moving the capillary through which the wire is inserted while the wire is clamped to disconnect the wire from the second bonding point;

a disconnection determination step of applying a predetermined electrical signal between the second bonding target and the wire after the capillary has been moved to disconnect the wire, and determining whether or not the wire is disconnected based on a response of the application of the predetermined electrical signal;

a projecting length determination step of determining whether or not the projecting length of the wire projecting from the tip of the capillary is appropriate when the wire has been determined to be disconnected, the determination being made based on detection on whether or not power is conductive when a predetermined inspection voltage is applied between the wire and an annular wire projecting length detection ring disposed coaxially with the capillary; and

an output step of, when the projecting length of the wire has been determined to be inappropriate, outputting an abnormal

signal determining that bonding at the second bonding point has not been performed and that the wire has been disconnected between the first bonding point and the second bonding point.

8. The method of manufacturing a semiconductor device according to claim 7, wherein

a predetermined inspection high voltage is applied between the wire and the wire projecting length detection ring to detect a presence of a discharge spark, if the power has been detected to be non-conductive when the predetermined inspection voltage is applied between the wire and the wire projecting length detection ring.

9. The method of manufacturing a semiconductor device according to claim 7, the method further comprising:

a preliminary bonding step of making a disconnected tip portion of the wire be an appropriate projecting length using a previously determined preliminary bonding point when the projecting length of the wire has been determined to be inappropriate.

CLAIMS

1. A wire bonding apparatus comprising:

a capillary through which a wire is inserted;

an annular wire projecting length detection ring disposed coaxially with the capillary; and

a projecting length determination unit configured to determine whether or not a projecting length of the wire projecting from a tip of the capillary is appropriate based on detection on whether or not power is conductive when a predetermined inspection voltage is applied between the wire and the wire projecting length detection ring.

2. The wire bonding apparatus according to claim 1, wherein

a predetermined inspection high voltage is applied between the wire and the wire projecting length detection ring to detect a presence of a discharge spark, if the power has been detected to be non-conductive when the predetermined inspection voltage is applied between the wire and the wire projecting length detection ring.

3. The wire bonding apparatus according to claim 2, wherein

the projecting length determination unit:

previously obtains a relation regarding detection among the projecting length of the wire, the inspection high voltage, and the presence of a spark;

sets the inspection high voltage according to a bonding condition for wire bonding; and

determines whether or not the projecting length of the wire is suitable for the bonding condition.

4. The wire bonding apparatus according to claim 3, further comprising:

a disconnection determination unit configured to apply a predetermined electrical signal and to determine whether or not the wire is disconnected based on a response of the

application of the predetermined electrical signal, the predetermined electrical signal being applied between a bonding target and the wire in a clamped state after an operation of disconnecting the wire from a second bonding point is performed by moving the capillary while the wire is in the clamped state after wire bonding at the second bonding point is performed subsequent to wire bonding at a first bonding point, wherein

when the disconnection determination unit has determined that the wire is disconnected, the projecting length determination unit determines whether or not the projecting length of the wire is appropriate, and when the projecting length of the wire has been determined to be inappropriate, outputs an abnormal signal determining that bonding at the second bonding point has not been performed and that the wire has been disconnected between the first bonding point and the second bonding point.

5. The wire bonding apparatus according to claim 4, further comprising:

a preliminary bonding unit configured to, when the projecting length of the wire has been determined to be inappropriate, make a disconnected tip portion of the wire be an appropriate projecting length using a previously determined preliminary bonding point.

6. The wire bonding apparatus according to claim 4, wherein

the wire bonding at the first bonding point and the second bonding point is performed according to a wedge bonding method.

7. A method of manufacturing a semiconductor device, the method comprising:

a first wire bonding step of bonding a wire to a first bonding target at a first bonding point of wire bonding using a capillary through which the wire is inserted, the bonding being performed according to a wedge bonding method;

a second wire bonding step of feeding the wire by a predetermined wire length from the first bonding point after the wire bonding at the first bonding point, and bonding the wire to a second bonding target at a second bonding point of the wire bonding;

a movement step of, after the wire bonding at the second bonding point, moving the capillary through which the wire is inserted while the wire is clamped to disconnect the wire from the second bonding point;

a disconnection determination step of applying a predetermined electrical signal between the second bonding target and the wire after the capillary has been moved to disconnect the wire, and determining whether or not the wire is disconnected based on a response of the application of the predetermined electrical signal;

a projecting length determination step of determining whether or not the projecting length of the wire projecting from the tip of the capillary is appropriate when the wire has been determined to be disconnected, the determination being made based on detection on whether or not power is conductive when a predetermined inspection voltage is applied between the wire and an annular wire projecting length detection ring disposed coaxially with the capillary; and

an output step of, when the projecting length of the wire has been determined to be inappropriate, outputting an abnormal signal determining that bonding at the second bonding point has not been performed and that the wire has been disconnected between the first bonding point and the second bonding point.

8. The method of manufacturing a semiconductor device according to claim 7, wherein

a predetermined inspection high voltage is applied between the wire and the wire projecting length detection ring to detect a presence of a discharge spark, if the power has been detected to be non-conductive when the predetermined inspection

voltage is applied between the wire and the wire projecting length detection ring.

9. The method of manufacturing a semiconductor device according to claim 7, the method further comprising:

a preliminary bonding step of making a disconnected tip portion of the wire be an appropriate projecting length using a previously determined preliminary bonding point when the projecting length of the wire has been determined to be inappropriate.