Method for Permanent Connection of Two Metal Surfaces

Description

The invention relates to a method for the production of a permanent connection between two metal surfaces.

The production of permanent, electrically conductive, metallic connections between two metal surfaces is gaining increasing importance in the semiconductor industry. Primarily for new types of packaging technologies in the area of so-called "3D integrated devices or ICs (3D IC)," metallic bond connections between two functional planes play a decisive role. In this case, first active or passive circuits are manufactured on two independent substrates, and the latter are permanently connected to one another in a bonding step, and the electrical contacts are established. This connection step can be accomplished either by connecting two wafers (wafer to wafer - W2W), by connecting one or more chips with a wafer (chip to wafer - C2W), or by connecting one or more chips with a chip (chip to chip - C2C) method. In the case of these connection methods, direct connections between two connecting surfaces are of great interest, whereby both surfaces consist of the same material (metal) to a large extent. Here, methods that, to a large extent, do not require additional materials in this connection plane are quite especially preferred. In this connection, copper (Cu) or aluminum (Al) or gold (Au) is commonly used as metallization. It should be clarified, however, that this invention basically also operates in interaction with other metals, and the metal selection is based predominantly on requirements of chip structures and pre-conditioning steps. Therefore,

Embodiments of this invention disclose a method with which a reduced process temperature and/or a reduced process time can be achieved in metallic bond connections.

According to an aspect, there is provided a process for the production of a permanent, electrically conductive connection between a first metal surface of a first substrate and a second metal surface of a second substrate with the following method steps: - Conditioning of the first and second metal surfaces by implanting gas ions or by application of metallic nanoparticles in such a way that in a connection of the metal surfaces a permanent, electrically conductive connection - produced at least by surface diffusion of metal ions and/or metal atoms of the two metal surfaces and/or grain boundaries diffusion - is produced,- Orientation and connection of the first and second metal surfaces, whereby during the conditioning, orientation and connection, a process temperature of at most 300°C is not exceeded.

Also, all combinations that consist of at least two of the features that are indicated in the description, the claims and/or the figures fall within the scope of the invention. In the indicated ranges of values, values that lie within the above-mentioned limits are also disclosed as boundary values and can be claimed in any combination.

This invention now presents methods and processes by means of which the bond temperature for authentic bond connections can be reduced dramatically, and this thus makes possible the use of connections, which do not require foreign metal, for a broad area of use. An additional use of this invention is also the acceleration of the process, which can be achieved in the case of ideal, selected process parameters and which increases the economic efficiency of the process.

Diffusion can be divided in general into substitutional and interstitial diffusion.

In the substitution diffusion, the diffusion jumps of the individual atom take place along each point in the grid, on which other atoms could be located. As a result, such a diffusion jump can actually take place, if necessary, at the position to which an atom would jump but no other atom can be located (exceptions exist: direct atom exchange mechanisms, which are discussed scientifically but are not yet detected; if they exist, they occur so rarely in comparison to the other atom exchange mechanisms that they can be

Claims

1. Process for the production of a permanent, electrically conductive connection between a first metal surface of a first substrate and a second metal surface of a second substrate with the following method steps:

- Conditioning of the first and second metal surfaces in such a way that in a connection of the metal surfaces a permanent, electrically conductive connection - produced at least by surface diffusion and/or grain boundary diffusion of metallic ions between similar metal ions and/or metal atoms of the two metal surfaces – is produced,
- alignment and bonding of the first and second metal surfaces, whereby during the conditioning, alignment and bonding, a process temperature of at most 300°C is not exceeded.

2. Method according to Claim 1, wherein the first and/or second metal surface(s) has (have) a layer thickness $S < 5$ nm.

3. Method according to one of the preceding claims, wherein hydrogen is implanted during conditioning of the first and second metal surfaces.

4. Method according to one of the preceding claims, wherein the conditioning comprises the adjusting of the surface roughness of at least one of the metal surfaces to < 20 nm.

5. Method according to one of the preceding claims, wherein the first substrate comprises a metallic region surrounding the metal surface and/or the second substrate comprises a metallic region surrounding the metal surface.