Method for Applying a Bonding Layer

The invention relates to a method for applying a bonding layer as well as a substrate provided with a bonding layer.

In the state of the art, countless methods to connect various materials to one another exist. In the semiconductor industry, in recent years, primarily the bonding technology to connect two substrates temporarily or permanently to one another has gained acceptance. Very often, the bonding process takes place between semiconductor(s) and/or metal structures on the substrate. The best-known metal bonding technology of recent times is copper bonding. Substrates are the carriers for functional assemblies such as microchips, memory chips, or MEMS assemblies. In recent years, increasingly attempts were made to produce a connection between assemblies arranged on various substrates in order to avoid a wire-bonding process between the assemblies that is labor-intensive, costly, and susceptible to flaws. In addition, the direct bonding variant has the enormous advantage of elevated assembly density. The assemblies must no longer be positioned beside one another and connected via wires, but rather are stacked on one another and connected vertically to one another by various technologies. In most cases, the vertical connections are produced by contact points. The contact points of different substrates must be identical to one another and are oriented to one another before the actual bonding process.

Another little-used process is aluminum bonding. In this process, aluminized points on the surface of a substrate are to be bonded with a material lying on a second substrate. In this case, this can be aluminum or a suitable, different material. One drawback of aluminum is its extreme oxygen affinity. Even with copper, the oxygen affinity is high, so that copper oxides must be regularly removed before a bonding process. With aluminum, the oxygen affinity is higher by a multiple. Aluminum still forms relatively thick, passivating aluminum oxide layers, which are difficult to remove. In contrast to copper, aluminum is therefore little used for bonding connections, since at this time, because of the very stable oxide layers, no reliable bonding result

can be achieved at a reasonable cost. Nevertheless, aluminum is widely used in the semiconductor area to produce metal connections on the chip surface in the lateral direction. Here, aluminum is distinguished in that it has significantly slower diffusion behavior in silicon than, for example, copper or gold. Metal diffused into silicon would impair the characteristics of transistors or make the latter completely unfunctional. Based on this advantageous diffusion behavior, paired with low costs and relatively good electrical conductivity, aluminum has been established over many years as the material that is mainly used for producing electrical connections laterally on the semiconductor chips. Recently, in chips of the newest generation, aluminum is increasingly being replaced by copper because of its better electrical conductivity; however, aluminum still enjoys great importance, primarily in the production of chips on 200 mm substrates with somewhat older production technology. It is specifically these production surrounding areas/plants that in recent times have found enhanced use for the production of MEMS (micro-electro-mechanical systems) components. The production of these MEMS components in turn frequently requires bonding processes, so that the need for a reliable aluminum bonding process increases. Outside of the semiconductor industry, aluminum is also a structural material that is in demand, since it is light, inexpensive, and primarily hardenable. In the semiconductor industry, based on the above-mentioned reasons, it has been attempted for some time to develop processes that make aluminum usable as structural material and in particular material for bonding connections.

The greatest problem when using oxygen-affine materials such as copper and aluminum is the avoidance of oxidation on bonding surfaces and/or the complete removal of oxide from bonding surfaces before a bonding process. Extremely oxygen-affine materials such as aluminum produce, moreover, oxides that are strong and difficult to reduce. Plants for oxide removal are expensive, labor-intensive and under certain circumstances dangerous (toxic substances).

Embodiments of this invention disclose a method as well as a substrate provided with a bonding layer, with which an oxidizable material (such as in particular aluminum) can be used for bonding.

According to first aspect of the present invention, there is provided a method for bonding a first substrate with a second substrate, said method including: applying an oxidizable basic material as a basic layer on a bonding side of the first substrate; at least partially covering the basic layer with a protective layer having a thickness of less than 100 nm, the protective layer being comprised of a protective material containing at least one non-metal chemical element selected from the group consisting of Si, Se, C, O, and Te; and bonding the first and second substrates, wherein the protective material is dissolved completely in the basic material during the bonding.

According to second aspect of the present invention, there is provided a method for bonding a first substrate with a second substrate, said method including: applying an oxidizable basic material as a basic layer on a bonding side of the first substrate; at least partially covering the basic layer with a protective layer having a thickness of less than 100 nm, the protective layer being comprised of a protective material containing at least one non-metal chemical element selected from the group consisting of Si, Se, Te, C, O, and B; and bonding the first and second substrates, wherein the protective material is dissolved completely in the basic material during the bonding.

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

Embodiments of this invention provide a bonding layer, consisting of a basic layer and a protective layer, in particular as a diffusion pair, on the substrate,