Method for Permanent Bonding of Wafers

Specification

This invention relates to a method for bonding of a first contact surface of a first substrate to a second contact surface of a second substrate.

The objective in permanent or irreversible bonding of substrates is to produce an interconnection which is as strong and especially as irreversible as possible, therefore a high bond force, between the two contact surfaces of the substrates. There are various approaches and production methods for this in the prior art.

The known production methods and the approaches which have been followed to date often lead to results which cannot be reproduced or can be poorly reproduced and which can hardly be applied especially to altered conditions. In particular production methods which used at present often use high temperatures, especially > 400°C in order to ensure reproducible results.

Technical problems such as high energy consumption and possible destruction of structures which are present on the substrates result from the high temperatures of partially far above 300°C which have been necessary to date for a high bond force.

Other demands consist in the following:

- front-end-of-line compatibility.

  This is defined as the compatibility of the process during the production of the electrically active components. The bonding process must therefore be designed such that active components such as transistors, which are already present on the structure wafers, are neither adversely affected nor damaged during the processing. Compatibility criteria include mainly the purity of the chemical elements (mainly in CMOS structures) and mechanical loadability, mainly by thermal stresses.

- low contamination.

- no application of force.

The reduction of the bond force leads to more careful treatment of the structure wafer and thus to a reduction of the failure probability by direct mechanical loading.

Embodiments of this invention devise a method for careful production of a permanent bond with a bond force which is as high as possible.

According to an aspect of the present invention, there is provided a method for bonding of a first contact surface of a first substrate to a second contact surface of a second substrate said method comprising: forming a reservoir in a surface layer on the first contact surface, wherein the reservoir is formed by plasma activation, wherein reduced species of the ions present in the plasma process are located in the reservoir, at least partially filling of the reservoir with a first educt or a first group of educts, contacting the first contact surface with the second contact surface for formation of a prebond connection and forming a permanent bond between the first and second contact surface, said permanent bond at least partially strengthened by the reaction of the first educt with a second educt contained in a reaction layer of the second substrate.

All combinations of at least two of the features given in the specification, the claims and/or the figures also fall within the framework of the invention. At the given value ranges, values within the indicated limits will also be disclosed as boundary values and will be claimed in any combination.

The basic idea of embodiments of this invention is to devise a reservoir for holding a first educt at least on one of the substrates, to react it after making contact or producing a temporary

Claims

1. Method for bonding of a first contact surface of a first substrate to a second contact surface of a second substrate said method comprising:

- forming a reservoir in a surface layer on the first contact surface, wherein the reservoir is formed by plasma activation, wherein reduced species of the ions present in the plasma process are located in the reservoir,
- at least partially filling of the reservoir with a first educt or a first group of educts,
- contacting the first contact surface with the second contact surface for formation of a prebond connection and
- forming a permanent bond between the first and second contact surface, said permanent bond at least partially strengthened by the reaction of the first educt with a second educt contained in a reaction layer of the second substrate.

2. Method as claimed in claim 1, wherein formation and/or strengthening of the permanent bond takes place by diffusion of the first educt into the reaction layer.

3. Method as claimed in claim 1, wherein the formation of the permanent bond takes place at a temperature between room temperature and 200° Celsius, especially during a maximum of 1 hour.

4. Method as claimed in claim 1, wherein the irreversible bond has a bond strength of greater than 1.5 J/m^2.

5. Method as claimed in claim 1, wherein during the reaction a reaction product with a greater molar volume than the molar volume of the second educts is formed in the reaction layer .

~~6. Method as claimed in claim 1, wherein the reservoir is formed by plasma activation, wherein reduced species of the ions present in the plasma process are located in the reservoir.~~

~~7~~6. Method as claimed in claim 1, wherein the reduced species are O_2-, N_2-, H_2-, Ar-ions.

~~8~~7. Method as claimed in claim 1, wherein the surface layer is comprised of an amorphous material and the reaction layer is comprised of an oxidizable material.

~~9~~8. Method as claimed in claim 1, wherein between the second contact surface and the reaction layer there is a growth layer comprised predominantly of native silicon dioxide.

~~10~~9. Method as claimed in Claim ~~9~~8, wherein before formation of a permanent bond the growth layer has an average thickness A between 1 angstrom and 10 nm.

~~11~~10. Method as claimed in claim 1, wherein a reservoir is formed in a vacuum.

~~12~~11. Method as claimed in claim 1, wherein the reservoir is filled by one or more of the following steps:

- exposing the first contact surface to a fluid comprising deionized H_2O and/or H_2O_2, and
- exposing the first contact surface to N_2 gas and/or O_2 gas and/or Ar gas and/or forming gas comprising 95% Ar and 5% H_2.

~~13~~12. Method as claimed in claim 1, wherein the reservoir is formed in an average thickness (R) between 0.1 nm and 25 nm.

~~14~~13. Method as claimed in claim 1, wherein the average distance (B) between the reservoir and the reaction layer immediately before formation of the permanent bond is between 0.1 nm and 15 nm.

~~15~~14. Method as claimed in one of the preceding claims, wherein the irreversible bond has a bond strength which comprises 2 times the prebond strength.