OR0505

Multipin corona treatment – a new surface activation method for low-temperature direct bonding

Benedikt Michel[1], Marko Eichler[2], Claus-Peter Klages[1]

[1]Institut für Oberflächentechnik, Braunschweig, Germany [2]Fraunhofer Institut für Schicht- und Oberflächentechnik, Braunschweig, Germany

b.michel@tu-bs.de

We developed a multipin-corona treatment process, which was found to be an effective and non-destructive method, activating silicon surfaces for the application of low-temperature direct bonding in microsystems technology.
A common attribute of well known and industrially established surface activation methods (i.e. DBD and low pressure plasma) is the direct access of the plasma to the surface. This can be troublesome, especially in cases where micro devices and insulating films on the wafer will be damaged due to the impact of high electric fields. By contrast, the new corona process makes use of the inhomogeneity of the electric field in the vicinity of a needle tip. The voltage applied to the needles is increased only so far, that the plasma is ignited solely within a small volume surrounding each needle tip. The plasma zone and the wafer surface are spatially separated and the electric field stress at the wafer surface is greatly reduced.
However, the distance between the plasma zone at the needle tip and the substrate is still small enough for charged species (e. g. oxygen ions) to be transferred by the driving force of the electric field. The latter is especially of academic interest, because it can be helpful in gaining a better understanding of electron and ion influence on the activation.
The mechanical setup consists of a single row of copper needles with a pitch of 5 mm. The silicon wafer is fixed on a grounded chuck, while an alternating high voltage (Vp = 2 to 2.5 kV, f = 19 to 23 kHz) is applied to the row of copper needles, mounted at a distance of a few millimeters above the silicon surface. In contrast to the DBD setup, there is no dielectric barrier in the electrical path.
Initial experiments were done with oxide-free silicon wafers, which were moved for a few ten seconds through the corona zone. The activated wafers were rinsed with DI water and spin dried prior to direct bonding. Annealing was done at 200 °C for 5 hours. Bond strength values, which were usually determined by the crack opening (or "razor blade") method, showed a significant increase for corona pretreated wafer pairs, compared to wet chemically (i.e. RCA-) cleaned samples. Upon parameter optimization, bond strength could be increased to a level, where the compound regularly broke upon insertion of a 40 µm blade, indicating fracture surface energies well beyond 1.5 J/m².

Keywords
Corona

Surface Activation
Low Temperature Direct Bonding