On the effect of plasma treatments on low-temperature bonding

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Because completely processed wafers are used in microsystem technologies, the application of wafer bonding processes require annealing steps after bonding below 400°C. This is generally known as low-temperature wafer bonding. Annealing steps below 400°C after bonding of conventional hydrophilic wafers cause low interface energies and the formation of interface defects (bubbles) which are avoidable by an additional surface activation before bonding. Today a plasma treatment is mostly applied as activation process. There are numerous publications in the literature using different plasmas (oxygen, inert gases, fluorides, etc) produced by different sources (RIE, ICP, ECR). The results of these investigations are also different [1].

The present paper deals with detailed analysis on the effect of different plasmas produced by different sources on the surface structure of silicon wafers and on the bonding behaviour. Especially plasmas produced by RIE (barrel reactor, plate reactor), ICP, and microwaves were studied. Besides these low-pressure plasma sources, also atmospheric plasma processes are regarded. The investigations were carried out with plasmas of oxygen and inert gases which are most important for further applications.

The surface structure of silicon (100)-wafers was analyzed after the different plasma treatments by infrared spectroscopy (ATR, reflection spectroscopy), ellipsometry, and AFM. It is shown that strong differences exist depending on the plasma applied. Also the conditions of the plasma effect the surface structure (power, pressure, time).

The bonding behavior of silicon wafers is different for the different plasma treatments. Analysis of the bonded interface proved that the different surface structure is the main reason for the different behavior. The most important factors (interface energy, bubble formation) are presented for the different treatments.

The application of the different plasma activation processes for MEMS applications are discussed.

References:

[1] different examples are presented during the last conference on wafer bonding organized by the Electrochemical Society (1997, 1999, 2001)