Plasma assisted low-temperature wafer bonding

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The thermal budget requirements in direct wafer bonding can be significantly reduced by appropriate treatments to enhance the reactivity of the surface prior to bonding. This is particularly important when materials with different thermal expansion coefficients or preprocessed structures are bonded.

The most efficient way of activation is the exposure of the surfaces to bombardment by energetic ions [1,2,3]. We have previously demonstrated that strong hydrophilic Si to SiO_2 bonding can be achieved at temperatures below 200 ^oC by exposing the wafers to plasma in RIE mode prior to bonding [4]. Both inert gases such as argon and reactive species such as oxygen and nitrogen result in strong bonding indicating that the activation results from physical modification of the surface. The surface energy of 2500 mJ/m^2 measured using the crack opening method suggests that the surface is almost saturated with Si-OH groups that react into siloxane bonds at the interface.

This paper will review recent experimental results and progress made in plasma assisted low-temperature wafer bonding. Some interpretations of the underlying physics including ion induced damage and plasma induced surface charge will be discussed. It will show that plasma activation is a key element in controlled wafer bonding where the bonding strength can be varied from full strength to a level enabling various layer transfer processes.

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