HEAT TRANSMISSION IMAGING OF DIRECT WAFER BONDING USING PHOTOACUSTIC DETECTION

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Direct wafer bonding is widely used for joining semiconductor wafers without the use of any intermediate layers. One important applications of this technique is the manufacture of "silicon-on insulator"(SOI) substrates. The same method can be and has been used to join different materials, including metals, semiconductors and dielectrics, and therefore to obtain hybrid substrates which take advantage of the properties of both materials.

Imperfections in the topography of the surfaces, particles or pre-bonding surface contamination leads to the appearance of voids in the interface, both before and after high-temperature anneals. It is therefore important to monitor the homogeneity of the bonded interface . The standard method of imaging by infrared transmission is limited by the optical gap of the bonded materials, and its applicability decreases as the energy gap of at least one of the materials decreases. Even in the case of silicon to silicon bonding, heavy doping or metal coating of one of the wafers can make this kind of imaging uneffective.

Heat conduction, on the other hand, is not limited by the gap, and therefore can be used for imaging both semiconductors and metals. In this communication, we demonstrate thermal imaging of the very thin voids (less than one micron thick) in the interface of directly bonded silicon pairs, using a simple arrangement based on a standard photoacoustic technique. The imaged region is not touched by any probe, minimizing wafer contamination, and unlike some other techniques, this one does not require the outer surfaces of the bonded wafers to be polished.

The bonded pair is illuminated on one side with white visible light focused to a small spot, which heats up the sample locally. The transmitted heat is detected from the backside, using an air-filled cell and a microphone. The incident light is modulated by a chopper, and the periodic pressure variation on the microphone is detected sinchronously using a lock-in amplifier. The light spot is scanned on the sample, and the amplitude and phase of the signal are recorded as a function of the position.

We obtained a remarkably high contrast between the void regions, and the well-contacted areas, even though the voids are so thin, and buried between half-millimeter thick silicon samples. The amplitude contrast ratio is of the order of 1.5:1 and the phase difference is of the order of tens of degrees.

We demonstrated the effectiveness of the method for infrared-opaque materials by coating the silicon bonded pairs with aluminum and black paint and obtaining an improvement in the contrast.