Wafer Bonding Interface X-Ray Characterization

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ABSTRACT

The wafer direct bonding technique has found many applications ranging from mass production of SOI substrates to 3D and heterogeneous integration. Understanding the effects of the bonding process parameters and the physical and chemical mechanisms operating during bonding requires the possibility to study the structure of the bonding interface. This is a challenging task as the vertical extension of the interface is in the nanometer range while it is often buried under bulk materials of millimeter thickness, sideling most surface sensitive probes. We will show that X-ray interfacial reflection (and scattering) using high energy synchrotron radiation meets the seemingly contradictory requirements of a high penetration to access the interface and a high sensitivity to the ultra-thin interfacial layers[1]. Examples will be given of interface studies from silicon oxide to silicon oxide direct bonding[2] and metal/metal bonding[3]. In the case of silicon oxide to oxide hydrophilic bonding, we will show that the technique allows a detailed balance of the different species present at the interface, allowing a detailed mechanism for interface closure to be given. Adhesion energy evolution, behavior upon annealing and strain and defect formation can then be explained. The inversion of scattering data will be discussed.

FIGURE 1. Density profile across a Si/Si bonding interface as obtained from X-ray reflection experiments

REFERENCES