Wafer bonding has been developed as a technology to meet the demands of integrating materials with different properties in the microelectronics, -mechanics and optoelectronics industry. To continue the development of smaller and more complex integrated circuits is it necessary to join different materials in order to obtain the desired properties.

Direct wafer bonding or fusion bonding is a process where two clean and smooth surfaces are brought into proximity at room temperature. Attractive forces pull the surfaces into contact thereby forming week van der Waals like bonds. In order to strengthen these bonds high temperature annealing of the samples is widely used. However the heating might hamper the applicability, e.g. in the case of sensor fabrication when metal wires are already attached to the structures or when dissimilar materials with different thermal expansion coefficients are bonded.

We have studied a technique, which now receives more and more attention where Si wafers are activated with an O₂ plasma prior to the bonding process. The bond strength reached in this process which is carried out at room temperature is comparable to the bond strength of fusion bonded Si wafers; however, the latter process requires annealing at ~850°C. Our focus has mainly been on obtaining structural information from the interface of Si wafers joined in the room temperature process to achieve a better understanding of the chemistry and physics responsible for the strong bonds. X-ray diffraction experiments are an excellent tool to obtain information about the structure of an internal or external interface at the atomic scale.

In the diffraction experiments at the HASYLAB wiggler beam line BW2 we have studied plasma bonded Si wafers treated according to several different recipes in Reactive Ion Etching (RIE) and Inductively Coupled Reactive Ion Etching (ICP-RIE) machines respectively. The experiments comprise measurements of the specular reflectivity of single wafers treated with oxygen plasma. Furthermore measurements in transmission geometry of the specular reflectivity from the internal interface in strips of approximately 100µm thickness (depending on the energy of the incidence beam), which were cut from bonded wafers. The x-ray setup is illustrated in Figure 1.

We are currently working on a model describing the composition of the interface. The reflectivity curves are conspicuously different, varying both in intensity and periods. We have confirmed that dipping the wafer surfaces prior to the bonding in deionized water improves the success rate of the process and results in reflectivity curves which indicate a different composition at the interface compared to the samples bonded without water dip. The periods of the intensity
oscillations observed in the specular reflectivity are in close connection to the measured oxide thickness after the plasma activation.

As simple box models are not sufficient to describe the system, we are modelling the reflectivity curves [1] using a self-written program for the data analysis, which optimises a quasi-continuous (histogram) density profile employing a genetic-algorithm approach. Rapidly oscillating solutions are suppressed by penalizing the curve length of the fitted density profile. An example of fitted data is depicted in Figure 2 and Figure 3 showing concordant curves of fit and data and a density profile with several levels in the Scattering Length Density (SLD).

Together with complementary results obtained by Transmission Electron Microscopy (TEM) and X-ray Photoelectron Spectroscopy (XPS) measurements should the obtained density profiles give us a fundamental knowledge of the impact of the plasma treatment.

We thank DanSync for financial support and the HASYLAB staff for practical support during the beamtimes.

References