	Experiment title: Grazing incidence diffraction studies on defects in Si layers above buried oxide layers	**Experiment number:** SI-645
Beamline: ID01	**Date of experiment:** from: Jun 13th 2001 to: Jun 19th 2001	**Date of report:** Aug 28th 2001
Shifts: 15	**Local contact(s):** Virginie Chamard	*Received at ESRF:*

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Report:

We have investigated the structural properties of silicon on insulator material by means of grazing incidence diffraction. The samples consist of an about 200 nm thick Si layer on top of an about 100 nm thick layer of SiO_2. In order to investigate the structure of the Si layers, we employed grazing incidence diffraction and recorded the diffuse scattering around the (220) and (400) Bragg reflections of Si. As SiO_2 is amorphous and does not diffract, no diffuse intensity stems from the oxide.

For two different incidence angles α_i, reciprocal space maps have been recorded in the q_x-q_z-plane, where q_x is the angular direction in reciprocal space and q_z is perpendicular to the sample surface. For $\alpha_i = 0.18°$, which is smaller than the critical angle of external reflection α_c for the used wavelength of $\lambda = 1.543$ Å, the penetration depth of the x-rays is much smaller than the thickness of the top Si layer. For $\alpha_i = 0.5°$, the whole Si layer and the oxide are penetrated by the x-ray beam. Figure 1 shows two representative maps for the two incidence angles.

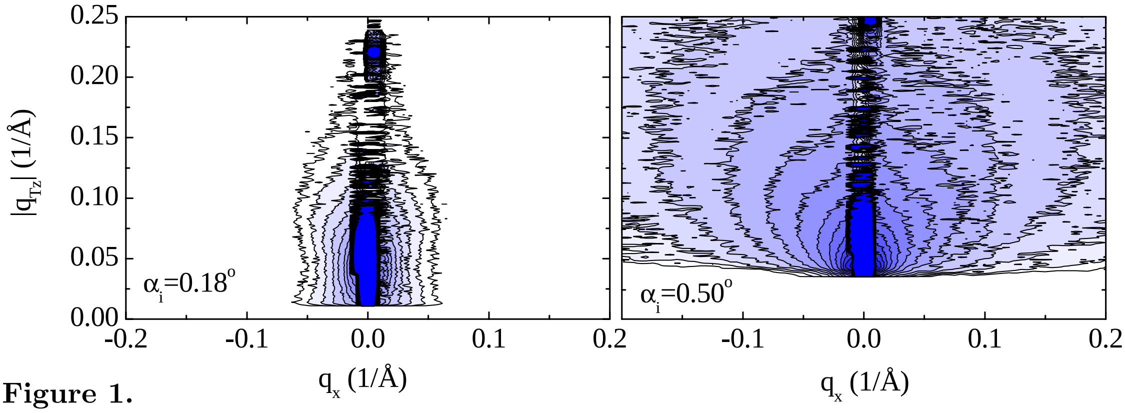

Figure 1.

For $\alpha_i = 0.18°$, the main contribution to the diffuse scattering stems from the roughness of the top surface. The measurement at $\alpha_i = 0.5°$ is influenced by both the roughness of the top surface and the roughness of the buried interface between Si and SiO_2. In order to obtain information on the buried interface, the two measurements have been subtracted from each other, after corrections for refraction, absorption, and the transmission function of the surface. This intensity differnce can be expressed as a function of the properties of the second interface only:

$$\begin{aligned} \Delta I_T(q_x, |q_{Tz}|) &= B\sigma_2^2\Lambda_2^2\ \Phi(q_x\Lambda_2, \sigma_2|q_{Tz}|) \\ \Phi(a,b) &= 2\pi\frac{\mathrm{e}^{-b^2}}{b^2}\int_0^\infty \mathrm{d}t\ tJ_0(at)\left[\mathrm{e}^{a^2 f(t)} - 1\right] \\ f(\mathbf{t}) &= \frac{1}{\sigma^2}C(\mathbf{t}\Lambda) \end{aligned}$$

where $C(x)$ is the correlation function of the interface. This correlation function can be determined using a fitting procedure: By applying an inverse Fourier transformation of ΔI_T, we obtain a function

$$S(x, |q_{Tz}|) = \frac{\int_0^\infty \mathrm{d}q_x q_x J_0(q_x x)\Delta I_T(q_x, |q_{Tz}|)}{\int_0^\infty \mathrm{d}q_x q_x \Delta I_T(q_x, |q_{Tz}|)},$$

and from the definition of Φ it follows that this function is connected with the interface correlation function via

$$S(x, |q_{Tz}|) = \frac{\mathrm{e}^{|q_{Tz}|^2 C(x)} - 1}{\mathrm{e}^{\sigma_2^2|q_{Tz}|^2} - 1}.$$

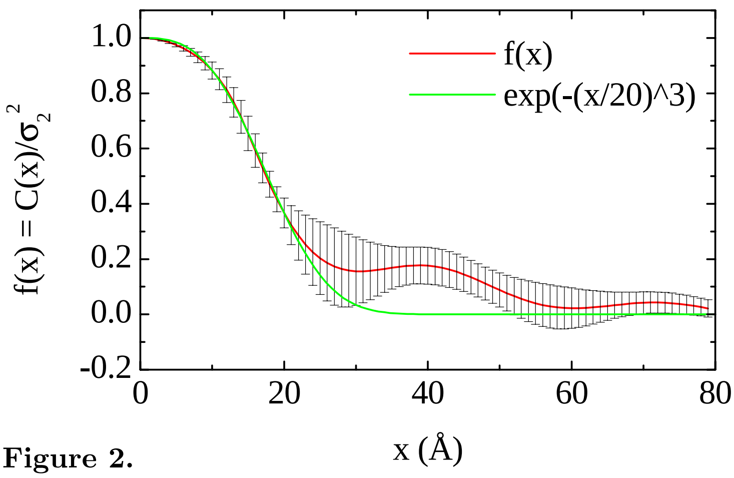

Figure 2.

Hence we calculate $S(x, |q_{Tz}|)$ from the experimental data and fit it using σ_2 and $C(x)$ (separately for each x) as free parameters. By this method we obtain an r.m.s. roughness of the buried interface of $\sigma_2 = 11 \pm 2$ Å. The resulting correlation function is shown in Fig. 2 (red line; green is a fit to the central part with an exponential function). The small oscillations are probably numerical artifacts. However, from the shape of the curve it is evident that the characteristic lateral feature size is about 20 Å.