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## X-rays guided by linearly graded SiGe layer grown on relaxed SiGe/Si structure

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Strained Si, $Si_{1-ß}Ge_{ß}$ and Ge have attracted considerable attention for their potential applications in high frequency devices. This has stimulated considerable interest in the study of strain-relaxed $Si_{1-\beta}Ge_{\beta}$ buffer layers called as "virtual substrates" (e.g. see [1,2]), which can be used for the growth of high mobility structures and the integration of III-V devices on Si. If a layer of $Si_{1-\beta}Ge_{\beta}$ is grown directly onto a Si substrate and exceeds the critical thickness, then the layer relaxes but forms a dislocation density at the surface of order $10^{12}$ cm$^{-2}$ [1,2]. However, growth techniques are modified, so $Si_{1-\beta}Ge_{\beta}$/Si material with defect densities of order $10^{5}$ cm$^{-2}$ is now routinely available.
Here we are considering theoretically a $Si_{1-\alpha(z)}Ge_{\alpha(z)}/Si_{1-\beta}Ge_{\beta}$/Si heterostructure with linearly graded $Si_{1-\alpha(z)}Ge_{\alpha(z)}$ cup layer grown up on the strain-relaxed $Si_{1-\beta}Ge_{\beta}$ buffer layer, where the coefficient $\alpha(z)$ is defined by the relation: $\beta \leqslant \alpha(z) = \beta + \beta_0 (z - z_2)/(z_1 - z_2) \leqslant 1$, $\beta$ and $\beta_0$ are the heterostructure composition parameters, plane $z = z_1$ is the entrance surface of heterostructure, plane $z = z_2$ is the interface between linearly graded $Si_{1-\alpha(z)}Ge_{\alpha(z)}$ layer and $Si_{1-\beta}Ge_{\beta}$ virtual substrate. Such multiplayer structure could be grown e.g. by molecular beam epitaxy (MBE) at a growth temperature of 300°C.
Proposed investigation method is based on the high-resolution and non-destructive Grazing-angle Incidence X-ray Backscattering diffraction (GIXB) technique, which is the Bragg diffraction in the conditions of total external reflection, and is extremely sensitive to spacing period variations of the diffracting lattice planes and to incident radiation wavelength [3-5]. Particularly, the X-ray wave field reflectivity coefficient of considered heterostructure, as well as the X-ray transmission coefficient of the $Si_{1-\alpha(z)}Ge_{\alpha(z)}/Si_{1-\beta}Ge_{\beta}$ bi-layer, are calculated depending on the values of the Bragg angle for the case when the GIXB takes place inside bulk silicon substrate. Obtained coefficients are compared with those in non-diffracting case. Also we are investigating in this paper the appearance of X-ray waveguide effect inside $Si_{1-\alpha(z)}Ge_{\alpha(z)}/Si_{1-\beta}Ge_{\beta}$ bi-layer depending on the values of the composition parameters $\beta$ and $\beta_0$, as well as on the Bragg angle.

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## Multilayer Optics for High Brightness X-Ray Sources

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X-ray optics, such as capillaries, single crystal monochromators, total reflection and multilayer mirrors, are commonly used as beam conditioning devices in analytical instruments for crystallography applications. [1, 2] Beam conditioning includes the optimization of the total flux on the sample, the improvement of the spectral purity and the control over the beam shape and divergence. A good criterion to compare the performance of different optics is the brightness of the optical system (*i.e*. source plus optical element(s)). Brightness is defined as the flux density (*i.e*. the intensity) divided by the 2D divergence of the beam. [3] An X-ray optical system with high brightness yields a very concentrated high intensity beam with moderate divergence. A recent experimental comparison of different X-ray optics combined with a micro-focus X-ray source showed that multilayer mirrors are in terms of brightness and spectral purity superior to other optics, such as mono- and poly-capillaries. [4] The advantages of synthetic multilayer mirrors are, in particular, their selectable band pass and beam-shaping characteristics, good beam homogeneity, high reflectivity and thermodynamic stability. [5, 6, 7] The combination of a state-of-the-art high brilliance rotating anode X-ray source with a tailor-made focusing multilayer mirror provides an intense X-ray beam with high flux density and low divergence comparable to the beam intensity of second generation synchrotron sources. [8]
We will present selected aspects on the simulation, preparation and characterization of multilayer X-ray mirrors for micro-focusing sources as well as latest results of their application in macromolecular crystallography.

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