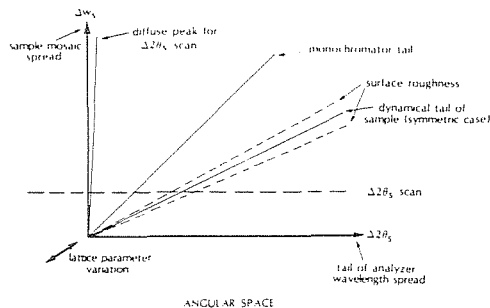11.X-9   INVESTIGATIONS OF ASYMPTOTIC-BRAGG AND
KINEMATICAL SCATTERING FROM ION-IMPLANTED AND OTHER
SILICON SAMPLES USING AN X-RAY TRIPLE-AXIS
DIFFRACTOMETER. By S.W. Wilkins and A.W. Stevenson,
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J. Harada, N. Kashiwagura, S. Kimura, M. Sakata and
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Triple-axis X-ray diffractometry offers the exciting
possibility of cleanly separating dynamical,
kinematical, instrumental and parasitic components of
the scattering near a Bragg peak. In particular
Eisenberger, Alexandropoulos and Platzman [Phys. Rev.
Letts., 1972, 28, 1519-25] and later Iida and Kohra
[Phys. Stat. Solidi (a), 1979, 51, 533-42] showed that
for nearly perfect crystals dynamical and kinematical
components of the scattering could be readily separated
by scanning a perfect crystal analyzer. Examination of
the theory for dynamical diffraction from a perfect
crystal shows that the tail of the dynamical
diffraction peak extends along the direction normal to
the crystal surface. In the case of symmetrical Bragg
reflection, the dynamical tail extends parallel to the
scattering vector or, equivalently along the
$\omega_s/2\theta_s$ scan line in $\Delta 2\theta_s - \Delta\omega_s$ space (where $\Delta 2\theta_s$ and
$\Delta\omega_s$ are detector and sample angular sittings relative
to Bragg condition). On the other hand, the
kinematical component of the scattering can extend in
various directions in k-space. For example, mosaic
spread extends the Bragg scattering along a direction
normal to the scattering vector in the plane of
diffraction corresponding to the $\Delta\omega_s$ direction in
$\Delta 2\theta_s - \Delta\omega_s$ space, while isotropic diffuse scattering
leads to a broad peak centred on the line

$$\Delta\omega_s = \frac{1}{2}(1 - \cos^2\theta_B)^{-1} \Delta 2\theta_s \quad \text{in a } \Delta 2\theta_s\text{-scan.}$$

Instrumental factors can lead to a streak along
$\Delta\omega_s = \Delta 2\theta_s$ corresponding to the rocking-curve tail of
the monochromator being Bragg reflected by the sample
and a streak along $\Delta 2\theta_s$ direction corresponding to
$\Delta\lambda$-spread or to the tail of the analyzer crystal.
These various features of the scattering are
illustrated schematically in the figure below.

ANGULAR SPACE

In addition to cleanly separating instrumental
characteristics, triple-crystal diffraction is a
sensitive probe of sample properties, especially in the
near surface region, [see e.g. Afanasev, Kovalchuk,
Kovev and Kohn, Phys. Stat. Sol. 1977, 42, 415-22] and
Cowley and Ryan, J. Phys. D. 1987, 20, 61-8]. In the
present work, we present triple-crystal measurements on
ion-implanted and other silicon samples which were
carried out using the 6-circle Huber diffractometer on
beam-line 4C at the Photon Factory. These results
include observations of Bragg peaks over nearly 8
orders in magnitude and show that the method can provde
valuable information on near-surface structure (such as
strained layers and surface roughness).

11.X-10   SENSITIVITY OF X-RAY DYNAMICAL REFLECTING
POWER TO THE STRAIN PROFILE IN HETEROSTRUCTURES. By
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Many   modern   electrooptics   devices   make use of
heteroepitaxial structures. In order to fully
understand their optical and transport properties, it
has often proved necessary to control a posteriori
the actual parameters : composition, thickness and
state of strain of individual layers. X-ray
diffractometric techniques have become now widely
used for this purpose since they are non destructive
and rather simple to achieve. It is then necessary to
determine the ultimate strain sensitivity of the
technique.
Let us recall its principle : nearly plane wave X-ray
rocking curves are recorded on a double crystal
spectrometer and analyzed through a best fit
procedure between experimental and computed profiles,
the computation relying on Takagi-Taupin equations.
Among others, the example of a single heterostructure
whose only imperfection is a strain distribution at
the interface will be discussed.
In order to characterize the strain profile by a
single parameter, a simple but nevertheless realistic
strain model has been chosen : the ε_{zz} strain
where z is a coordinate normal to the junction is
taken equal to $f/(1+\exp(z-z_i)/C)$ where f is the
misfit or relative lattice parameter difference
between the epilayer and the substrate, z_i is
the mid-position of the interface and C the parameter
which describes the spreading of the strain (S.
Bensoussan, C. Malgrange and M. Sauvage-Simkin, to be
published in J. Appl. Cryst. 1987).
In the rocking curve, the features which proved to be
the most sensitive to the strain are the intensities
of the first subsidiary peaks on both sides of the
epitactic layer main peak : the intensity assymetry
between both subpeaks increases as the value of C
increases. The variation of the ratio ϱ of these peak
intensities with the value of C has been studied in
the case of $Ga_{1-x}Al_xAs/GaAs$ heterojunctions,
a 400 reflection for two different wavelengths, as a
function of the misfit f and the depth z_i of the
junction. The sensitivity defined as the minimum
detectable strain spreading is given in each case and
proved to be enhanced as either the thickness of the
layer decreases or the misfit increases. Writing
Takagi-Taupin equations with suitable dimensionless
parameters, it is shown that the conclusions can be
extended to other reflections and wavelengths
provided that the ratio χ_{hi}/χ_{hr} of the
imaginary and real part of χ_h (respectively
proportionnal to the absorption coefficient and the
structure factor of the reflection) is kept below
10^{-1}. Some experimental results which have been
analyzed with this method will be presented.