Time-Resolved X-ray Diffraction Setup for In-Situ Observation of Thin Film Growth

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X-ray diffraction is widely used to characterize semiconductor thin films, for example to determine lattice constants, strain, domain sizes and interface roughness. In-situ X-ray diffraction measurements during thin film growth can provide valuable information for understanding growth processes [1]. In this contribution, an X-ray diffraction setup for time-resolved measurements will be presented that has been installed at BL11XU of SPring-8, where it can be used in combination with a surface X-ray diffractometer/MBE chamber.

An X-ray optical setup in the experimental hutch is used to transform the collimated and monochromatized synchrotron radiation beam from the beam line optical system into a convergent X-ray beam with a large convergence angle. First, a V-channel-cut silicon crystal is used to spread the X-ray beam vertically, then reflection at a cut silicon crystal transforms the beam to a circle arc. Finally, it is focused to the sample position using a curved crystal. This produces a convergent beam with a wide range of incident angles onto the sample. By observing the intensity distribution of the diffracted X-rays with a two-dimensional detector, the scattering distribution in a wide range of momentum transfer can be observed simultaneously with a single detector exposure. It is not necessary to move any part of the instrument during the measurements, which makes it possible to realize fast time resolutions. Test experiments showed that the reciprocal space map around the 022 Bragg peak of an InGaAs thin film could be obtain in 10 ms.

The instrument was applied to the MBE growth of InGaAs on GaAs(001). The transition from strained growth to relaxed growth with increasing thickness was observed with a time resolution of 100 ms.

[1] M. Takahasi, Jpn. J. Appl. Phys. 57, 050101 (2018).