Time-Resolved X-ray Diffraction From Nitride Thin Films: Observation of the Specular Rod

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In-situ X-ray diffraction measurements during thin film growth can provide valuable information for understanding growth processes, like lattice relaxation and the generation of defects [1]. Our group has recently developed an X-ray diffraction method that can be used for in-situ observations of non-repeatable phenomena with a time resolution of 10 ms [2]. The reported setup could only measure non-specular diffraction rods, however. In this contribution, we report the extension of the method to the specular rod, and its application to the growth of InGaN thin films.

Experiments where conducted at BL11XU of SPring-8, where a surface X-ray diffractometer combined with a molecular beam epitaxy (MBE) chamber is installed. An X-ray optical system has been setup in the experimental hutch to transform the collimated and monochromatized synchrotron radiation beam entering the hutch into a convergent X-ray beam with a large convergence angle. For this purpose, first the X-ray beam is spread vertically by reflection at a channel-cut silicon crystal, then it is transformed to a circle arc and finally focused onto the sample using two other silicon crystals. This produces a fan-shaped 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. The direction of the optical system has been rotated by 45° compared to the previous report [2], so that the momentum transfer has a component both in and out of the surface plane, enabling us to observe the specular rod as well as non-specular rods.

The setup was used to observe the growth of an InGaN thin film on GaN. The initial stages of the growth as well as the relaxation of the InGaN film when its thickness increased where observed with a time resolution of 100 ms.

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

[2] W. Voegeli, M. Takahasi, T. Sasaki, S. Fujikawa, T. Shirasawa, E. Arakawa, T. Takahashi, 79th JSAP Autumn Meeting, 18p-212B-3 (2018).