ESRF	**Experiment title: Determination of microscopic polarity from GaN thin films heterostructures with spatially resolving x-ray standing wave method**	**Experiment number**: SI 791
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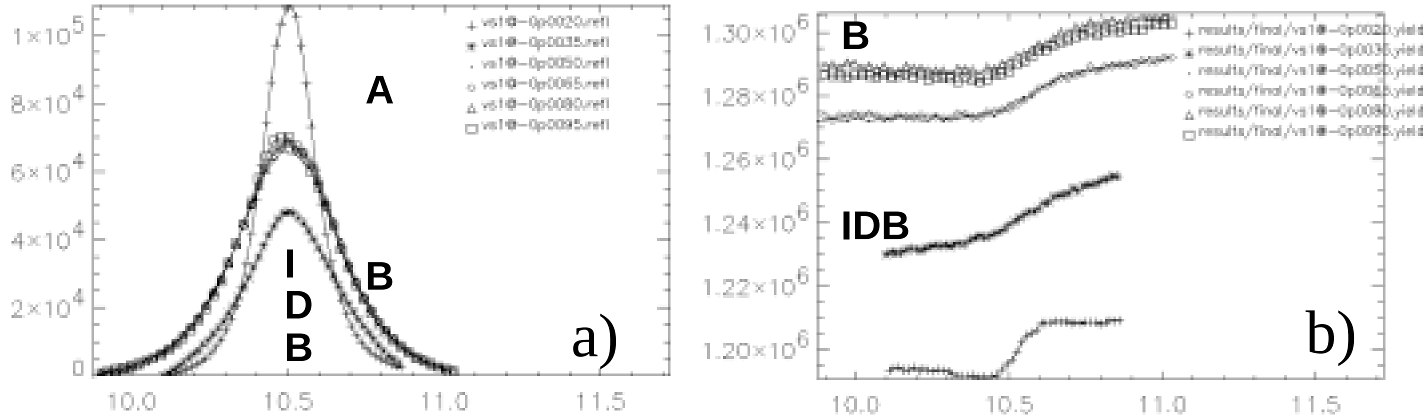
Report:

We have recently advanced the XSW-method into a microscopic technique, that allows us to study crystalline arrangement with micrometer resolution. We demonstrated this with an first test-experiment, where we investigated an epitaxially grown GaAs/$Al_{0.1}Ga_{0.9}As$/GaAs(001) heterostructure in cross section with microscopic (1.5 µm) resolution [1].
In this work we apply this new technique to the study of crystallographic polarity of microscopic domains of an GaN-films grown on sapphire. These GaN-films display few micrometer wide domains that are prepared to have a change in polarity from one to the other. The Ga polarity (Ga termination) is achieved by the presence of a prior deposited AlN nucleation layer [2].

We found the GaN thin films beeing of relatively poor crystaline quality, with rocking curve widths between 0.5° and 1°, and with very low reflectivity of about 1% and less (Figure 1a). Anyhow, these are typical examples of real epitaxial films in the case of a large mismatch between film and substrate, which in our case is 16%, and thus a realistic case to be studied.
To account for the low reflectivity and therewith low modulation of the fluorescence yield we aquired many data sets at same conditions, which were added up to decrease statistics. The such aquired XSW-fluorescence yields are shown in Figure 1b. Allthough the modulation is around 1% only, the data are of good quality. Such XSW-scans were performed at different locations through adjoined polarity domains (Figure 1c).
On the other hand, the broad rocking curve width allowed us to experiment with a modified scheme of our micro-XSW set-up, which might be promising for future applications, as well. Due to the large angular acceptance the small incident beam divergence in the diffraction plane is not necessary and we could replace the 1-dimensional focusing lens by a 2-dimensional focusing lens and thus reduce the focal spot to 10 µm horizontal * 1.5 µm vertical. The focal line obtained with 1-dimensional focusing exhibits a 10 times lower flux-density.



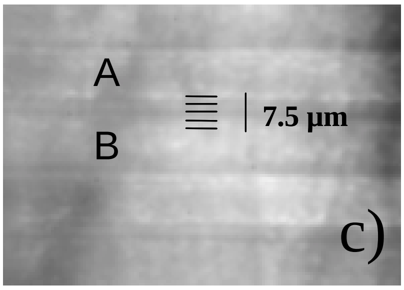


Figure 1: GaN lateral polarity inversion thin films; micro-XSW and x-ray topography; experimental data
a) local reflectivity GaN (220) from two opposite polarity domains (A, B), and inter-domain boundary (IDB)
b) local XSW Ga Kα fluoresence yields obtained from locations same as in Figure 1a)
c) high-resolution topogram of the investigated sample region. Five black horizontal lines indicate locations of local XSW-scans. Opposite polarity domains are indicated by A and B.

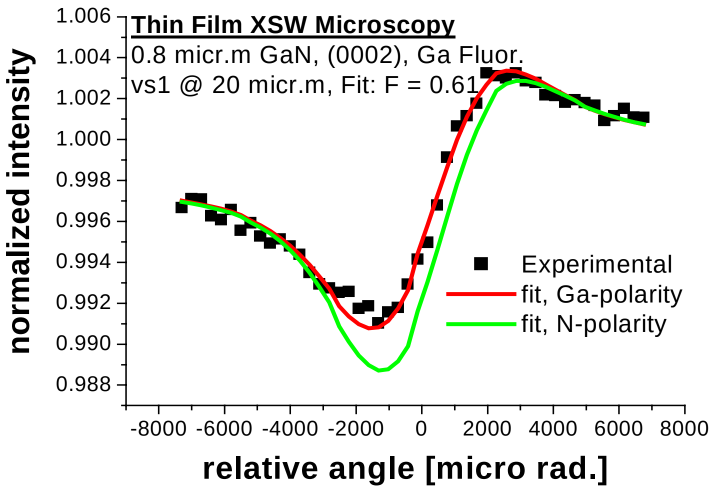


Figure 2: micro-XSW on GaN-film with Ga-polarity; experimental data and theoretical data. Fits are calculated for both polarities with the same parameters for film-thickness, mosaicity, and coherent fraction.

We have processed data and obtained by XSW-fits a clear signature of the crystallographic polarity of the domains labeled A. These domains have been grown on an AlN nucleation layer, and they show Ga-termination. This finding is in agreement with XSW-measurements of large GaN films grown directly on sapphire, which have the opposite, i.e., have N-polarity [3]. Further data evaluation is in progress.

References:

1. M. Drakopoulos, J. Zegenhagen, A. Snigirev, et al., Appl. Phys. Lett. 81, 2279 (2002)
2. R. Dimitrov et al., J Appl. Phys. 87, 3375 (2000)
3. A. Kazimirov, G. Scherb, J. Zegenhagen et al, J. of Appl. Phys. 84, 1703 (1998)