# Selective Area Growth of GaN Nanowires and Nanofins by Molecular Beam Epitaxy on Heteroepitaxial Diamond (001) Substrates - Supporting Information

Florian Pantle,* Fabian Becker, Max Kraut, Simon Wörle, Theresa Hoffmann, Sabrina Artmeier, and Martin Stutzmann*

*Walter Schottky Institut and Physics Department, Technische Universität München, Am Coulombwall 4, 85748 Garching, Germany*

E-mail: florian.pantle@wsi.tum.de; stutz@wsi.tum.de

## Diamond Substrates

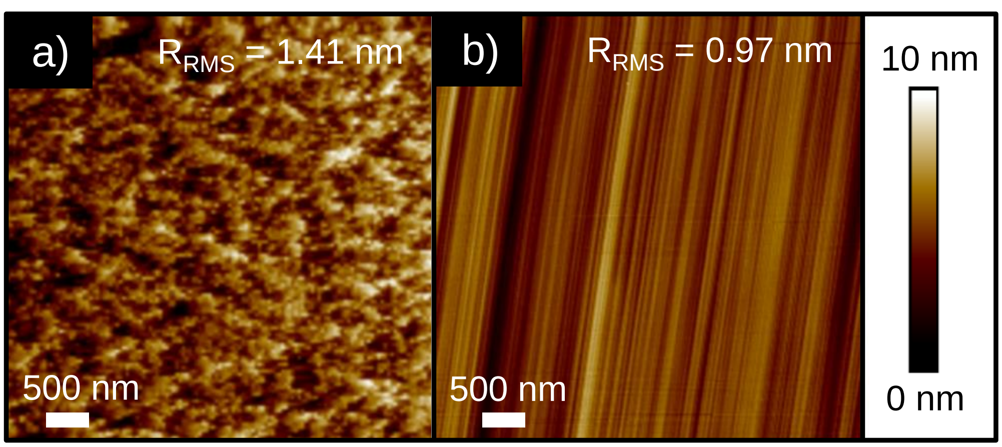


**Figure S1:** AFM images of the diamond substrates: a) SCD (111) and b) HD (001).

Figure **S1** depicts 5 x 5 $\mu m^2$ AFM images of the diamond substrates. The surface of the SCD (111) (Fig. **S1**a) shows a structuring with an RMS roughness of 1.41 nm. This morphology is a consequence of prior multiple recycling the SCD for several GaN NW growth runs and the following cleaning of the diamond surface via etching the sample in hot KOH, O-plasma treatments and $H_2O_2$/HF solutions. The less expensive HD substrates were used only once. The structure visible in Figure **S1**b) is due to the polishing of the HD (001) surface, which results in an RMS roughness of 0.97 nm. These polishing grooves are along the [100] diamond axis.

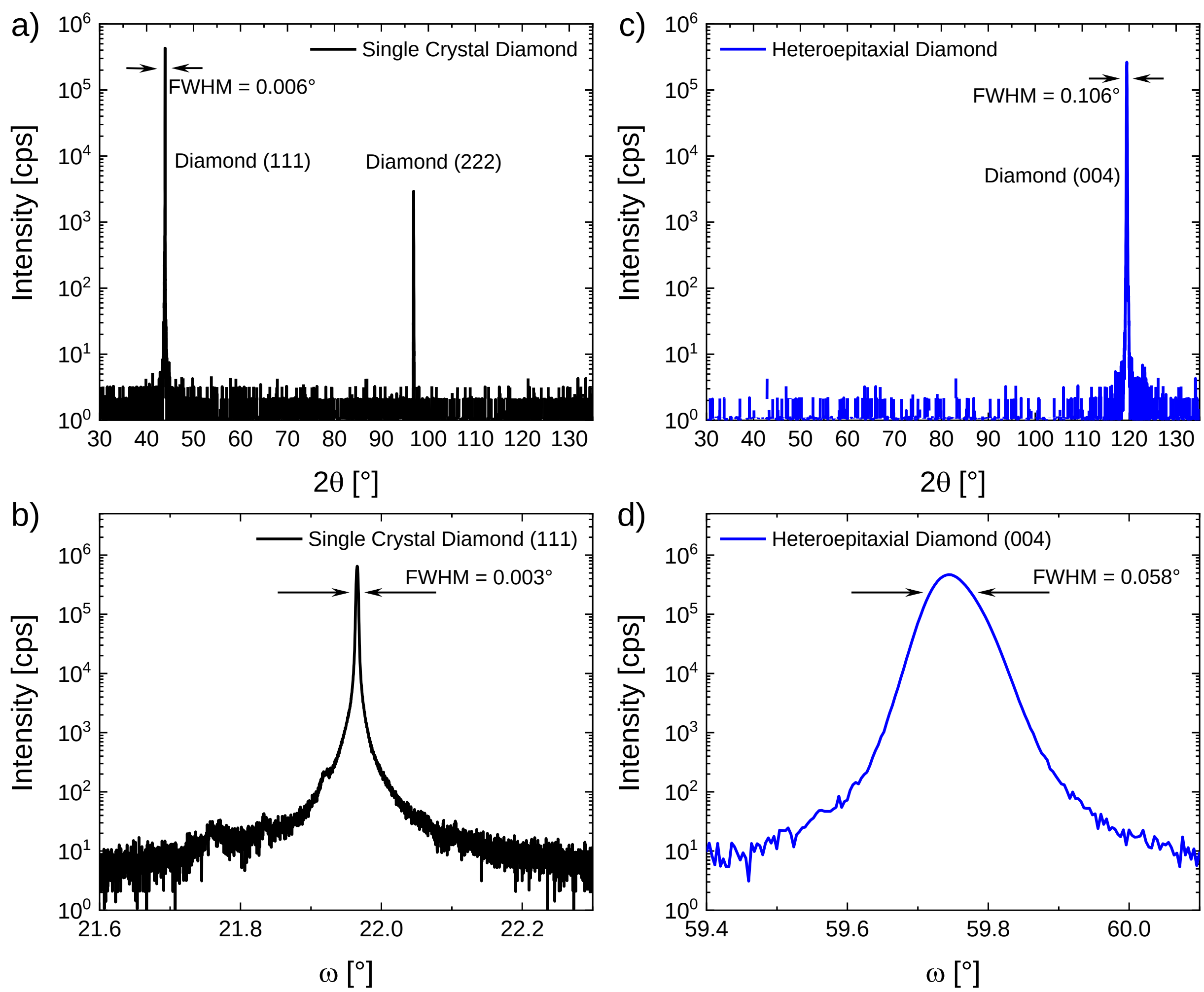


**Figure S2:** High resolution XRD of the diamond substrates: a) $2\theta/\omega$-scan and b) $\omega$-rocking curve of the SCD (111), c) $2\theta/\omega$-scan and d) $\omega$-rocking curve of a HD (001).

Figure **S2** shows high resolution XRD data of the diamond substrates used. In Figure **S2**a), the diamond (111) and (222) reflexes are at a $2\theta$-angle of 43.93° and 96.87°, respectively. The $\omega$-rocking curve of the SCD (111) reflex (Fig. **S2**b) has a FWHM of 0.003°. Figure **S2**c) shows the $2\theta/\omega$-scan of a HD (001) with the diamond (004) reflex at 119.49°. The $\omega$-rocking curve of the HD (004) reflex (Fig. **S2**d) has a FWHM of 0.106°.

## AlN Buffer Thickness

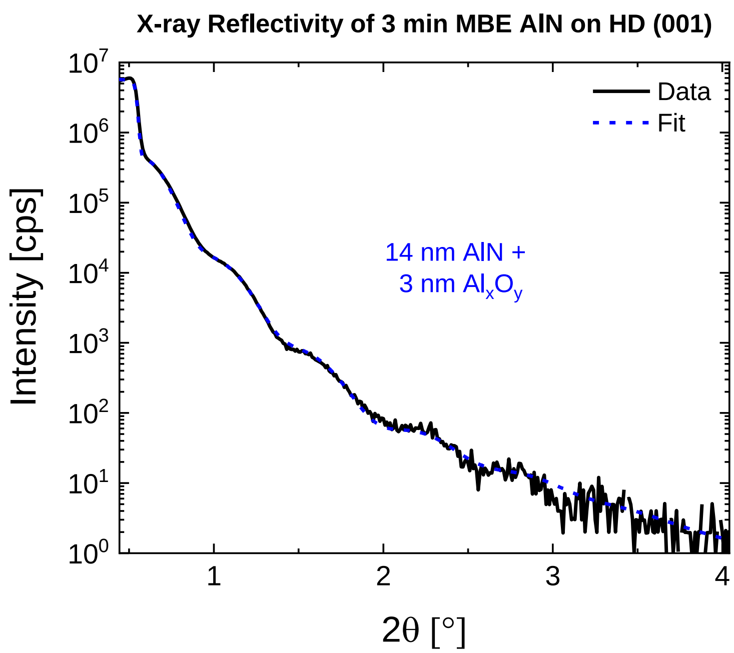


**Figure S3:** X-ray reflectivity data (black curve) of an AlN buffer on HD (001) grown for 3 min. A fit (dashed blue curve) for which a native surface oxide is assumed estimates an AlN thickness of approx. 14 nm with a surface oxide thickness of approx. 3 nm.

In Figure **S3**, the X-ray reflectivity data of an AlN buffer layer grown for 3 min is shown. The blue dashed line depicts a fit, which assumes a native surface oxide on top of the AlN. Using this model, an AlN thickness of approx. 14 nm with a native surface oxide thickness of approx. 3 nm was determined.

## Lithographic Limits

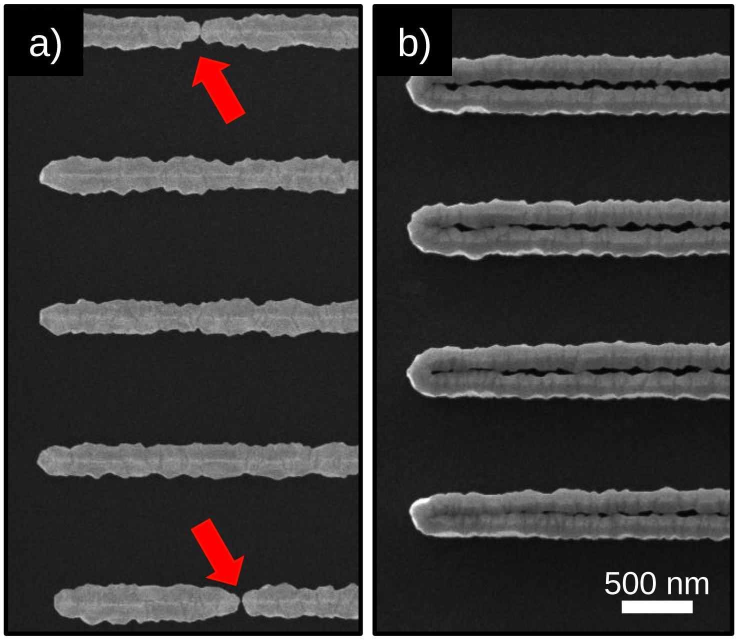


**Figure S4:** Top view SEM images of GaN NFs on AlN-buffered HD (001) at the lithographic process limits: a) Thin NFs and b) thick NFs.

Figure **S4** shows the limitations of the GaN NF thickness variation on AlN-buffered HD (001). Too small exposure doses during electron beam lithography result in non-continuous slits in the Ti mask. This leads to breaks in the NFs, which are marked by the red arrows in Figure **S4**a). In contrast, too high doses result in an overexposure of the electron beam resist. This hinders the resist lift-off in the middle of the nano-slit. Consequently, the thickest NFs split up in a double fin (Fig. **S4**b).

## Polarity of GaN NSs

In Figure **S5** GaN NSs on AlN-buffered HD (001) before and after polarity-selective KOH etching at 85°C for 1 min are shown. The height of the NSs decreased by approx. 40 nm and the average NS width by almost 100 nm. Further, an under-etching of the GaN NFs is observed, whereas the GaN NWs are only slightly attacked by the etchant at the bottom.

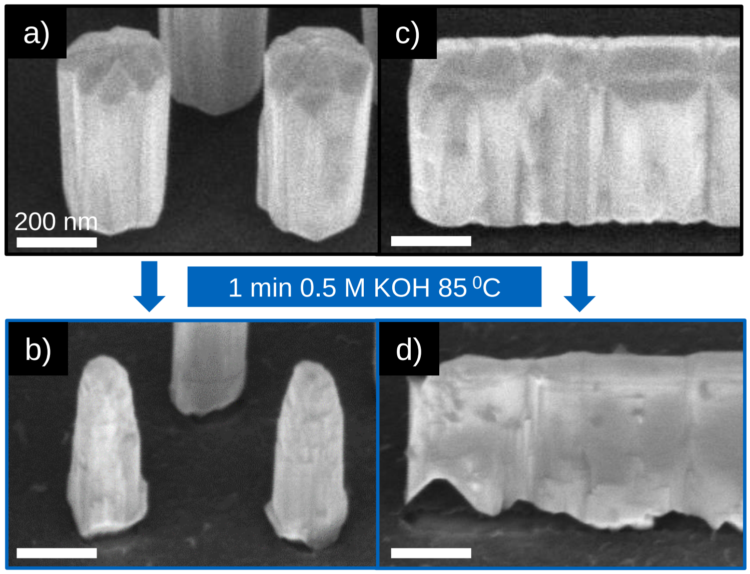


**Figure S5:** SEM images of GaN NWs and NFs grown on AlN-buffered HD (001) a), c) before and b), d) after etching with 0.5 M KOH at 85°C for 1 min.

Figures **S6**a) and b) show GaN NWs on bare HD (001) before and after etching for 1 min.

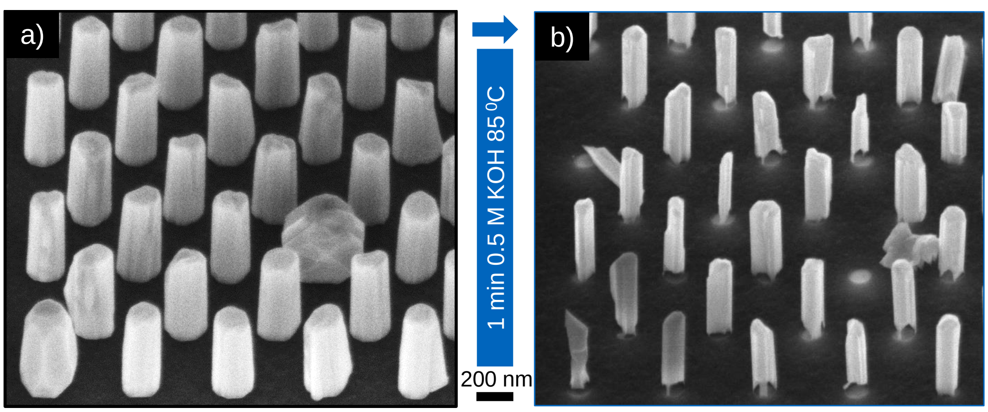


**Figure S6:** SEM images of GaN NWs on bare HD (001) a) before and b) after etching with 0.5 M KOH at 85°C for 1 min.

The etched NWs are thinner but not significantly shorter. A lateral etch rate of approx. 40 nm/min has been determined. Moreover, all NWs show signs of etching at the bottom.