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Potential mapping in GaN nanowire p-n junctions via off-axis electron holography

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GaN nanowires (NWs) have been applied in devices including light emitting diodes (LEDs) photodetectors and laser diodes, but control of the dopant distribution has been a difficult task [1]. Also it is well known that polarization effects have an influence on device properties. A previous report on GaN NWs found an effect of strain on the charge distribution via off-axis electron holography EH [2]. We report the measurement of the electric potential and depletion width in GaN NW p-n junctions using EH which is carried out using transmission electron microscopy (TEM) [3]. Nanowire p-n junctions grown by Molecular Beam Epitaxy, with Mg and Si as the p and n-type dopants, had doping concentration of 5 x 10¹⁷ and 1 x 10¹⁹ cm³, respectively, based on planar growth calibrations. A high density of basal plane (0001) stacking faults was found to be present within the p-type side whereas the n-side was free of detectable defects. Also the diameter of the p–type segment of the wires was always larger and highly anisotropic compared to the more uniform diameter n-type side. Phase images and potential profiles, extracted from the EH measurements, showed both an effect of thickness and the presence of a junction. An average built-in voltage of 0.5 ± 0.1 V and depletion width of 80 ± 5 nm were measured which both indicate either a smaller carrier activation or reverse biasing from charging or polarization effects. Results from a variety of growth conditions and structures will be presented.

1. Wallentin, J et al. Doping of semiconductor nanowires. J. Mater. Res. 26, 2142 (2011).
2. Chen, X et al. Controlling charges distribution at the surface of a single GaN nanowire by in-situ strain. Prog. Nat. Sci. Mater. Int. 27, 430–434 (2017).
3. Darbandi, A et al. Direct Measurement of the Electrical Abruptness of a Nanowire p–n Junction. Nano Lett. 16, 3982–3988 (2016).

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