Strain relation in GaN nanowires with HfO_2 and Al_2O_3 shells examined by X-ray diffraction and Raman spectroscopy techniques

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Recent years have exhibit the dynamic development of integration photonics with electronics on a single platform. GaN nanowires (NWs) are often studied as a potential building blocks of such systems since NWs grow virtually free of strain and defects even on substrates with large lattice mismatch [1, 2]. Usually side surfaces of NWs are passivated by oxide shells. Thus, the question arises about the strain induced by such shells.

In this work we studied self-assembled GaN nanowires of ~100 nm diameter and 2 µm height, grown by plasma-assisted molecular beam epitaxy on Si(111) substrates. The NWs were covered with shells of HfO_2 and Al_2O_3 using atomic layer deposition. The nominal thicknesses of the shells were 5, 10 and 20 nm. The dimensions of the NWs, such as diameters and shell thicknesses, were measured from SEM images. The uniformity of shells covering GaN NWs was analyzed in the SEM transmission mode.

Structural properties of GaN core-shell NWs were examined using X-ray diffraction (XRD) and Raman spectroscopy techniques. In particular, the values and the type of strain were investigated, together with their dependence on the shell thickness. First, the XRD curves and high resolution XRD maps were measured to calculate the accurate values of lattice parameters of GaN core parts. $2\theta/\omega$ scans of 0002 GaN reflections (see Fig. 1(a)) revealed changes in interplanar distances in the GaN core with the magnitude depending on the thicknesses of shell parts. Calculations of a and c lattice parameters allowed to find the in-plane (ε_{xx}) and out-of-plane (ε_{zz}) strain values for the studied samples. Next, the Raman spectroscopy was used to study the lattice vibration mechanisms, crystalline quality and strain in GaN/HfO_2 and GaN/Al_2O_3 core-shell structures. The comparison of in-plane strain values (ε_{xx}) obtained by these two techniques is presented in Figure 1 (b). The origin of strain and influence of oxide shell thickness on strain distribution in GaN/oxide core-shell nanowires will be discussed within this work.

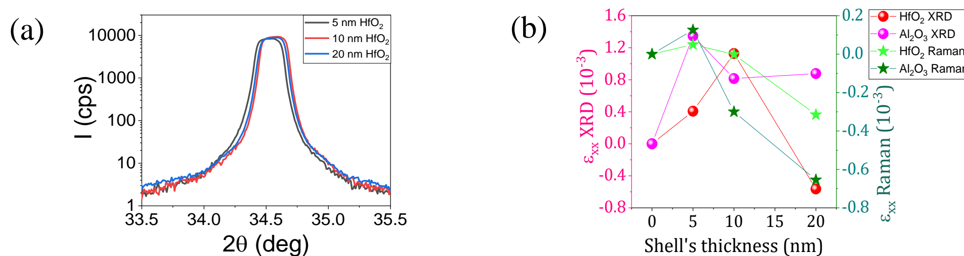

Figure 1. (a) XRD $2\theta/\omega$ scans of 0002 GaN reflection for GaN NWs with HfO_2 shell of different thickness, and (b) the values of ε_{xx} strain component calculated from XRD and Raman measurements of GaN/oxide NWs of various shell thickness.

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[2] S. Li and A. Waag, *J. Appl. Phys.* **111**, 071101 (2012).
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