An insight into the optical properties of GaN nanowires with Al_2O_3 and HfO_2 shells

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Recent development of gallium nitride-based heterostructures to a great extent is based on nanostructures, which help to overcome the limits of heteroepitaxy. Among others, nanowires (NWs) arrays bring many advantages since they eliminate global stress, increase the photoluminescence efficiency, and provide new opportunities for the construction of modern devices by changing the NWs composition, architecture or dimensions. This may lead to the next generation of ecological and highly efficient light emitters and detectors.

In this work, we have studied self-assembled GaN nanowires of ~90 nm diameter and 2 μm height, grown by plasma-assisted molecular beam epitaxy on a Si(111) substrate. The NWs were covered with oxide shells of Al_2O_3 and HfO_2 prepared by atomic layer deposition process. The nominal thicknesses of the shells were 5, 10 and 20 nm. The structural parameters of the NWs, such as diameters and fill factors, were derived from SEM images. The core-shell architecture was verified in the SEM transmission mode.

The influence of shells on the optical properties of GaN NWs was studied in optical reflectance and photoluminescence measurements. First, the reflectance spectra were measured and examined within the wavelength range of 300-1800 nm at room temperature. The effective medium approximation model was used to fit the observed interference patterns [1] (Fig. (a)). Based on the reflectance measurements, spectral dependence of effective refractive index was calculated. It has been shown that the experimental data precisely follow the theoretical model. Moreover, the fill factors were estimated with the Bruggeman model [1]. Their values were found to agree very well with those obtained from SEM images.

Finally, the optical properties of the NW samples were studied in the temperature range of 10 to 300 K. The photoluminescence signal (Fig. (b)) was observed in the ultraviolet region with strong emission bands around 3.45 eV, 3.42 eV and 3.18 eV [2, 3]. Their origin and dependence on oxide shell thickness will be discussed.

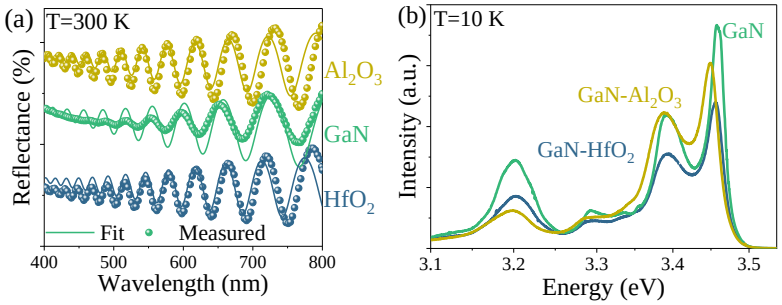

Fig. (a) Reflectance spectra (points) with theoretical fits (lines), and (b) PL spectra at 10 K of GaN/Si NWs with various oxide shells.

[1] H. Y. Chen, et al., Opt. Express **16**, 8106 (2008)
[2] K. P. Korona et al., J. Phys.: Condens. Matter **30**, 315301 (2018)
[3] K.P. Korona et al., J. Luminescence **155**, 293 (2014)

This work was partially supported by the Polish NCN grants 2021/43/D/ST7/01936 and 2022/45/B/ST5/02876.