Cathodoluminescence and electron microscopy studies of gallium nitride nanowires with passivated surfaces

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Although a clear influence of surface conditions on the transport and optical properties of semiconductor nanowires (NWs) was noticed already in the first decade of this century, methods of controlling surface states and inhibiting their harmful impact on the characteristics of NWs still remain an important and current subject of research. This applies especially to nanowires made of group III nitrides. Passivating by wet chemical treatments or coating of NWs with oxide layers are considered suitable means of protecting and passivating the NW sidewalls. Since low-dimensional nanostructures containing gallium nitride (GaN) and its alloys with aluminium nitride or indium nitride are promising structural elements of novel optoelectronic devices, such modifications of the NW surface may also significantly affect the operating parameters of NW-based devices.

In this work, we present the results of detailed transmission electron microscopy (TEM) and scanning electron microscopy (SEM) studies of GaN NWs grown by plasma-assisted MBE and then modified by etching their surfaces in KOH and HCl solutions or covered with hafnium oxide coatings by atomic layer deposition. The results are correlated with those from cathodoluminescence studies, which reveal light emission from individual NWs. It was found that the cathodoluminescence of GaN/HfO_x NWs, its intensity and distribution along the NW as well as its spectral characteristics, are strongly related to the properties of the oxide coating - its thickness, morphology and structure. Coating parameters leading to optimal cathodoluminescence of the structures are assessed.

SEM observations revealed significant changes in the morphology of NWs etched in KOH and HCl solutions. TEM examination provided high resolution insight into the atomic structure of the NWs and its changes caused by etching. Cathodoluminescence (CL) mapping and spectroscopy revealed strong emission changes associated with extended defects of NWs. Comparison of the results obtained using the techniques based on electron microscopy supplemented with XRD studies made it possible to reveal structural changes caused by surface etching in KOH or HCl solutions and leading to an increase in the luminescence of the nitride NWs.

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