Photoelectrochemical characterization of $In_xGa_{1-x}N$ alloys grown on GaN nanowire substrates

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ABSTRACT

Epitaxial growth on planar substrates has been pursued for creating single crystal layers of new materials. In many important materials systems, such as heteroepitaxy onto planar substrates leads to phase segregation and misfit dislocations due to lattice mismatch-induced stresses and strain. Recently, our group showed that using hetero-epitaxy on nanowire substrates grow thick layers (~200 nm) without the problems associated with planar substrates due to the lower interfacial contact area and stress relaxation. Specifically, using hetero-epitaxy, we were able to obtain single crystalline layers of $In_xGa_{1-x}N$ alloys with composition over the entire range for indium from 0 to 100%.[1] $In_xGa_{1-x}N$ alloys with indium composition from 45-65 % can have the right band gap between 1.7-2.2 eV necessary for photoelectrochemical water splitting applications.

The hetero-epitaxial growth of InGaN alloys on GaN nanowire substrates exhibited different growth morphologies depending upon nanowire growth direction. Typically, the "c" plane-oriented GaN nanowires exhibit stacking faults perpendicular to growth direction where as the "a" plane-oriented GaN nanowires exhibit stacking faults parallel to growth direction. Similarly, the hetero-epitaxial InGaN layers on "c" plane oriented nanowires developed stacking faults perpendicular to growth direction. The photocurrent for InGaN epilayers on GaN nanowire arrays was found to be on the order of only 100-150 $\mu A/cm^2$. In some cases, there was no photoactivity. This "poor" photoelectrochemical performance is attributed to the extension of defects in the epilayers grown using "c" wires and the corresponding poor conductivity of the "c" direction wires.[2] In order to address this problem, we have been creating "a" plane oriented nanowire arrays on both stainless steel and sapphire substrates and use them for producing InGaN epilayers. In this presentation, we will highlight work our results on photoelectrochemical properties of InGaN layers grown specifically on "a" direction nanowire arrays. Several properties such as flat band potential and stability are of interest as a function of indium composition in InGaN alloys in addition to photoactivity.

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