Surface Carrier Density in 2D and 3D Indium Nitride Structures

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Narrow-bandgap materials have gained increased attention due to their great applicability in infrared systems. [1] In particular, indium nitride (InN) offers extraordinary advantages to the industry of ultra-fast high-power electronics due to its high mobility, low effective electron mass, and widely tunable plasmonic activity. But, the challenging fabrication of InN-based devices makes it difficult to explore its benefits. The accumulation of electrons at the surface of indium nitride structures has been previously reported for 2D and 3D materials. However, the control of such charge accumulation using growth parameters is yet to be explored. [2]

In this study, we investigate the morphology, structure, and optical features of a series of 2D and 3D InN structures grown using different In/N flux ratios. By evaluating the longitudinal optical phonon-plasmon coupled modes of InN using Raman spectroscopy, we measure the surface carrier concentration increasing from approximately 10^{17} to 10^{18} cm^{-3} as the surface-to-volume ratio decreases. By simulating the InN structures using the k.p method we show that the morphological evolution from 3D to 2D structures modifies the electron occupation near the surface, as shown in Figure 1. Our key finding shows that the charge profile along the InN structure is influenced by its structural features, such as porosity, surface-to-volume ratio, in-plane strain, and roughness of the material by modifying the bending of the conduction and valence bands along the InN material.

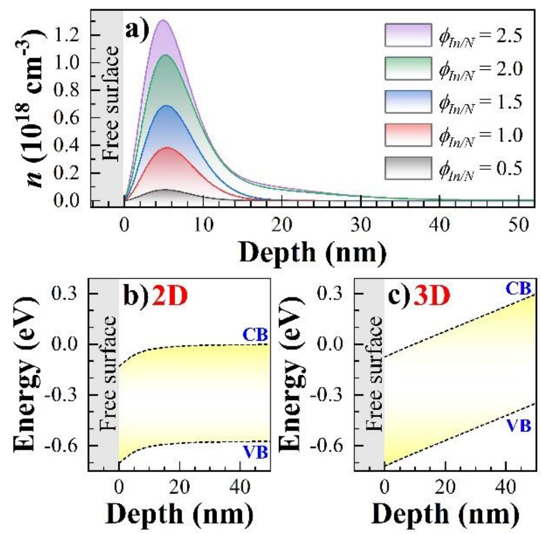

Figure 1 – a) Depth profile of the charge density into the InN layer for each sample in the region close to their InN free surface. b) Conduction (CB) and valence (VB) band edges of 2D (sample grown at $\boldsymbol{\phi_{In/N}}$ = 2.5) and c) 3D (sample grown at $\boldsymbol{\phi_{In/N}}$ = 0.5) InN structures.

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