

Self-Assembled Nanostructures in  $\text{In}_x\text{Ga}_{1-x}\text{N}$  Epitaxial  
Layers and Their Applications in Solar Conversion  
Devices  
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$\text{In}_x\text{Ga}_{1-x}\text{N}$  crystallizes in the wurtzitic structure which consists of two interpenetrating h.c.p. sub-lattices. The In and Ga atoms reside on one sub-lattice, whereas the nitrogen atoms occupy the second sub-lattice. An interesting question is whether or not the In and Ga atoms, which differ in covalent tetrahedral radii, are distributed at random on their sub-lattice.

To address the above issue, we investigated microstructures of  $\text{In}_x\text{Ga}_{1-x}\text{N}$  layers for x values ranging from 0.03 to 0.34. These layers were grown by metalorganic chemical vapor deposition on (0001) GaN/sapphire composites. Subsequently, they were evaluated using high resolution x-ray diffraction, photoluminescence and plan-view and cross-sectional transmission electron microscopy.

The atomic species are distributed at random for  $x=0.03$ . However, for  $x=0.12$  or higher, we observe satellites close to the Bragg reflections. This implies the occurrence of phase separation in these layers. From the positions of satellites we determined wavelengths of modulations; the higher the indium content, the smaller the wavelength. The modulations occur along the  $\langle 10\bar{1}0 \rangle$  and  $\langle 11\bar{2}0 \rangle$  directions lying in the (0001) plane, and consist of In-rich and Ga-rich regions. They evolve to reduce the strain energy of the system. In addition, we observe 1:1 atomic ordering on the (0001) plane that changes the atomic arrangement in the random alloy,  $A(\text{Ga},\text{In})a(\text{N})B(\text{Ga},\text{In})b(\text{N})A(\text{Ga},\text{In})a(\text{N})\dots$  to  $A(\text{Ga})a(\text{N})B(\text{In})b(\text{N})A(\text{Ga})a(\text{N})B(\text{In})b(\text{N})\dots$  in the ordered layer.

The band gaps of GaN and InN are, respectively, 3.42 and 0.8 eV.  $\text{In}_x\text{Ga}_{1-x}\text{N}$  layers with x ranging from zero to hundred cover the whole solar spectrum. Therefore, it should be feasible to design solar conversion devices based on  $\text{In}_x\text{Ga}_{1-x}\text{N}$  materials that would serve as effective absorbers of solar energy. However, an important question is how does the presence of In-rich (low band gap) and Ga-rich (high band gap) regions affect the separation of photon-induced electron – hole pairs? We will consider this issue.

The support of the work by NSF is gratefully acknowledged.