Proposal of III-N-based Novel Next Generation Solar Cells and Novel Blue-Green Light Emitters

Akihiko Yoshikawa, Yoshihiro Ishitani, and Kazuhide Kusakabe

Graduate School of Electrical and Electronic Engineering, and Venture Business Laboratory, Chiba University
1-33 Yayoi-cho, Inage-ku, Chiba 263-8522 Japan

The III-Nitride semiconductor system consisting of AlN, GaN, and InN can cover a wide optical wavelength range corresponding to the energy bandgaps from 6.2 to 0.65 eV. This indicates almost whole effective solar spectral range as well as whole visible color and near IR emissions can be covered by these III-N photonic devices.

We have been studying for a long time on the epitaxy and material control of InN, GaN and related alloys under both +c(In,Ga)-polarity and –c(N)-polarity growth regimes. On the basis of systematic studies / deep understanding on the residual donors in unintentionally n-type doped InN and In-rich InGaN as well as systematic acceptor (Mg) doping study for very wide range [Mg]s, we have recently achieved/confirmed successful p-type doping in InN and In-rich InGaN. This is a very important fact and a mile stone when considering their application for any photonic and electronic devices.

Furthermore, in order to find one of solutions for minimizing the effects arising from large lattice mismatch for InN/GaN/AlN-based heterostructures, we have also been studying fabrication and characterization of InN/GaN-based fine heterostructures.

On the basis of these studies/understandings on epitaxy and heterostructure fabrication for GaN, InN, AlN and related alloys, we propose III-N-based novel structure next generation solar cells. The theoretical maximum conversion efficiency for the 6-tandem cells utilizing photo-sensitization effect is expected to be as high as 56 % for AM1.5-sun and 65 % for the 250-times concentration. Furthermore, it is shown that the proposed III-N heterostructures are applicable for novel blue-green light emitters.

Principle and features of the proposed photonic devices, related epitaxy processes for those novel structures, and their fundamental properties will be discussed in this talk.