Recent Advancement of Growth of InN and In-rich InGaN by RF-MBE

Yasushi Nanishi[1], Tomohiro Yamaguchi[2] and Tsutomu Araki[1]

[1]*Ritsumeikan University, 1-1-1 Noji-Higashi, Kusatsu, Japan*
[2]*Kogakuin University , 2665-1 Nakano-machi , Hachiouji, Japan*

Finding much narrower bang gap of InN in 2002 gave great impact and drew much attentions on new and exciting expectations to expand application fields of group III nitrides from UV to IR wavelength range. Further studies on material properties of InN revealed much higher mobility and smaller effective mass than we have ever believed, which again brought much attention on application of InN to high frequency devices. As this material system covers almost all spectrum range of solar energy, extending application field to highly effective solar cell also attracted much attention.

Research and development on these devices, however, have not made big progress during the last 14 years, due to difficulty in obtaining high quality material of InN and In-rich InGaN. Low dissociation temperature coupled with low growth temperature, large lattice miss-match between InN and GaN and inherent immiscible nature of InGaN are the main causes of poor quality of this material system.

We have developed a new RF-MBE growth method called DERI (Droplet Elimination by Radical Beam Irradiation) for the purpose to grow high quality InN reproducibly. This growth method is consisted of the two series of growth steps with In-rich growth step (MRGP: Metal Rich Growth Process) and consecutive nitrogen radical beam irradiation step (DEP: Droplet Elimination Process). In this growth method, InN is gown under the condition very similar to atomic level liquid phase epitaxy, which makes it possible to grow InN under almost thermal equilibrium condition.

We have applied this DERI method to InGaN alloy growth, where we have observed strong phase separation, with preferable capture of Ga to growing crystal from In-Ga metal coverage layer on the surface and In is swept out. Using this phase separation phenomenon positively, we have successfully grown InN/ InGaN and InGaN/InGaN MQW layers. This growth technology has a potential for fabrication of IR and green wavelength light emitting devices based on group III nitride semiconductors.

This material system tends to make strong phase separation. This implies essential difficulty to obtain uniform InGaN alloys throughout entire compositional range. We have found new method to obtain uniform and thick InGaN in full compositional range by DERI method through controlling Ga flux while maintaining growth surface covered by more than two mono-layers of In. This technology offers very useful method for application of InGaN both to solar cell and to relaxed template for longer wavelength LEDs. Trial to passivate misfit dislocations induced by large lattice mismatch between InN and GaN is underway using phase separation positively growing wider bandgap alloy surrounding dislocation cores.

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