Find the way to go beyond the simple blue-light-emitting materials

The current status and difficulties which hinder the realization of high-crystal-quality group-III nitride alloy thin films and bulk crystals were assessed, and the way to solve these problems to open up novel device applications were intensively discussed. The critical importance of the strict trials on the crystal growth scheme was addressed, such as utilization of high-pressure, highly-nonequilibrium condition and exotic templates.

The international workshop "Intensive discussion on growth of nitride semiconductors" was held on October 22nd-23rd, 2012 in the Katahira Sakura Hall, Tohoku University. This workshop aimed to analyze the status quo, and to find the direction to take in the future and the problems that need to be solved in the field of nitride semiconductors.

Starting from the vapor-phase synthesis of GaN in 1969, the research on nitride semiconductors has progressed so that InGaN-based light emitting diodes and laser diodes in the visible wavelength regime are commercially available. In spite of these fruitions, however, the crystal qualities of these materials were still poor and have difficulties in the extension of the operating wavelength toward deep-UV and/or IR regimes with increasing the AlN and/or InN mole fractions, respectively. In particular the application of the semiconducting materials to novel devices operating at these extremely short and longer wavelengths were encouraged, in order to replace mercury gas tubes as well as conventional lasers by highly-luminescent emitters to meet the energy-saving policies of current world societies.

Based on the above targets, spirited 47 researchers from nine countries, most of them are crystal growers, gathered to share the problems such as immiscibility and lattice mismatch of nitride semiconductor thin films and bulk crystals. Numbers of novel techniques to improve the crystal quality have been spread out. Among all, in case of growth of alloy films with immisible compositions, the precise control of in-plane stress by the adoption of pseudomorphic growth throughout the heteroepitaxial systems is expected to be useful to diminish the miscibility gap. This idea of intentional strain application has also been expanded to the unique idea, modulation of the electronic band profiles without impurity doping via piezoelectric effect, *i.e.* polarization doping, characteristic of the wurtzite crystals.

As for the trials on the alloy composition never achieved under thermodynamical equilibrium conditions with relavant growth apparatuses, the successful deposition of the volatile high-indium-content InGaN and InN films were reported by different groups: MOVPE growth under raised-pressure ambient up to 8 atm, droplet induced liquid-solid growth based on MBE as well as ultra-low-temperature pulsed sputtering deposition. As for the high aluminum content AlGaN, free standing AlN substrates grown by hydride vapor phase epitaxy and solid-source solution techniques are presented since the importance of the lattice-matched substrates has been stressed. Also the reduction of the threading dislocation density by selective area growth and use of the patterned substrates founds to be still applicable to the improve the performances of InGaN based devises, clearly shown by the successful realization quasi-step-free growth surface which is beneficial for obtaining high-quality quantum well structures.

The workshop chairs found a great deal of satisfaction in all the topics, and would like to say thank to all the panelists and participants who boosted the fruitful discussions.

Fig. 1 Taking a short break preventing the device failure due to the heating up.

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