Closing Green Gap in LEDs Technology: Challenges and Future Solutions

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By 2020, demand would be strong in Malaysia lighting market, witnessing rapid growth residing in applications such as commercial/industrial lighting, horticultural lighting and medical/health care lighting. Great progress on blue LEDs based on III-V nitrides has been achieved, with their efficiency is more than 80%. Nonetheless, this is not the case for longer wavelength emission LEDs, which covers visible energy spectrum from green to red. The external quantum efficiency (EQE) of those devices is reported to degrade significantly with increasing current. Such problem is related to high droop efficiency and this phenomenon is known as 'Green gap'. In principle, longer emission wavelength LEDs requires more indium composition in $In_xGa_{1-x}N$ quantum wells. Nevertheless, growing $In_xGa_{1-x}N$ materials with high indium composition is difficult due to indium decomposition issue, which always leads to significant reduction of internal quantum efficiency (IQE) and subsequently EQE of the LEDs. To overcome this issue, several novel methods have been proposed in literature and will be discussed in the talk. Furthermore, major challenge to increase IQE/EQE of longer wavelength emission LEDs is quantum-confinement Stark effect (QCSE), which becomes more significant in $In_xGa_{1-x}N$ materials with high indium composition. The effect reduces wavefunction of electrons and holes, resulting low internal radiative quantum efficiency of LEDs. Growing longer emission wavelength LEDs on semipolar and non-polar GaN substrate is one of ways to eliminate the QCSE phenomena, but is this technique desirable from industrial practical point of view? Towards the end of the talk, future plan to develop longer emission wavelength LEDs at INOR, USM will be proposed. Discussion on design structure of the LEDs, with substrate choice in order to suppress the droop efficiency of the LEDs will be presented.