Nano-structures and luminescence mechanisms of InGaN-based quantum well light emitting diodes (Abstract)

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Energy-efficient and environmentally friendly solid-state light sources, in particular GaN-based light emitting diodes (LEDs), are currently revolutionizing an increasing number of applications, and bring apparent benefits to vast areas of development, such as lighting, communications, biotechnology, imaging, and medicine. It is expecting that LEDs may replace the traditional light bulbs and tubes to achieve a new lighting echo.

InGaN/GaN multiple quantum wells are the key components of these commercial devices emitting UV-green and white light, acting as the active layer, which can exhibit intense luminescence despite of a high dislocation and defects density existed. However, despite an impressive commercial success, the mechanism of luminescence from InGaN/GaN is not yet well-understood and the physical origin of efficient light generation is unveiled incompletely.

This presentation reviews our wide range of studies on the nano-structural features, the correlation with optical properties and luminescence emission mechanisms from a large number of InGaN/GaN MQW LEDs, prepared by metalorganic chemical vapor deposition (MOCVD). Analytical techniques of photoluminescence (PL), PL excitation (PLE), time resolved PL (TRPL), high-resolution (HR) X-ray diffraction (XRD) and HR transmission electron microscopy (TEM) have been used to investigate InGaN-LEDs. They have shown the excellent optical and structural properties, evidenced by HRXRD with high order (some up to 10^{th} order) QW XRD satellite peaks and fine fringes and by HRTEM with sharp MQW structures and V-shaped defects. The quantum dot like structure features are revealed to exist within the MQW structures, which leads to unique T-behaviors of PL spectra. Quantum confined Stokes effect was observed from the comparison of PL and PLE measurements, even at room temperature (RT). TRPL exploration with the variation of detecting energy and temperature and modeling analyses together with above other analytical investigation have provided new insights of physics on the luminescence mechanism of InGaN/GaN MQWs. Different mechanisms and arguments from literature are introduced and discussed.

Brief Biography

Prof. Zhe Chuan FENG, received the BS (1968) and M.S. (1981) from Peking University, and Ph. D in University of Pittsburgh, 1987. He had worked at Emory University (1988-92), National University of Singapore (92-94), Georgia Tech (95, 2002-03), EMCORE Corporation (95-97), Institute of Materials Research & Engineering, Singapore (98-2001), and Axcel Photonics (2001-02), in all places with fruitful results and achievements. Since August 2003, Feng has joined National Taiwan University as a professor at Graduate Institute of Electro-Optical Engineering& Department of Electrical Engineering, currently focusing on MOCVD growth and investigation of wide gap semiconductors of III-Nitrides, ZnO and SiC, as well as III-V and other nano-materials/devices.

He has published six review books on advanced compound semiconductors and microstructures, porous Si, SiC and III-Nitride materials. The 7^{th} book on III-Nitride devices and Nano-Engineering is currently in editing. Feng has published >350 scientific/technical papers with half selected by Science Citation Index and cited >1500 times. He has been visiting/Guest professors at Huazhong University of Science & Technology, Nankai University and Tianjin Normal University. He is currently a member of International Organizing Committee of Asian Conferences on Chemical Vapor Deposition, and Board of Directors, Taiwan Association for Coating and Thin Film Technology (TACT).