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Microcharacterization of GaN Nanomembranes Using Cathodoluminescence Microanalysis.

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Gallium nitride (GaN) is a thermally stable, chemically inert wide-band-gap compound semiconductor with applications in high temperature, high power, high frequency electronic devices, solid state sensors,[1] optoelectronics applications, light emitting diodes and lasers,[2] and spintronics where the GaN is ferromagnetic transition-metal-doped,[3] etc. Recent efforts have been focused on controlling technologically useful GaN properties through nanostructuring using a variety of deposition or etching techniques[4]. The combination of surface charge lithography (SCL) as a low energy ion beam pre-treatment, followed by photoelectrochemical (PEC) etching, enables the maskless fabrication of nano-perforated and continuous GaN membranes with nanometer-scale thickness.[4,5] and may provide the possibility of using GaN for MEMS/NEMS applications, which rely on thin membrane technologies.[6]

The useful properties of technologically important GaN are strongly influenced by microstructural defects which can result from impurities, and native imperfections (e.g. dislocations, vacancies, etc.). Cathodoluminescence microanalysis (CL) provides nanoscale spatial resolution, high sensitivity detection of trace levels of impurities at high spatial resolution.[7] A *JEOL 7001F* field emission SEM equipped with a *Gatan XiCLone* cathodoluminescence (CL) microanalysis system and LN_2 cryostage has been used for comparative morphological and CL characterization of the GaN nanomembranes.

CL hyperspectral and monochromatic imaging have been used to characterise the GaN nanomembranes which have been produced on a low pressure MOCVD 3-µm-thick wurtzite n-GaN layer on 25nm GaN buffer on (0001) c-plane sapphire substrate. For example, the spatial distribution of CL from a typical region is shown in Fig 1. Monochromatic CL images collected at energies of 3.4 eV and 2.25 eV give insight into the CL emission associated with key features of the GaN nano-membranes including the suspended nano-membranes, the etch-resistant dislocation-related whiskers and the underlying etched regions of the 3-µm-thick GaN layer. The monochromatic CL images of this typical region show that the dislocation-related whiskers emit mainly a broad yellow defect associated emission, while the underlying etched GaN is dominated by the ~3.4 eV GaN near-band-gap emission. In contrast, suspended nano-membranes are characterized by both 2.25 eV and 3.4 eV emissions noting that majority of the UV component originates from the underlying etched regions due to the transmission of both incident electrons and resultant CL through the thin suspended nano-membranes. Knowledge of the defect