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Yellow Luminescence and Optical Quenching of Photoconductivity in Ultrathin Suspended GaN Membranes Produced by Surface Charge Lithography

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Spatial and spectral distribution of cathodoluminescence as well as photoelectrical properties under excitation with two beams of monochromatic radiation of various wavelengths are investigated in ultrathin suspended GaN membranes produced by surface charge lithography as compared to bulk GaN layers. GaN membranes are designed by focused ion beam treatment of GaN epilayer surfaces with subsequent photoelectrochemical etching. The analysis of the spatial and spectral distribution of microcathodoluminescence demonstrates that the membranes exhibit mainly yellow luminescence (YL). In investigating photoelectrical properties, the first beam of radiation induces photoconductivity, while the second beam is used for the investigation of optical quenching (OQ) effects. It was found that the second beam of radiation produces OQ of photoconductivity, but not quenching of the persistent photoconductivity (PPC), in bulk layers. In contrast to this, OQ of both photoconductivity and PPC occurs in ultrathin GaN membranes. We suggest that the enhancement of YL and the OQ of PPC in ultrathin membranes involved are related to each other, and both phenomena can be attributed to the same point defects which are most likely gallium vacancies.

Keywords: Utrathin Membranes, Surface Charge Lithography, Focused-Ion Beam Treatment, Cathodoluminescence, Persistent Photoconductivity, Optical Quenching.

RESEARCH ARTICLE

1. INTRODUCTION

GaN is a wide band gap semiconductor compound ($E_g =$ 3.4 eV at 300 K) exhibiting pronounced chemical and thermal stability with applications in high temperature and high power electronics, optoelectronics for light emitting diodes and lasers, etc. It was recently suggested that GaN has a large potential for applications in MEMS/NEMS in addition to traditional applications.[1] However, this potential relying on thin membrane technologies is poorly explored. Among few reports on this subject one can mention the fabrication of 500 nm thick GaN membranes or of 350 nm thick GaN photonic crystal membranes suspended over Si by using bulk micromachining techniques[2,3] and the fabrication of 20–35 nm thick AlN/GaN crystalline porous free-standing membranes on Si(111) by selective silicon etching.[4] On the other hand, the previously proposed surface charge lithography (SCL)[6,7] provides wide possibilities for a controlled fabrication of GaN membranes, nanowalls and nanowires.

SCL is a maskless approach based on direct writing on the surface of semiconductor by a focused ion beam of negative charge which shields the material against PEC etching. Ultrathin GaN membranes suspended on specially designed GaN micro- and nanostructures have been recently fabricated in a technological process combining SCL with two selected doses of ion beam treatment of GaN layers.[1] The analysis of the spatial and spectral distribution of microcathodoluminescence demonstrated that the membranes exhibit mainly yellow luminescence (YL). However, the origin of this emission and its interrelation with other effects such as persistent photoconductivity

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