PREPARATION AND CHARACTERIZATION OF UNDOPED POROUS GALLIUM NITRIDE (GaN) BY UV ASSISTED ELECTROCHEMICAL ETCHING

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5.0 Report

5.1 Proposed Executive Summary

III-V nitride semiconductors such as GaN, InN and AlN and their alloys (AlGaN, InGaN, AlInGaN) have been investigated intensively in the last decade for their practical applications in short wavelength optoelectronic devices and high power/high frequency/high temperature electronic devices. These excellent applications are based on the unique and superior properties of nitride semiconductors such as wide direct band gap, strong piezoelectric effects (~0.2 – 0.6 GV/m), high-saturation velocity ($\sim 2.7\times10^{4}$ cm/s) and high breakdown field ($\sim 0.2\times10^{9}$ V/m) [1].

A great deal of interest displayed in porous semiconductors in recent years is motivated by the prospects that they present in optoelectronics, chemical and biochemical sensors. The reduction of dimensions to nanometer sizes changes dramatically the physical properties of semiconductors and hence opens alternative possibilities for their applications. Porous semiconductors are also under study as possible templates for epitaxial growth where the pores might act as sinks for mismatch dislocations and accommodate elastic strain in heterostructures.

The project proposed here is to prepare and study III-nitrides (GaN-based) porous structures. Various approaches such as electroless etching and other novel techniques will be investigated to prepare these nanoporous structures. Various characterization tools such as scanning electron microscopy (SEM), high resolution x-ray diffraction (HRXRD), photoluminescence and Raman spectroscopy will be used to investigate the structural and optical properties of the structures.

5.2 Enhanced Executive Summary

In this project, works are focusing on the investigation of the porous GaN materials. Since porous GaN is a new form of material, the properties are scarcely found in the literature. In this project, various characterization tools have been used to investigate the structural, morphological and optical properties of porous GaN generated by ultra-violet assisted electrochemical etching method. In this work, porous GaN layers were prepared by ultraviolet (UV) assisted electrochemical etching method using unintentionally doped (UID) n-type GaN films grown on sapphire (0001) substrate with GaN thickness of 6 μm. Platinum (Pt) wire was used as a cathode electrode. The wafer was cleaved into few pieces and subsequently dipped into 2 % concentration of KOH electrolyte under illumination of 500 W UV lamp for various anodization duration and applied voltages.

From the SEM micrographs, the pore size of all the samples was found to be varied widely, and different shapes could be observed. For the SU1, SU2, SU3 and SU4 samples, the etching was in the initial stage; pores started to form, and the size of the pores were relatively small, therefore mostly circular shaped structures were observed. For SU5, SU6 and SU7 samples, the surface became relatively rough. SEM images revealed that the average pore size for samples were around 0.16μm to 0.43 μm. The average pore size of the samples was found to be influenced significantly by the anodization duration and the change of applied voltage. The size of the pores increased with the increase of the anodization duration. Furthermore, it can be observed that the pores are not distributed uniformly. On the other hand, it is interesting to note that the porous GaN prepared by the electrochemical etching method does not always produce similar surface morphology.

Photoluminescence (PL) measurements revealed that the near band edge peak of all the porous samples were red-shifted; moreover, the PL intensity enhancement was observed in the porous samples. The red shift was also ascribed to the relaxation of the compressive stress in the porous samples. Raman spectra exhibited the shift of E_2 (high) to the lower frequency for porous samples. In contrast, the forbidden modes, A_1 transverse optical (TO) and E_1 (TO) phonon modes were present in Raman spectra only for SU5, SU6 and SU7. Generally, the studies showed that porosity could influence the structural and optical properties of the GaN.