MORPHOLOGY AND OPTICAL PROPERTIES OF POROUS GaN GENERATED VIA METAL-ASSISTED ELECTROLESS ETCHING

Diego J. Díaz, Todd L. Williamson, Paul W. Bohn
Beckman Institute for Advanced Science and Technology and Department of Chemistry, University of Illinois at Urbana-Champaign, 405 N. Mathews Ave., Urbana, IL 61801

Porous gallium nitride (PGaN) is produced by Pt-assisted electroless etching of GaN. Ultrathin Pt films are sputtered onto the surface of GaN, and etching is carried out in a $CH_3OH:HF:H_2O_2$ solution. The catalytic reduction of peroxide on the Pt surface injects electron-hole pairs into the GaN, which are subject to in-plane drift and ultimately assist the chemical etching. SEM analysis reveals that etching proceeds by first forming a network of small pores, after which ridge structures form, with the porous network in trenches between the ridges. SEM and AFM studies are used to characterize the evolution of these ridge structures as etching progresses. SEM cross section studies reveal that the pores are highly columnar and show little evidence of lateral branching, except at the surface.

Cathodoluminescence (CL) spectroscopy and imaging show the ridges to be optically dark, suggesting that the ridges might arise from grain boundaries or dislocations present in the starting GaN material. CL emission is confined to the porous areas between the ridges. CL properties of the PGaN vary depending on the source of the original, non-porous GaN material. Undoped and unintentionally doped materials from hydride vapor-phase epitaxy produce PGaN which shows only bandgap emission at 368 nm before and after etching, whereas PGaN produced from Si-doped MOCVD material exhibits two blue-shifted luminescence bands at 358 nm and 326 nm. The origin of the 358 nm blue-shifted emission can plausibly be explained by quantum confinement effects, but the 326 nm band can only be explained by other mechanisms, such as the creation of specific surface states by etching. The difference in light emission properties must be ascribed to growth conditions, or the nature and concentration of the dopants.

Raman spectroscopy shows that as etching proceeds, two TO modes of GaN, which are forbidden in the z(xx)z' backscattering geometry, grow in. Typically the appearance of polarization-forbidden TO bands in processed semiconductors is taken as evidence of disorder in the lattice, although X-ray diffraction data does not validate such explanation. The correlation between the etched morphology and the optical properties will be addressed.

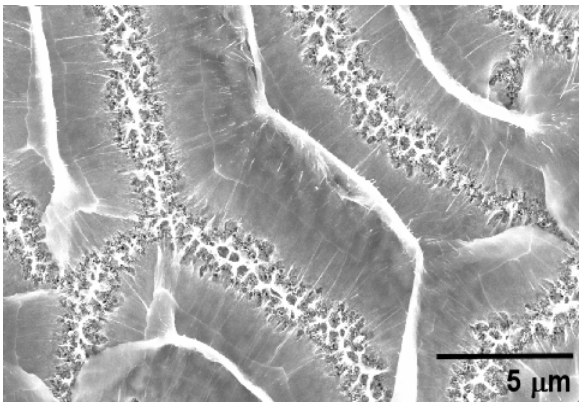

Figure 1. SEM image of porous GaN etched for 45 minutes, showing the ridge structures and the porous morphology between the ridges.

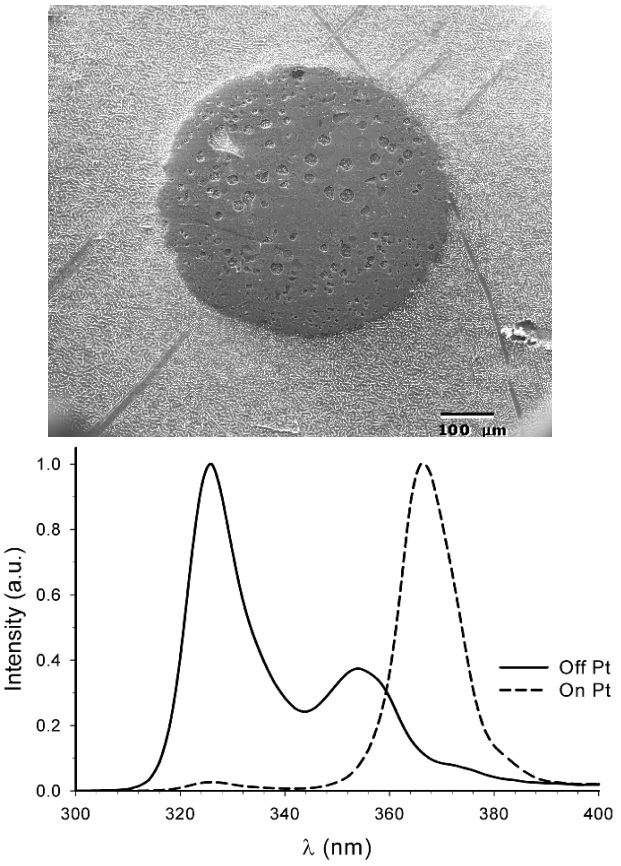

Figure 2. (Top) SEM Image of the Pt dot sputtered on GaN and the areas outside the Pt, after etching for 45 minutes. (Bottom) CL spectra shows the emergence of two blue shifted bands (326 and 358) nm on areas outside of the Pt, whereas only bandgap emission is observed on the Pt disk.