Supporting Information for:

Wide Bandgap III-Nitride Nanomembrane for Optoelectronic Applications

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Nanomembrane epitaxial structure and hydrofluoric acid based electrochemical etching

The metalorganic chemical vapor deposition (MOCVD) growth on sapphire begin with 1-μm-thick undoped GaN using a standard two-step growth[1] followed by moderately n-doped layer (Si concentration of 5×10^{18} cm^{-3}, 500 nm in thickness) to ensure uniform distribution of the anodization bias across the sample. This n-type layer is protected from electrochemical (EC) etching by another undoped GaN with thickness of 500 nm above which the sacrificial layer is grown with a Si doping concentration of 1.2×10^{19} cm^{-3} (200 nm in thickness). A thin layer of highly doped n-type GaN Si concentration of 4.8×10^{19} cm^{-3}, 10 nm in thickness) was inserted at

both the top and bottom of sacrificial layer to enhance the contrast in conductivity. Photolithography followed by chlorine-based reactive ion etching (ICP-RIE, Oxford Plasmalab 100) is used to open via windows with a depth that reaches the sacrificial layer to expose the sidewalls of heavily doped n-type GaN. Photoresist (Shipley Microposit S1827) is used as a mask for chlorine-based reactive ion etching.

EC etching of GaN nanomembrane (NM) structures is conducted in a two-electrode cell at room temperature with NM including n-type GaN as the anode and a platinum wire as the counter electrode (cathode).[2] The electrolytes are prepared by adding glycerol and ethanol to hydrofluoric acid (HF, 49 %) with a volume ratio of 3 (glycerol) : 2 (ethanol) : 1 (HF). The ethanol is added to the electrolyte to increase the electrolyte wettability. The partial substitution of ethanol with glycerol is found useful in further improving the smoothness after EC etching.[3] The anodization process is carried out in a potentiostatic (constant voltage) mode controlled by a Keithley 2400 source meter, while etching current is recorded. The parameters of lateral HF EC etching have been explored previously.[4]

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