Mechanism of electrochemical anodic etching of n-GaN in oxalic acid

King Abdullah University of Science and Technology,

°Artem Shushanian, Daisuke Iida, Zhe Zhuang, Yu Han and Kazuhiro Ohkawa

E-mail: kazuhiro.ohkawa@kaust.edu.sa

III-nitride materials are a trending basis for solid-state lighting devices. A selective electrochemical (EC) etching of n-doped GaN layers makes possible to relax a lattice strain in heterogeneous thin-film structures enhancing their emission at longer wavelengths[1)] and to fabricate air-gap distributed Bragg reflector (DBR) sublayers that increase light extraction efficiency in light-emitting diodes.[2)] Furthermore, air-gap GaN DBRs reveal the possibility of fabrication of vertical-cavity surface-emitting lasers with unique optical properties.[3)] Despite the popularity of this approach, there are a few studies to investigate a chemical mechanism of EC etching of n-GaN. Thus, with a lack of reaction product analysis, it is considered to be 3-electronic ($z = 3$).[4)]

We ran a series of experiments on EC etching of n-GaN to clarify its chemical mechanism. Oxalic acid was chosen as a media to study n-GaN interactions with solvent by tracking the transformations of oxalic anion on an inorganic carbon analyzer. We registered the reaction current (Fig. 1a), investigated Ga concentration via inductively coupled plasma-optical emission spectrometry (ICP-OES) (Fig. 1b), and determined composition of generated gases at the anode and cathode by a gas chromatography.

According to the analysis of the products we discovered a 6-electronic ($z = 6$) nature of n-GaN EC etching process in oxalic acid[5)]. The reaction proceeded uniformly through the formation of adsorbed intermediate compounds with Ga–O bonds. Hereby, this mechanism reveals a clear understanding of n-GaN etching reaction for its further precise control for the design III-nitride-based devices.

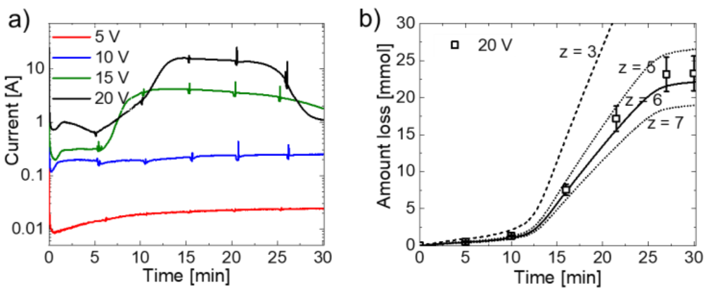

Fig. 1. (a) Etching currents, (b) GaN loss (squares) measured by ICP-OES and (lines) estimated from current at 20 V.

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