Toward Understanding Radiation-Induced Trap States in Gallium Oxide Devices

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Abstract:

Beta-phase gallium oxide (β-Ga_2O_3) has material properties that have generated a large and growing interest for applications in opto-electronics, power devices, and RF devices. The wide bandgap of ~4.6-4.8 eV leads to a large breakdown field that increases the Baliga and Johnson figures of merit, indicating potentially superior performance in high power and high frequency devices. The large bandgap also indicates a propensity for better radiation hardness due to higher required displacement energies. With the introduction of the complimentary material aluminum gallium oxide (b-$(Al_xGa_{1-x})_2O_3$), heterostructures can be realized to expand the range of devices. There are many opportunities and application for the β-Ga_2O_3 material system.

Recently, β-Ga_2O_3 grown by metal organic chemical vapor deposition (MOCVD) has demonstrated excellent material quality having high electron mobility of 184 cm^2/Vs.[1] In this work, MOCVD material is exposed to proton radiation at an energy of 1.8 MeV to understand how proton damage will influence the defect spectrum. Additionally, in the same MOCVD reactor, two b-$(Al_xGa_{1-x})_2O_3$ samples targeted at 10% Al were grown atop a Sn-doped β-Ga_2O_3 substrate.

Characterization of the MOCVD grown samples are done through multiple methods, mainly C-V, admittance spectroscopy (AS), and deep level transient and optical spectroscopy (DLTS/DLOS). The carrier removal rate of 185 $cm^{-1}$for 1.8 MeV proton radiation in MOCVD β-Ga_2O_3 is significantly lower than published work on the same energy proton radiation in n-type GaN Schottky diodes.[2] Characterization of the b-$(Al_xGa_{1-x})_2O_3$ Schottky diodes is underway. The doping concentration for the two samples were measured to be 1.9×10^{18} cm^{-3} and 3.3×10^{18}. Ideality factors were measured to be 1.60 and 1.55, respectively.

This work will focus on understanding the changes caused by proton radiation for each defect level and also getting a baseline of the b-$(Al_xGa_{1-x})_2O_3$ material quality and defect spectrum. With the knowledge of which defects are intrinsic and respond to radiation, theoretical studies for the displacement energies and possible intrinsic defects associated with each level will be discussed.

[1] Z. Feng et al., Appl. Phys. Lett., vol. 114, no. 25, p. 250601, Jun. 2019

[2] Z. Zhang et al., J. Appl. Phys., vol. 119, no. 16, p. 165704, Apr. 2016