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Dielectric Interfaces Poster Session

DI-MoP-1 Band Offsets of MOCVD Grown β-(Al0.21Ga0.79)2O3/β-Ga2O3 (010) Heterojunctions*, T. Morgan, J. Rudie, M. Zamani-Alavijeh, A. Kuchuk,* University of Arkansas*; N. Orishchin, F. Alema,* Agnitron Technology Incorporated*; A. Osinsky,* Agnitron Technology Incorporated, United States Minor Outlying Islands (the)*; R. Sleezer,* Minnesota State University at Mankato*; G. Salamo,* University of Arkansas, United States Minor Outlying Islands (the)*; **Morgan Ware,*** University of Arkansas

Recently, high quality alloys of β-$(Al_xGa_{1-x})_2O_3$, have been grown demonstrating excellent properties for use in high power, high frequency, and high voltage systems and devices such as wireless communication, satellite electronics, and electrified transportation.A natural step to follow the formation and study of these alloys is the study of their thin film heterostructures and subsequent devices. In order to support this, the heterostructure band offsets must be known well enough to model device performances. These values will vary slightly with crystal direction, i.e., the growth plane, as will the optimized growth conditions and film quality. Theoretical predictions for the monoclinic (β) aluminum oxide/gallium oxide interface predict a type-II interface with a maximum VBO value of 0.33 eV for Al_2O_3.

The presented study focuses on the stable (010) heterointerface. Several films of high quality β-$(Al_{0.21}Ga_{0.79})_2O_3$ were grown by metal organic chemical vapor deposition on bulk (010) oriented β-Ga_2O_3.The indirect bandgap of the β-$(Al_{0.21}Ga_{0.79})_2O_3$ was determined through optical transmission to be 4.69 eV with a direct transition of 5.37 eV, while β-Ga_2O_3 was confirmed to have an indirect bandgap of 4.52 eV with a direct transition of 4.94 eV. Theoretical calculations for this interface predict a type-II band alignment with a small VBO of only 0.08 eV and a conduction band offset (CBO) of 0.4 eV for a fully strained, 21% Al film on (010) β-Ga_2O_3.Experimentally, in the presented work, the band offsets for this β-$(Al_{0.21}Ga_{0.79})_2O_3$/β-$Ga_2O_3$ (010) heterojunction were then measured using x-ray photoelectron spectroscopy.The resulting band alignment was determined to be of type II with the valence and conduction band edges of the β-$(Al_{0.21}Ga_{0.79})_2O_3$ being -0.26eV and 0.43 eV, respectively above those of the β-Ga_2O_3 (010). These values can now be used to help better design and predict the performance of β-$(Al_xGa_{1-x})_2O_3$ heterojunction-based devices.

DI-MoP-2 Optimization of MOCVD Grown In-situ Dielectrics for β-Ga_2O_3*, G. Wang,* University of Wisconsin - Madison*; F. Alema,* Agnitron Technology Inc.*; J. Chen,* University of Wisconsin - Madison*; A. Osinsky,* Agnitron Technology Inc.*; C. Gupta,* University of Wisconsin-Madison*; **Shubhra Pasayat,*** University of Wisconsin - Madison

For ultra-WBG semiconductors, the development of dielectrics that can hold a much larger electric field demands high-quality films free of buried charges and traps. For Ga_2O_3, Al_2O_3 has proven to be a promising gate dielectric[1], typically grown using ALD at ~250 °C utilizing trimethylaluminum (TMA) and H_2O as precursors. Recently, MOCVD grown Al_2O_3 on β-Ga_2O_3 was demonstrated [2], using TMA and O_2 precursors but grown at 600 °C, with Ar carrier gas. In this prior work, a lower fixed charge of 2 x 10^{12} cm^{-2} compared to 3.6 x 10^{12} cm^{-2} in ALD Al_2O_3 on β-Ga_2O_3 was observed[2]. Higher growth temperatures lead to efficient pyrolysis of metal-organic sources like TMA, resulting in lower unintentional C content. The presence of C leads to donor and acceptor level creation, hence low C content allow lower leakage, higher V_{BR}, and reduced interface-state densities of MOS devices[3]. In addition, dielectrics grown within the MOCVD reactor (in-situ), as opposed to ALD chamber (ex-situ), avoid a regrowth interface, lowering interface-state densities[4]. Using triethylaluminum (TEA) instead of TMA, may improve the quality of in-situ Al_2O_3 as the ethyl radical is readily desorbed from the growth surface by the β-hydride elimination of ethene, reducing the C in Al_2O_3[5].

In this work, the Al_2O_3 dielectric growth using TEA and O_2 precursors in a 7x2” MOCVD reactor with close injection showerhead is reported, grown at 500-900°C on Sn-doped Ga_2O_3 and Si substrates. A constant TEA flow of 4.75 µmol/min was introduced into the reactor using Ar and N_2 carrier gases while the O_2 flow was varied as 100, 400, and 700 sccm, resulting in growth rates (GR) of 0.6, 1.4, and 1.7 nm/min, respectively. Compared to 1.2 nm/min GR reported using TMA precursor in an R&D MOCVD reactor [2], these GR demonstrate the prospect of TEA as a potential alternative to further improve the in-situ Al_2O_3 dielectric quality. The influence of N_2 as the sole carrier gas was also studied by introducing a TEA flow of ~3.4 µmol/min at an O_2 flow of 400 sccm, resulting in a 7x lower thickness variation across a 2” wafer without affecting the GR. The C content in Al_2O_3 resulting from TEA and TMA precursors, the use of alternate O precursors like N_2O, the D_{it} and V_{BR} comparison with other in-situ dielectrics like SiO_2 or $AlSiO_x$ will be quantified using CV and IV measurements on MOSCAP structures and reported at the conference.

1. K. D. Chabak *et al.* APL, vol. 109, no. 21, 2016 2. S. Roy *et al.* AEM, vol. 7, no. 11, 2021 3. M. Uenuma *et al.* AIP Adv., vol. 8, no. 10, 2018 4. S. H. Chan *et al.* APEX, vol. 11, no. 4, 2018 5. A. C. Jones, Chem. Soc. Rev. vol. 26, 1997

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