Advances in the MOCVD Growth of β-Ga_2O_3 and Related Heterostructures

Andrei Osinsky and Fikadu Alema

Agnitron Technology, Inc, Chanhassen, MN 55317, U.S.A

β-Ga_2O_3 has attracted extensive interest in power electronic applications owing to its large bandgap of ~ 4.9 eV, estimated high breakdown field of ~ 8 MV/cm, and availability of melt grown high quality β-Ga_2O_3 substrates. The growth of high-quality epitaxial films with low dislocation density and background impurity is critical to realize the projected device performances. Available epitaxial methods to grow β-Ga_2O_3 thin films include MBE, HVPE, and MOCVD. But, despite coming late to the field, the MOCVD method has proven to be suitable for producing high-quality epitaxial β-Ga_2O_3 films at a fast growth rate with uniform and controllable doping [1]. The highest purity β-Ga_2O_3 films have been reported from MOCVD with record low-temperature electron mobility exceeding 23,000 cm^2/Vs and low~10^{13} cm^{-3} compensating acceptors [2]. Also, a recent record-breaking result for lateral Ga_2O_3 MESFETs with a lateral figure of merit (LFOM) of 355 MW/cm^2 and a breakdown voltage of ~2.5 kV [3], and a record low specific contact resistance ~10^{-7} Ωcm^2 [4] were reported based on MOCVD grown epitaxial Ga_2O_3 films.

This presentation will discuss recent progress in the growth of high-quality β-Ga_2O_3 thin films and related materials using MOCVD. The use of Ga precursors, including triethylgallium (TEGa) and trimethylgallium (TMGa), for the growth of Ga_2O_3 will be presented. Their advantages and disadvantages in realizing high-purity, carbon-free, epitaxial Ga_2O_3 films will be discussed. Critical process conditions and MOCVD reactor geometries on achieving high purity β-Ga_2O_3 films with high electron mobility and low background carrier concentration, including doping control in this range, will be discussed. This paper will also discuss the MOCVD growth of high Al composition (up to 30%) high quality strained β-$(AlGa)_2O_3$/Ga_2O_3 heterostructures and superlattices on various orientations of β-Ga_2O_3 substrates. The MOCVD growth of heavily doped (>10^{20} 1/cm^3), highly conductive β-Ga_2O_3, and strained β-$(Al_xGa_{1-x})_2O_3$/β-Ga_2O_3 heterostructures will be presented. We will also present the demonstration of record low resistance Ohmic contacts on heavily Si doped epitaxial β-Ga_2O_3 and strained β-$(Al_xGa_{1-x})_2O_3$ epilayers with varying Al composition. A recent in-situ non-destructive etching of Ga_2O_3 in MOCVD followed by a regrowth process will also be discussed.

[1] F. Alema *et al.*, Journal of Crystal Growth 475 (2017) 77-82.

[2] G. Seryogin *et al.,* Applied Physics Letters 117 (2020) 262101.

[3] A. Bhattacharyya *et al.*, IEEE Electron Device Letters 42 (2021) 1272-1275.

[4] F. Alema *et al.,* EEE Electron Device Letters 43 (2022) 1649-1652.