Epitaxial growth of Ga_2O_3 thin films using pulsed-liquid injection MOCVD

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The demand for power electronic devices keeps increasing due to the rapid development of industries related to electricity, automotive, and consumer electronics. The use of ultrawide bandgap semiconductors such as diamond, aluminum nitride or gallium oxide (Ga_2O_3) has emerged as a potential avenue for development. Among these materials, the β-Ga_2O_3 monoclinic phase exhibits many advantages among other phases such as chemical stability, ultrawide bandgap energy (4.6-4.9 eV), high breakdown electric field (around 8MV/cm), and a decent electron mobility (around 250 cm^2/Vs) [1–3]. Although it is still early to suggest the finest technique for the epitaxial growth of Ga_2O_3thin films, recent progress in MOCVD has attracted the power electronics community due to the potential fast growth of high quality thin films and heterostructures at larger scales, the latter being suitable for device fabrication, and all of them being favorable for industrialization [4]. LMGP possesses a semi-industrial MC200 Annealsys reactor that allows injecting micro-amounts of liquid precursor into the evaporator in pulses in the framework of the pulsed-liquid injection metal-organic chemical vapor deposition (PLI-MOCVD) technique [5]. In-house studies have shown some advantages of using this innovative technique over conventional MOCVD in the growth of other materials. For instance, it prevented accumulation of condensed precursor of high-k oxides, which would have led to non-uniform layers [6]. In another study, PLI-MOCVD allowed a more controlled morphology and polarity transitions of ZnO [7]. Egyenes-Pörsök et al. [8] used a similar customized equipment for liquid-injection MOCVD (LI-MOCVD) to grow Ga_2O_3 thin films and reported more precise layer thickness control and the possibility to use low vapor pressure precursors including Ga acetylacetonate. In this work, we grow Ga_2O_3 thin films by PLI-MOCVD using triethyl Ga (TEGa) and O_2 gas (Fig. 1). We specifically study the impact of parameters such as precursor mass flow rates, O_2/Ar flow rate ratio, and substrate temperature, on the epitaxial thin film quality, as characterized by SEM, AFM, X-ray diffraction, Raman spectroscopy, TEM and electrical measurements.

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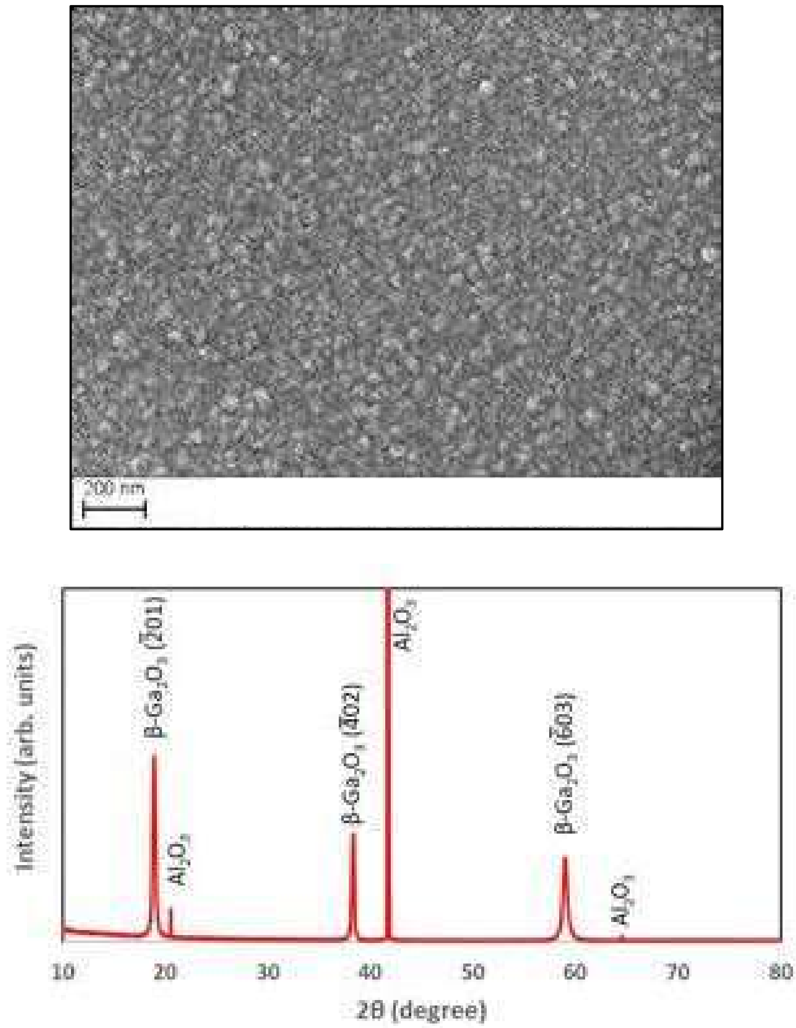

Fig. 1. (Top) Top-view SEM image and (Bottom) XRD patterns of β-Ga_2O_3 thin films grown by PLI-MOCVD on sapphire.