β−Ga2O3 thin films grown by Pulsed Electron Deposition

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Recently, ultrawide bandgap (UWBG) semiconductors have attracted great attention thanks to their potential for various applications. Among UWBG semiconductors, gallium oxide (Ga_2O_3) has become very popular because it can play a key role in several fields, especially high-power electronics, UV detectors and gas sensors, and offers some advantages over SiC and GaN: larger E_g, tunable electric properties and cost-effective production in wafer or thin film form. Ga_2O_3 is not a novel material and it has a long R&D history for over 70 years, but in the last period the number of publications significantly increased because of its unique physical properties. So far, most work was carried out on the thermodynamically stable β phase, however there is an increasing interest towards other metastable phases, particularly the hexagonal α and the orthorhombic κ.
Pulsed Electron Deposition (PED) has become a well-known vacuum technique for thin film growth of several materials. Thanks to its features, reliability and low running costs, the PED has been acknowledged as one of the most interesting sources, especially for complex and doped compounds such as Al-doped ZnO, $YBa_2Cu_3O_7$, $Cu(InGa)Se_2$, Cu-doped Sb_2Se_3 and others.
In this work, we present the first results of PED for depositing thin films of Ga_2O_3 on different substrates such as glass, amorphous quartz and c-plane sapphire. The best crystalline layers were obtained on c-oriented Al_2O_3, while films deposited on glass were mostly amorphous. Different growth conditions were applied, such as substrate temperature and electron beam accelerating voltage, to improve the characteristics of crystalline layers. The investigation by XRD and Raman of the samples obtained under variable conditions allowed to define the growth window to obtain a good crystalline quality. They also indicated that PED-grown deposition leads to polycrystalline β-Ga_2O_3 thin films generally (-201)-oriented although the texture variation depends on the growth conditions and the substrate. β phase is also confirmed by optical absorption measurements of the energy bandgap in the UV-VIS region. Morphology and composition studies by SEM-EDX allowed to identify the trade-off between deposition rate and surface roughness.
In summary, we demonstrated that the PED technique is a simple and affordable technique for growing β−Ga_2O_3 thin films, with good structural and compositional properties on crystalline substrate; encouraging results on the depositions at high temperature on amorphous quartz are also reported. The ongoing activity focuses on the increase of the conductivity of the Ga_2O_3 films, by using home-made doped Ga_2O_3 targets, in view of concrete application of our samples.