Growth and characterization of gallium phosphide on gallium oxide substrate for heterojunction diodes

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Gallium oxide (Ga_2O_3) is a promising candidate for next generation power electronics and it possesses excellent properties such as wide bandgap (4.6 - 4.9 eV), high breakdown field (8 MV/cm) and very high Baliga's figure of merit (BFOM) when compared with GaN, SiC and Si [1]. Because of its thermodynamic stability, the β-Ga_2O_3 polymorph is considered as the preferable form as the substrate for device fabrication. Optical floating zone (OFZ) technique is attractive to grow bulk β-Ga_2O_3 as it offers a crucible-free method and is flexible in growing conducting (n-type) and non-conducting substrates [2]. Ga_2O_3 p-n homojunction is difficult to achieve due to lack of p-type dopant as well as feasible polaronic hole transport. To circumvent this problem, heterojunction with n-Ga_2O_3 and a p-oxide, e.g., p-NiO has been attempted by Sohel et al. [3]. Recently, we demonstrated heteroepitaxial growth of p-GaP:Zn on Si and GaAs substrates for using it as a photocathode for water splitting and CO_2 reduction [4]. Encouraged by these results we attempted for the first time heteroepitaxial growth of GaP by hydride vapour phase epitaxy (HVPE) on OFZ grown n-Ga_2O_3 with the intention of fabricating p-GaP/n-Ga_2O_3.

β-Ga_2O_3 single crystals were grown by optical floating zone (OFZ) technique. The crystals were cleaved and polished to prepare β-Ga_2O_3 substrates [2]. The GaP thin film has been deposited on the β-Ga_2O_3 substrates at 710 °C in a low pressure (20 mbar) HVPE reactor using GaCl and PH_3 as precursors. In this first attempt we did not attempt to dope it. Our first results yielded GaP thin film on n-Ga_2O_3 and were characterized by x-ray diffraction (XRD) and Raman spectroscopy. The XRD pattern shows the presence of (111) phase with (002) peak of GaP. Raman spectrum exhibits GaP (TO) and (LO) phonon modes at 369 cm^{-1} and 405 cm^{-1}, respectively. These can be compared to the respective values of 365 cm^{-1} and 402 cm^{-1} observed for epitaxial GaP [5]. The optical microscopy confirms the uniform deposition of GaP on Ga_2O_3 which is the first of its kind to the author's knowledge. The thickness of the GaP thin film was estimated to be ~5μm. Further studies on band alignment between GaP and Ga_2O_3, doping of GaP and β-Ga_2O_3 substrates and its growth optimization will be discussed in detail.

References

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