Homo- and Hetero-epitaxial Growth of β-Ga_2O_3 Thin Films by Molecular Beam Epitaxy

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β-Ga_2O_3 is emerging as a next generation ultra-wide bandgap semiconductor (UWBGS) material with a bandgap of 4.5-4.9 eV with applications in high-power/temperature electronics devices [1-3]. A distinct advantage of β-Ga_2O_3 over other UWBGS materials is availability of inexpensive large area bulk substrates synthesized by melt growth techniques at atmospheric pressure [2]. Homoepitaxial growth on bulk substrates offers the potential of low defect density films for vertical power devices. Despite the crystalline quality advantages of homoepitaxy, future device performance is anticipated to be limited by the low thermal conductivity of β-Ga_2O_3, so one approach to improve thermal performance is through hetero-epitaxy of β-Ga_2O_3 on a high thermal conductivity substrate such as SiC. For these reasons, both homo- and hetero-epitaxial growth of Ga_2O_3 films are of general interest to be investigated.

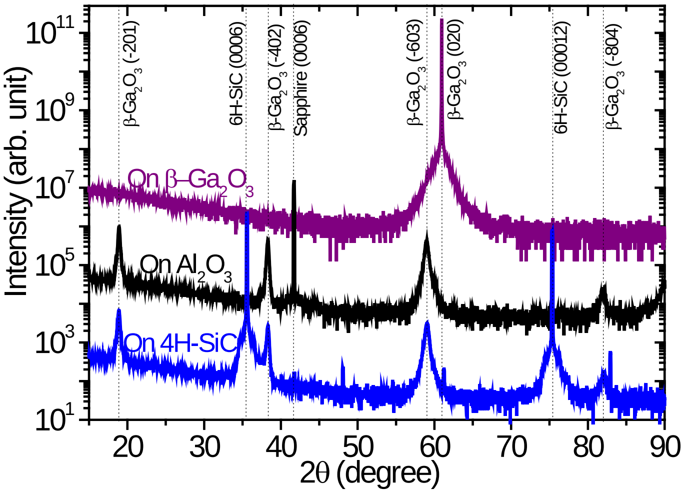

Figure 1. X-ray diffraction measurements of epitaxial β-Ga_2O_3 on on-axis 4H-SiC (blue, 86 nm thick), c-sapphire (black, 126 nm) and (010) β-Ga_2O_3 (purple, ~200 nm).

In this paper, we report homo- and hetero-epitaxial growth 100-200 nm thick β-Ga_2O_3 thin films on sapphire, (010) β-Ga_2O_3 and 4H-SiC substrates by molecular beam epitaxy (MBE) at 650 °C and compare the impact of substrate. The growth parameter space including thermocouple-measured growth temperature, relative Ga flux, and oxygen plasma flow were varied to grow β-Ga_2O_3 films on c-plane sapphire substrates. Figure 1 shows about 86-130 nm thick single phase MBE-grown β-Ga_2O_3 films that are insulating with relatively low surface roughness. The heteroepitaxial films have rocking curve full-width-at-half-maximum of 256 and 720 arc-sec on sapphire and SiC, respectively. In this paper we will discuss MBE growth parameter space optimization of β-Ga_2O_3 on sapphire and the structural, morphological, and electrical properties of MBE grown β-Ga_2O_3 thin films on (010) Ga_2O_3 and SiC.

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[2] K. Akito et al., Jpn. J. Appl. Phys. **55**, 1202A2 (2016).
[3] J.Y. Tsao, Adv. Electron. Mater. **4**, 1600501 (2018).

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Supplementary Information

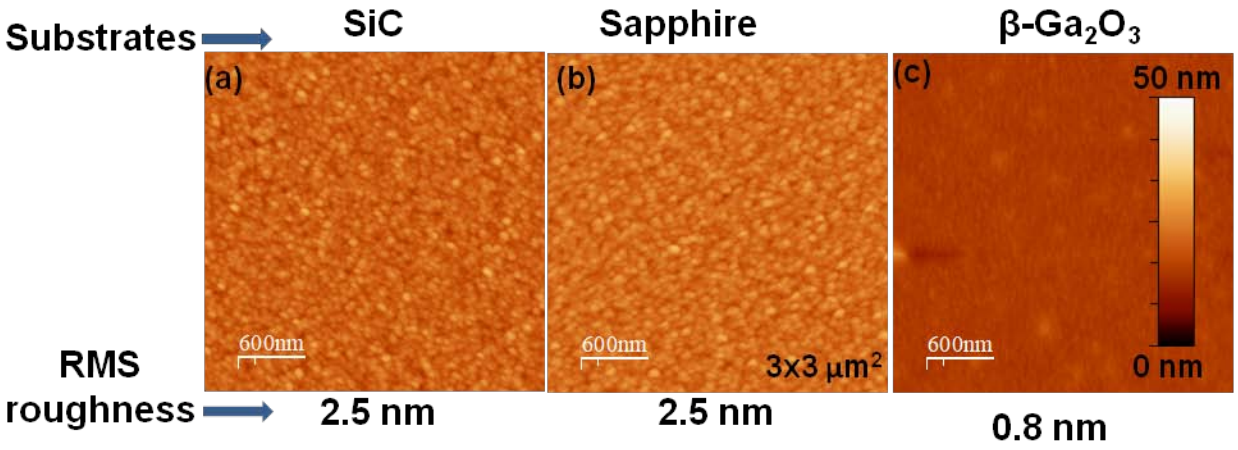

Figure 2. Atomic force microscopy images of β-Ga$_2$O$_3$ on on-axis 4H-SiC, *c*-sapphire and (010) β-Ga$_2$O$_3$.

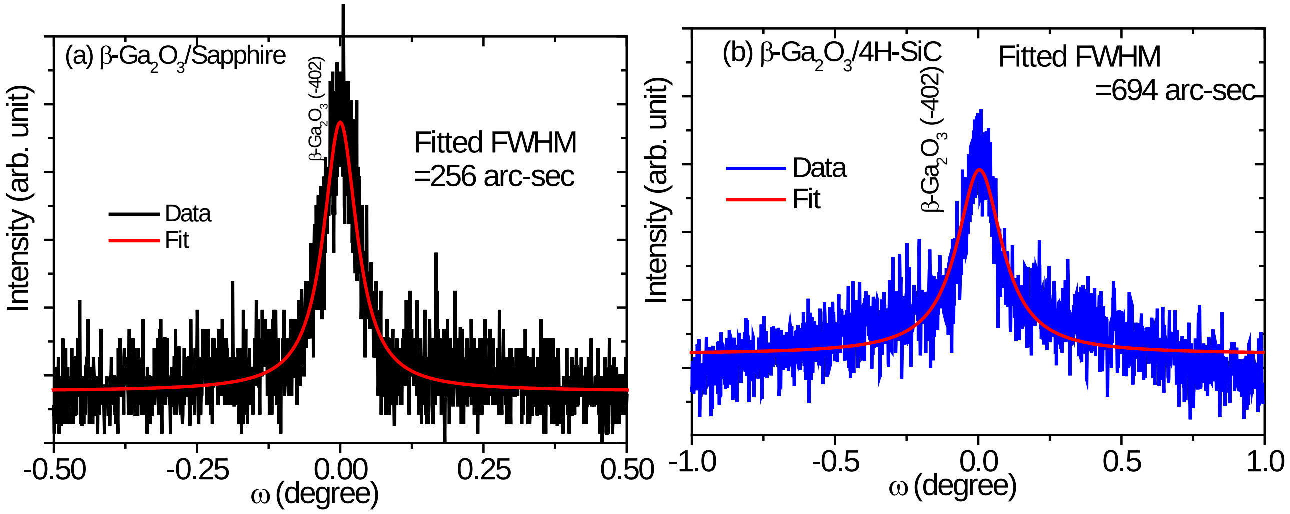

Figure 3. X-ray rocking curve (RC) of ($\bar{4}02$) diffraction peak of β-Ga$_2$O$_3$ on *c*-sapphire and on-axis 4H-SiC. Fitted RC full-width-half-maximum values are 256 and 694 arc-sec on sapphire and SiC, respectively.