Epitaxial Stabilization of Monoclinic Fe_2O_3 on β-Ga_2O_3

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There is a surge in interest in β-Ga_2O_3 because of its thermodynamic stability, wide bandgap, and excellent figures of merit for high power devices. Additionally, β-Ga_2O_3 is quite similar to structures found in magnetic 3d transition metal oxides, which also consist of networks of tetrahedra and octahedra. Specifically, there are several naturally occurring Fe_2O_3 phases, and Fe^{3+} and Ga^{3+} cations exhibit similar ionic radii. However, there are no Fe_2O_3 phases the same monoclinic structure as β-Ga_2O_3. Here, we investigate the possibility of using epitaxial strain to stabilize a new form of monoclinic Fe_2O_3 (μ-Fe_2O_3) on β-Ga_2O_3. Molecular beam epitaxy was used to grow a sample on a (010) β-Ga_2O_3 substrate, consisting of multiple Fe depositions of increasing amounts separated by 10 nm β-Ga_2O_3 spacers (Fig. 1(a)). Reflection high energy electron diffraction (RHEED) shows the preservation of the β-Ga_2O_3 overgrowth quality even for quite high μ-Fe_2O_3 thicknesses. High resolution X-ray diffraction of the structure shows distinct thickness fringes and superlattice peaks. High resolution scanning transmission electron microscopy confirms that the overgrown β-Ga_2O_3 reamins high quality after multiple Fe containing layers. The high Fe regions also show the same crystal structure as β-Ga_2O_3, i.e. μ-Fe_2O_3. The optical and magnetic properties of this new form of Fe_2O_3 will also be discussed.

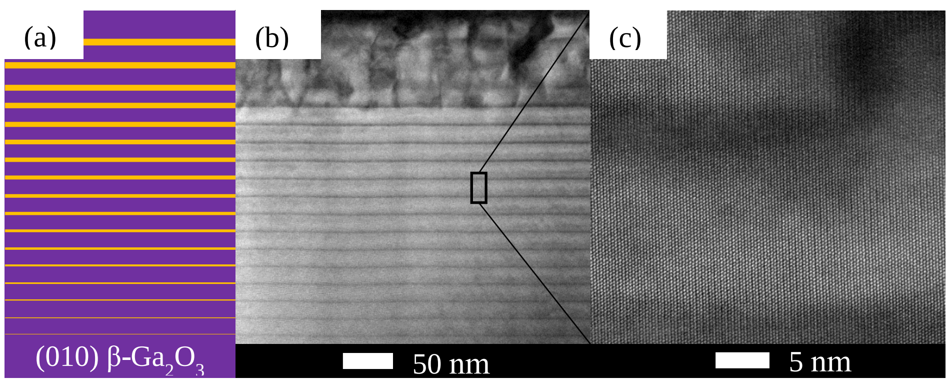

Figure 1: (a) Schematic of superlattice structure with increasing Fe deposition (yellow) between 10 nm β-Ga_2O_3 spacers (purple). (b) HR-STEM image of resulting structure and (c) atomic-resolution image of the of interface between Fe_2O_3 and β-Ga_2O_3.

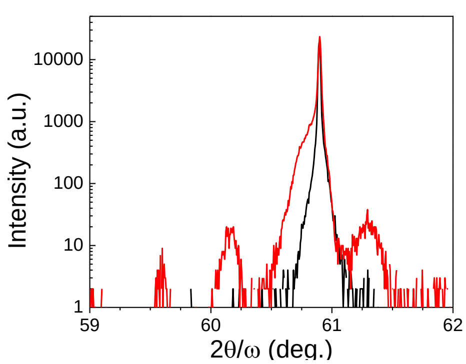

Figure 2: HR-XRD of β-Ga_2O_3 substrate (black) and the Fe_2O_3 / β-Ga_2O_3 superlattice structure (red) showing distinct superlattice fringes.