Comprehensive *In-Situ* Study of the Reaction Kinetics for the MBE growth of Ga_2O_3

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The poster presents a comprehensive reaction kinetics study of the plasma-assisted molecular beam epitaxial (MBE) growth of the transparent semiconducting oxide Ga_2O_3. By using MBE, an impinging gallium-flux (Φ_{Ga}) and supplied oxygen-flux (Φ_O) react amongst others to Ga_2O_3 on a heated, single-crystalline substrate under ultra-high vacuum conditions. All data illustrated were measured *in-situ* by a laser reflectometry set-up (LR) and a line-of-sight quadrupole mass spectrometer (QMS). With the LR the growth-rate (ρ_Γ) was measured. The QMS allowed identifying the species that desorbed off the substrate which were not incorporated into the layer.

We present the dependence of ρ_Γ as a function of all controllable experimental growth parameters: Φ_{Ga}, the growth temperatur (T_G), and the gallium-to-oxide ratio ($r = \Phi_{Ga}/\Phi_O$). We explain the data by a phenomenological model including sub-oxide formation (Ga_2O)[1], Ga desorption, and the reaction kinetics – depending on T_G and r – on the growth surface. Knowing the reaction kinetics provides guidance for the MBE growth of Ga_2O_3.

Figure 1 depicts ρ_Γ as a function of T_G for different r = 0.88, 0.7, 0.35, and 0.18, respectively. After a plateau ρ_Γ decreases with increasing T_G but different slopes, σ, depending on r. Figure 2 illustrates a comprehensive growth-mode diagram and plots r as a function of T_G. All growth-regimes, O- and Ga-rich, transport- (TL) and reaction-limited (RL) regimes with theit corresponding sticking coeffiecients, Θ_{Ga}^{O-rich} and $\Theta_{Ga}^{Ga-rich}$, are shown.
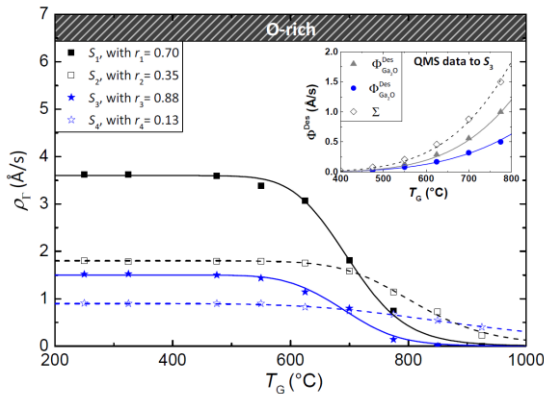

Fig. 1: The growth rate as a function of T_G for four different samples S_1 (black squares), S_2 (open black squares), S_3 (blue stars), and S_4 (open blue stars) for different r. Inset: desorbed fluxes Φ_{Ga}^{Des} and $\Phi_{Ga_2O}^{Des}$ as a function of T_G and their sum Σ for S_3.
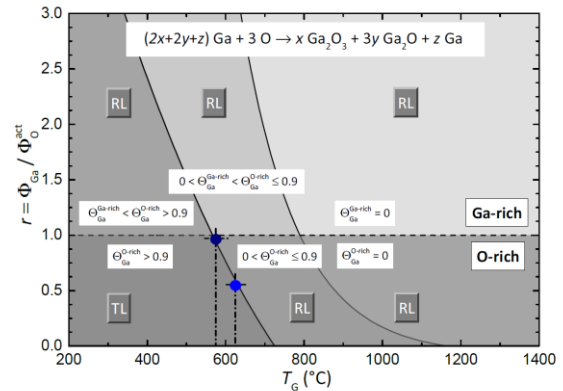

Fig.2: Growth-mode diagram of Ga_2O_3 shows r as a function of T_G. Two major growth regimes O- and Ga-rich regimes are subdivided into TL- and RL-regimes. The sticking coefficients are Φ_{Ga}^{O-rich} and $\Phi_{Ga}^{Ga-rich}$ for the O- and Ga-rich regime are drawn.

[1] Patrick Vogt and Oliver Bierwagen, Applied Physics Letters **106**, 081910, 2015