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Local User Project - 2021

Suboxide Molecular Beam Epitaxy—A new Thin Film Growth PARADIM

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PARADIM's in-house team worked with a collaborator at Penn State to develop a new variant of MBE that we call "suboxide MBE." In contrast to conventional MBE where the molecular beams are elemental, in suboxide MBE the molecular beams are pre-oxidized. Achieving the desired suboxide beams relies on extensive thermodynamic calculations made for the entire periodic table [1 + cover].

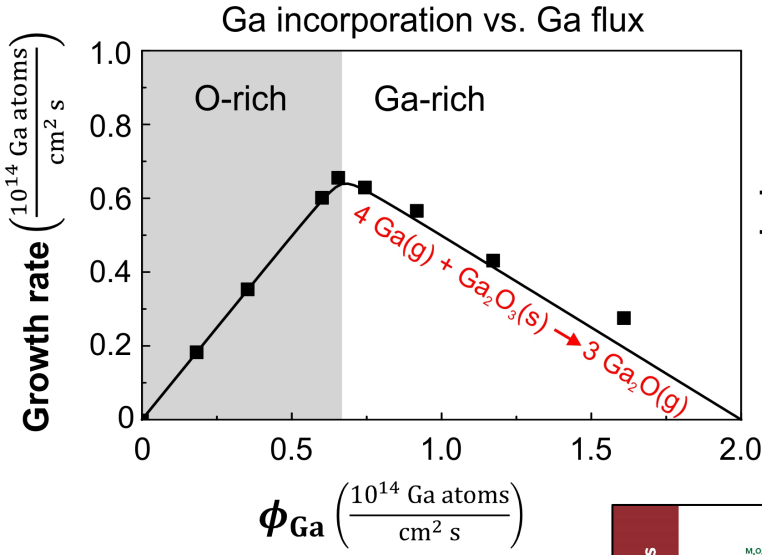
Seeing how well suboxide MBE works, this variant is now being used in 17 user projects! A recent publication from one of these users demonstrates its promise for the growth of the high-mobility, high-bandgap semiconductor β-Ga_2O_3.

Growing β-Ga_2O_3 by conventional MBE is quite challenging because it involves a 2-step oxidation reaction to go from the elemental Ga(g) of the molecular beam to Ga_2O_3(s):

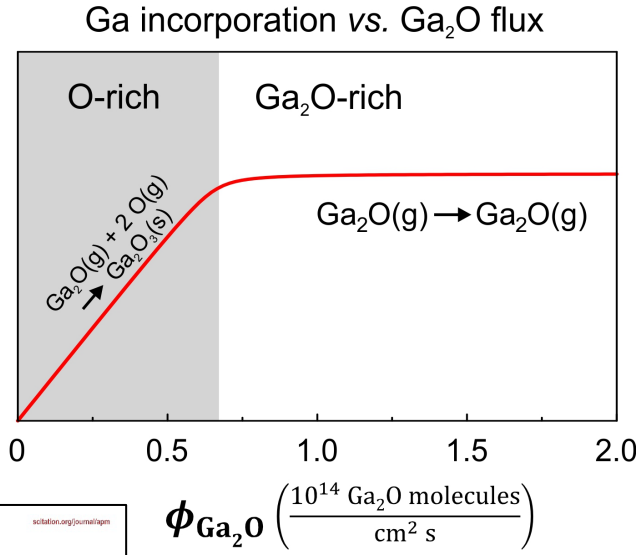
2 Ga + O → Ga_2O followed by Ga_2O + 2 O → Ga_2O_3 This results in a rather complex growth regime.

Using **suboxide MBE at PARADIM**, the first step is bypassed by supplying a 99.98% pure molecular beam of pre-oxidized Ga_2O. The result is a dramatic increase in the growth rate of device-quality β-Ga_2O_3 films that can readily be made sufficiently thick for vertical devices.

Conventional MBE of Ga_2O_3



Suboxide MBE of Ga_2O_3

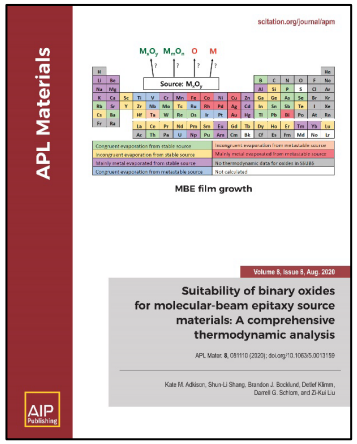


Challenges:

- Low growth rate (~0.2 μm/hr)
- Difficult to control
- Gallium vacancy defects

Advantages:

- Growth rate > 1 μm/hr
- Smoother surfaces
- Higher structural quality
- Lower growth temperature



P. Vogt *et al.* *APL Mater.* **9**, 031101 (2021). Data: www.doi.org/10.34863/a2jw-kh18.

[1] K.M. Adkison *et al.* *APL Mater.* **8**, 081110 (2020).