Suboxide Molecular-Beam Epitaxy—Translating a new Concept into β-Ga_2O_3 Transistors

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In 2020 PARADIM's in-house team—working with collaborators at Penn State—developed (and patented) a new variant of molecular-beam epitaxy (MBE) called "suboxide MBE." In contrast to conventional MBE where the molecular beams are elemental, in suboxide MBE the molecular beams are pre-oxidized. This method has since been widely applied by PARADIM users in 20 publications utilizing suboxide MBE + over 20 active user projects).

A recent publication from a team of PARADIM users:

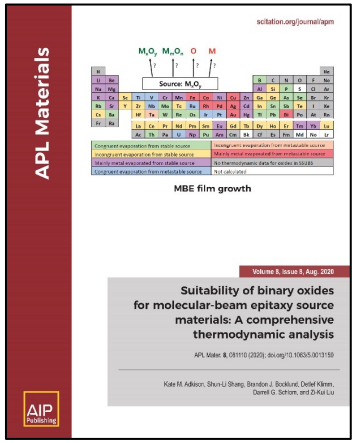
Local users (film growth, XRD, AFM, Hall effect, STEM)
In-House (film growth, XRD, Hall effect)
PARADIM PREM (SIMS)
Air Force Research Lab (transistor fabrication + testing)

demonstrates its promise for the growth of transistors of the high-bandgap semiconductor β-Ga_2O_3.

Suboxide MBE produced device-quality films with lots of advantages over conventional MBE including new records in lower background impurity levels and higher low-temperature mobility, despite the 10× higher growth rate and superb structural quality.

K. Azizie, *et al.* U.S. Patent #11,462,402 B2 (2022).
K. Azizie *et al.* *APL Mater.* **11**, 041102 (2023).
Data: https://doi.org/10.34863/zsda-pa72.

2020—Potential of *Suboxide* MBE Calculated[1]



2023—*Suboxide* MBE of Ga_2O_3 delivers mobility record (for MBE) + Transistors

Advantages Demonstrated over Conventional MBE

- 10× higher growth rate (> 1 μm/hr)
- Higher structural quality
- Higher mobility (60% higher at low temperature)
- Lower compensating acceptor (N_a= 4×10^{15} cm^{-3})
- Controlled Si doping (over 5×10^{16} to 10^{19} cm^{-3} range)

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