MBE Lab #1

Oxide MBE of Binary Oxides
(SnO, MgO, Dy₂O₃
depending on your group)

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Questions for MBE Lab #1

• Substrate to use (material and orientation)?
• Source material(s) to use?
• Temperature(s) of source material(s)?
• Crucible(s) to contain them?
• Deposition strategy (codeposition, shuttered growth, etc.)?
• Substrate temperature during growth?
• Oxidant and its pressure during growth?
• How to calibrate growth rate?
Substrate to Use (material and orientation)

- “Substrate Picker” from Materials Project
  [https://www.materialsproject.org](https://www.materialsproject.org)

Source Material(s) to Use

• Vapor Pressure of the Elements

• Vapor Pressures of Oxides

• “Material Deposition Chart” from Kurt J. Lesker Co.
  https://www.lesker.com/newweb/deposition_materials/materialdepositionchart.cfm?pgid=0
Source Temperature(s)

- **Vapor Pressure of the Elements**

- **Vapor Pressures of Oxides**

- **“Material Deposition Chart” from Kurt J. Lesker Co.**
  [https://www.lesker.com/newweb/deposition_materials/materialdepositionchart.cfm?pgid=0](https://www.lesker.com/newweb/deposition_materials/materialdepositionchart.cfm?pgid=0)
Crucible(s)

• “Material Deposition Chart” from Kurt J. Lesker Co.
  https://www.lesker.com/newweb/deposition_materials/materialdepositionchart.cfm?pgid=0

• Phase Diagrams
  ACerS—NIST Phase Equilibria Diagrams On-Line
Deposition Strategy
(codeposition, shuttered growth, etc.)

• This is the fun and freedom of MBE!

YBa$_2$Cu$_3$O$_7$

![Diagram showing deposition strategy and corresponding atomic structures with Y, Ba, Cu, and O species]
Substrate Temperature

Assuming growth rate of 0.1 monolayer/sec

$T_{\text{min}}$ for smooth epitaxial films (growth by step propagation)

$T_{\text{min}}$ for epitaxy

Optimal Growth Temperatures

\[
0.55 < \frac{T_{\text{sub}}}{T_{\text{melt}}} < 0.7 \text{ for semiconductors}
\]

\[
0.35 < \frac{T_{\text{sub}}}{T_{\text{melt}}} < 0.4 \text{ for metals}
\]

\[
0.1 < \frac{T_{\text{sub}}}{T_{\text{melt}}} < 0.4 \text{ for simple ceramics}
\]
Oxidant and its Pressure

- Ellingham Diagram

- Thermodynamics of MBE (TOMBE) Diagram

- If Desire Highest Oxidation State of all cations, then higher activity is better (within the limits of MBE, the equipment, and stable fluxes)
How to Calibrate Growth Rate

- Shadow Mask and Surface Profilometer
- Quartz Crystal Microbalance
- Ion Gauge
- RHEED Oscillations
- Shuttered RHEED Oscillations
- Rutherford Backscattering Spectrometry
- Mass Spectrometer
- Atomic Absorption Spectroscopy
- Atomic Emission Spectroscopy
- X-Ray Reflectivity, Ellipsometry, …
If your desired flux of Sr is 30% higher than your measured flux or Sr, by how many °C do you need to increase the temperature of the Sr effusion cell to get the desired flux?