Motivation

- Atomic layer deposition (ALD) an emerging material deposition technique:
  - Based on self-limiting surface reactions in a sequential manner.
  - Can grow thin films with sub-monolayer thickness precision.
  - Has ultimate 3D conformity.
- Plasma-enhanced atomic layer deposition (PE-ALD):
  - Low temperature deposition.
  - More film options as precursors un-reactive to molecular co-reactants become more available.
- The wide band-gap of Ga₂O₃ (~4.9 eV) makes it an exciting material for high-power and high-frequency electronics.
- In this work we study the impact of in situ Ar-plasma annealing on the low-temperature growth of Ga₂O₃ films in a PE-ALD system.

Experimental details

- **Substrate**: Si (100), sapphire, and glass.
- **System**: Plasma-assisted atomic layer deposition: Hallow-cathode plasma (HCP) and inductively coupled plasma (ICP) sources.
- **Precursor**: Triethyl-gallium (TEG).
- **Co-reactant**: Ar/O₂ and O₂-only plasma.
- **Plasma power**: 30-300 W. **Substrate temperature**: 150-240 °C.
- **In-situ ellipsometry**: To monitor the growth-per-cycle (GPC) characteristics and real-time growth behavior.

Results

I. The study of in situ ellipsometry monitoring of HCP-ALD grown Ga₂O₃ films.

II. Grazing-incidence XRD characterization of the PE-ALD grown Ga₂O₃ films.

III. HR-TEM analysis of Ga₂O₃ film grown at 240 °C using HCP-ALD.

Conclusion

- Polycrystalline monoclinic β-Ga₂O₃ films obtained at sub-200 °C when in situ Ar-plasma annealing was utilized.
- Polycrystalline peak intensity values improved as a function of increasing in situ Ar RF-plasma power and substrate temperature.
- In situ Ar-plasma annealing mainly enhances adatom migration and surface heating, which enable crystalline β-Ga₂O₃ film formation.

References