Studying the role of N\textsubscript{2}/H\textsubscript{2} radicals in the plasma-induced microstructural transformation of ALD-grown InN films

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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-assisted atomic layer deposition (PA-ALD):
  - Low temperature deposition.
  - More film options as precursors un-reactive to molecular co-reactants become more available.
- The narrow band-gap of InN (~0.7 eV) makes it exciting material with a wide range of electronic and opto-electronic applications.
- In this work we study the impact of varying plasma compositions and substrate temperature on the growth and electro-optical properties of InN films in hollow-cathode PA-ALD system.

Experimental details

- **Substrate**: Si (100)
- **System**: Hollow-cathode plasma-assisted atomic layer deposition (HCP-ALD)
- **Precursor**: Trimethyl-indium (TMI)
- **Co-reactant**: Variants of Ar/N\textsubscript{2}/H\textsubscript{2} plasma (N\textsubscript{2}-only, Ar/N\textsubscript{2}, and Ar/N\textsubscript{2}/H\textsubscript{2})
- **Plasma power**: 50-200 W
- **Substrate temperature**: 120-240°C
- **In-situ ellipsometry**: To monitor the growth-per-cycle (GPC) characteristics and real-time growth behavior

Results

I. The study of plasma chemistry of InN film growth.

II. The effect of substrate temperature on InN film growth.

III. Chemical composition and HR-TEM analysis of InN films.

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<tr>
<th>Table II: Film thickness, GPC, and effective index measurement for 600-cycle HCP-ALD grown InN films.</th>
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<tbody>
<tr>
<td>Ar\textsubscript{2}N\textsubscript{2}/H\textsubscript{2} flow (sccm)</td>
</tr>
<tr>
<td>50</td>
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<td>0</td>
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<th>Table III: XPS measurements of chemical composition of the 600-cycle InN samples.</th>
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<tr>
<td>Ar\textsubscript{2}N\textsubscript{2}/H\textsubscript{2} (sccm)</td>
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<tr>
<td>50</td>
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Conclusion

- Polycrystalline single-phase hexagonal InN only when Ar/N\textsubscript{2}-plasma was utilized.
- Crystalline indium oxide (In\textsubscript{2}O\textsubscript{3}) films when H\textsubscript{2} plasma gas was introduced.
- In\textsubscript{2}O\textsubscript{3} samples displayed polycrystalline character with peak intensity values changing as a function of RF-plasma power and substrate temperature.
- The role of H\textsubscript{2} in possible reaction mechanisms resulting in the replacement of nitrogen with oxygen is investigated.
- Electro-optical characterizations of the photo-detector devices will be studied in detail.

References