Growth of Indium Nitride Quantum Dots by Molecular Beam Epitaxy

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Background/Relevance

- III-Nitride materials are of interest for optoelectronic and electronic device applications due to the wide range of direct band gaps covered by its alloys (0.7eV-6.2eV).
- InGaN alloys suffer from fluctuations in composition due to strain.

Innovation

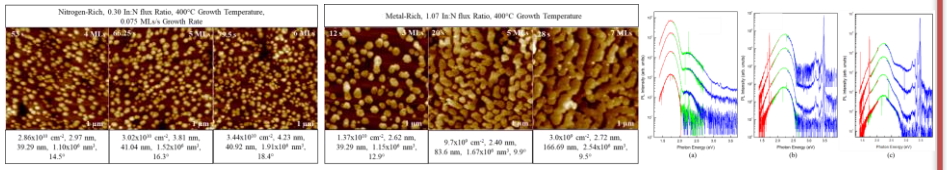
- Optoelectronic devices which emit/adsorb any visible wavelength (LEDs, solar cells, LASERs, etc.).
- InN/GaN QD structures which could perform at any communications wavelength (1260 - 1675 nm).

Approach

- Growth of InN QDs by MBE was divided into two parallel efforts: Nitrogen-Rich and Metal-Rich.
- Nitrogen-Rich samples were grown with an In:N flux ratio of less one. Metal-Rich samples were grown with an In:N flux ratio of greater than one.
- Each effort was studied to determine and understand the role of growth temperature, deposition time, and deposition rate on InN QD properties.
- The InN QD properties investigated through Atomic Force Microscopy were: QD density, height, diameter, deposition volume, contact angle/shape, and critical thickness.

Key Results

- Nitrogen-Rich sample properties behaved as typical SK growth with a transition thickness of approximately 2.0-2.2 MLs.
- Metal-Rich samples also behaved as typical SK growth with a transition thickness of approximately 3 MLs. However, a **preference for lateral growth** was observed suggesting the presence of a **new** growth mode.
- Optical emission was observed for confined InN/GaN QDs at 730 nm.



Conclusions

- Nitrogen-Rich: Behavior and control of density, height, diameter, volume, contact angle, and critical thickness with growth parameters were explained based on SK growth and Ostwald Ripening.
- Metal-Rich: Demonstrated a ***new lateral growth mode***, impacting the height, diameter, and contact angle of the QD. The lateral growth mode was hypothesized to be caused by the presence of excess indium on the growth surface. The presence of excess indium was confirmed through the use of HCl and AFM analysis.
- PL was observed from QDs grown in a Metal-Rich environment.

Future Work

- Investigate the control of PL wavelength from Metal-Rich samples.