Novel Designs of Indium Gallium Nitride Based Intermediate Band Solar Cells Through Graded Structures

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Background/Relevance

- Single junction solar cells reached their maximum theoretical efficiency so other materials and novel structures must be established.
- InGaN has a direct band gap from 0.7 eV to 3.4 eV that covers the solar spectrum and the novel designs of InGaN solar cells through graded structures will enhance the photovoltaic performance.

Innovation

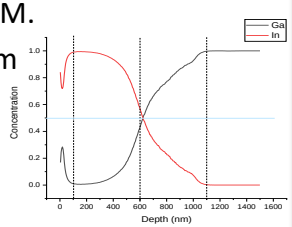
- Use full graded $In_xGa_{1-x}N$ layer starting GaN and grade down to InN. Then, reverse the grading going up to InGaN (30%).

Approach

- Deposit InGaN on sapphire substrates using MBE.
- Fabricate InGaN solar cells using photolithography techniques, dry etching, and metallization.
- Structure characterization using atomic force microscopy (AFM), and transmission electron microscopy (TEM).
- Photoluminescence (PL) measurements and Current-Voltage measurements.
- Absorbance, Reflectance and Transmission spectroscopy measurements will be performed.
- External quantum efficiency measurements and the efficiency of the solar cells will be measured.

Key Results

- Studying the effect of dopant concentration on the band diagram and the solar cell performance
- Optimizing EQE measurements and optical characterization of Ga2O3 and GaN.
- Low temperature PL and XRD for thick graded $In_xGa_{1-x}N$.
- Surface characterization using AFM and SEM.
- Nextnano3 simulation for the band diagram of graded InGaN/GaN structure.
- SIMS measurements to determine the elements composition.



SIMS elemental concentration depth profiles for graded InGaN (0-100% In) on GaN substrate. The top layer is reverse graded InGaN (100%- 70% In)

Conclusions

- The novel design of the graded layer will enhance the light-generated carriers absorption due to the novel grading design.
- The absence of the front contact and using only back contact will allow more light to be absorbed in this solar cell structure.

Future Work

- Analyzing TEM images for the growth of graded InGaN material.

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