

ECE Final PhD Defense

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Thin-Film III-V Devices for Low-Cost Detection and Energy Conversion

Friday, November 5th, 2021

3:00 – 5:00 pm • 1050 FMCRB & Virtual

<https://umich.zoom.us/j/91287892496?pwd=Ly9Qa2tjUDgzTmdVN1YyQjMwZlJzQT09>

Meeting ID: 912 8789 2496

Passcode: 386673

Chair: Professor Stephen Forrest

Abstract:

III-V semiconductors are widely used in high-performance optoelectronic devices, but often considered expensive compared to elemental semiconductors such as Si due to relatively low production throughput and high substrate cost. In this discussion, we propose potential pathways for cost reductions of III-V semiconductor, as well as energy harvesting devices using the thin-film active layer.

We introduce a non-destructive epitaxial lift-off (ND-ELO) process for thin-film solar cell fabrication and substrate recycling of GaAs on a 4" wafer. With the use of an AlAs sacrificial layer and InGaP / GaAs protection layer, the thin-film epitaxial layer is successfully separated from the original GaAs substrate and the remaining substrate is used for subsequent growth after treatment. We also propose a linear Molecular Beam Epitaxy (LMBE) concept using an elongated chamber with distributed effusion cells and multiple growth positions, designed for improved throughput. Our analysis expects the LMBE can improve the throughput of conventional MBE systems similar to other growth technologies such as metal-organic chemical vapor deposition (MOCVD) or hydride vapor phase epitaxy (HVPE).

Then, we demonstrate a thin-film InGaAs thermophotovoltaic (TPV) cell for energy harvesting. By carefully aligning the InGaAs cell with a Si emitter, we achieve nearly an order of magnitude enhancement of output power via near-field radiative heat transfer, which utilizes the evanescent mode photons near the surface of the high-temperature emitters. Finally, we demonstrate a Si TPV cell using air-bridge back surface reflector (BSR), with low series-resistance and high out-of-band (OOB) reflectance (~97%). High OOB reflectance allows the use of Si even under ~1500K source temperature where Si is considered impractical due to its high bandgap. We expect the use of thin-film devices with high OOB reflectance structure can expedite the widespread use of TPV energy conversion.

