Perovskite-Based Infrared Photodetectors: Materials, Device Architectures, and Performance Optimization

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Infrared (IR) photodetectors are key enabling components in a wide range of technologies, including night vision, environmental monitoring, biomedical diagnostics, optical communications, and emerging quantum and neuromorphic sensing platforms. Conventional IR detector technologies—such as HgCdTe, InGaAs, and quantum well/quantum dot devices—offer high performance but often rely on expensive materials, complex epitaxial growth, cryogenic cooling, and limited scalability.

Metal halide perovskites have recently emerged as a highly versatile class of semiconductors for optoelectronic applications. Their outstanding optoelectronic properties—such as strong optical absorption, long carrier diffusion lengths, tunable bandgaps, and solution or vacuum-processable fabrication—have led to rapid progress in visible photodetectors and solar cells. Extending perovskite-based technologies into the infrared spectral region represents an exciting and timely research frontier.

Infrared sensitivity in perovskite photodetectors can be achieved through several strategies, including bandgap engineering (e.g., tin-based or mixed Sn–Pb perovskites), low-dimensional and quantum-confined perovskite structures, defect- or dopant-assisted sub-bandgap absorption, and hybrid device architectures integrating perovskites with narrow-bandgap materials. These approaches open new pathways toward low-cost, room-temperature, and spectrally tunable IR photodetectors.

This thesis project aims to explore and develop perovskite-based infrared photodetectors, focusing on materials design, device physics, and performance optimization.

Objectives

The main objectives of this Master's thesis are:

1. To understand the physical principles governing infrared photodetection and benchmark existing IR detector technologies.
2. To investigate perovskite material systems suitable for infrared light absorption (near-IR to short-wave IR).
3. To design and fabricate perovskite-based IR photodetector devices using scalable processing routes.
4. To characterize the optoelectronic performance of the devices and identify limiting mechanisms.
5. To propose strategies for improving sensitivity, stability, and spectral response.