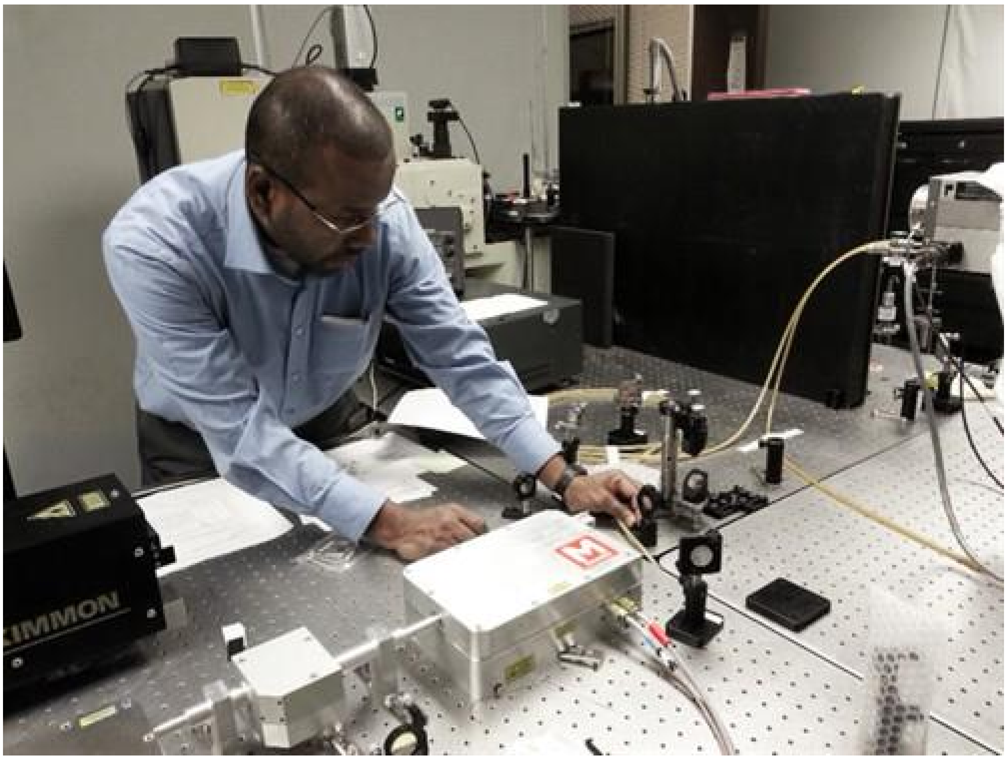
Photocurrent spectroscopy in heterostructured semiconductor nanowires and perovskite oxides with visible bandgap

The Mesoscale Materials Laboratory in Drexel University recently reported breakthroughs in optical and functional materials and probing absorption using photocurrent spectroscopy. The experiments use the SolsTiS system which covers a broad spectral range from visible to near-infrared (690 nm to 950 nm). Photocurrent spectroscopy reveals the optical transition energy from spectral features of excess carrier transport.



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Within a type-I heterostructured nanowire, the band offset at the interface is one of the most important properties. It determines fundamental physical phenomenon such as carrier confinement and electron transfer across the interface. However, conventional experimental methods in probing band offsets of nanomaterials are usually limited by signal intensity, requiring inevitably an ensemble measurement. Photocurrent signal from even single nanowire is instead easily accessible from electrical characterizations. With proper analysis, the clean spectra eventually led to an accurate measurement of band offset of single core-shell III-V nanowires [1].

Perovskite oxides, which are well-known as a family of materials hosting ferroelectric and ferromagnetic properties, bring a new concept of junction-less solar cell due to bulk photovoltaic effect. The wide bandgap of the material has been so far a major challenge for photovoltaic applications. In collaboration with Rappe's and Davies's groups in University of Pennsylvania, the team designed, synthesized and characterized a remarkable family of new single-phase perovskite that exhibits both ferroelectricity and compositionally tunable bandgaps in visible range. Photocurrent spectroscopy is also applied in this study as a direct measurement of bandgap in the form of absorption edge [2].

In photocurrent spectroscopy setup, we use SolTiS as the photon source to excite excess carrier within material located in a cryogenic probe station, electrically interfaced with a low-noise data collection system. The broad wavelength range and fine tunability up to 0.0001 nm guaranteed a continuous scan with high spectral resolution. Photocurrent spectra require an accurate calibration of photon intensity. The power stability is essential for acquiring reliable and consistent results. The alignment-free feature also enables efficient setup using microscopy when precise focusing is required.

1. Chen, G. et al. Direct measurement of band edge discontinuity in individual core-shell nanowires by photocurrent spectroscopy. *Nano Lett*. 13, 4152–7 (2013).

2. Grinberg, I. et al. Perovskite oxides for visible-light-absorbing ferroelectric and photovoltaic materials. *Nature* 503, 509–12 (2013).