Thin-film ferroelectric oxides for photovoltaic energy production

UCF
Stands For Opportunity

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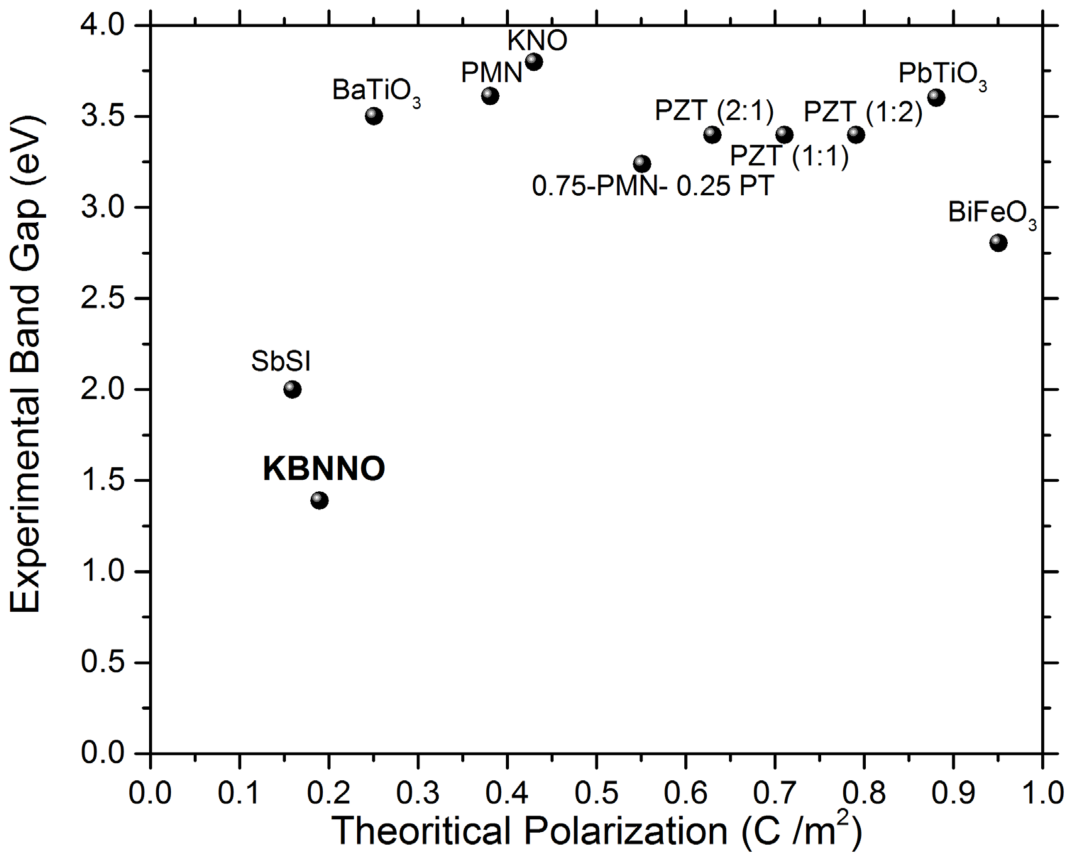
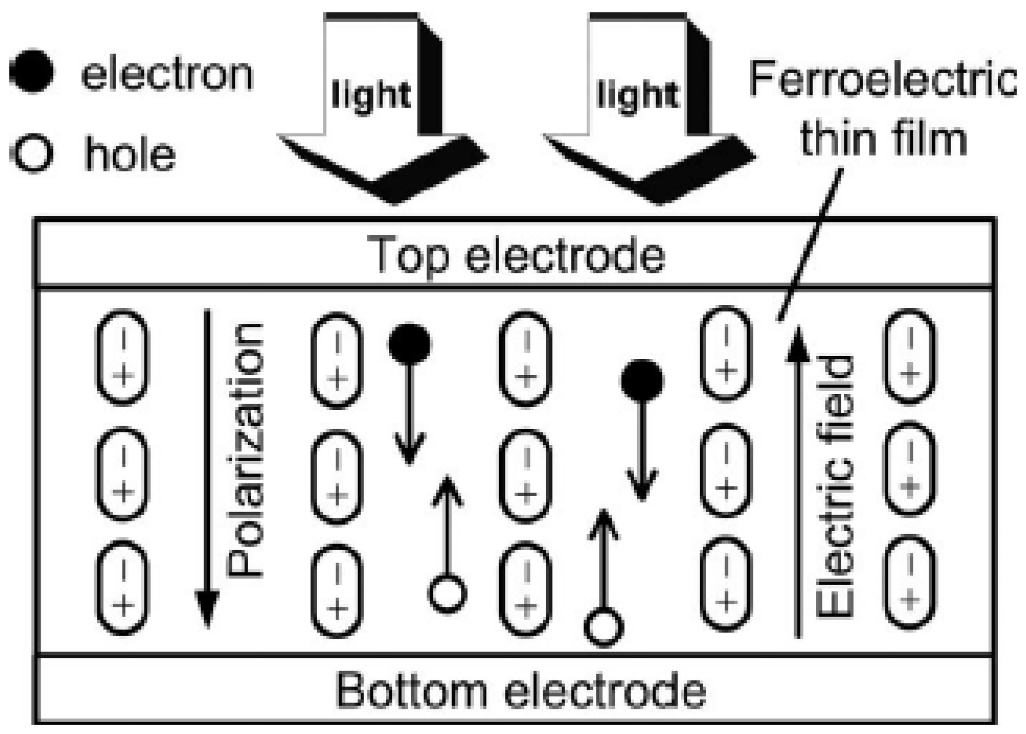
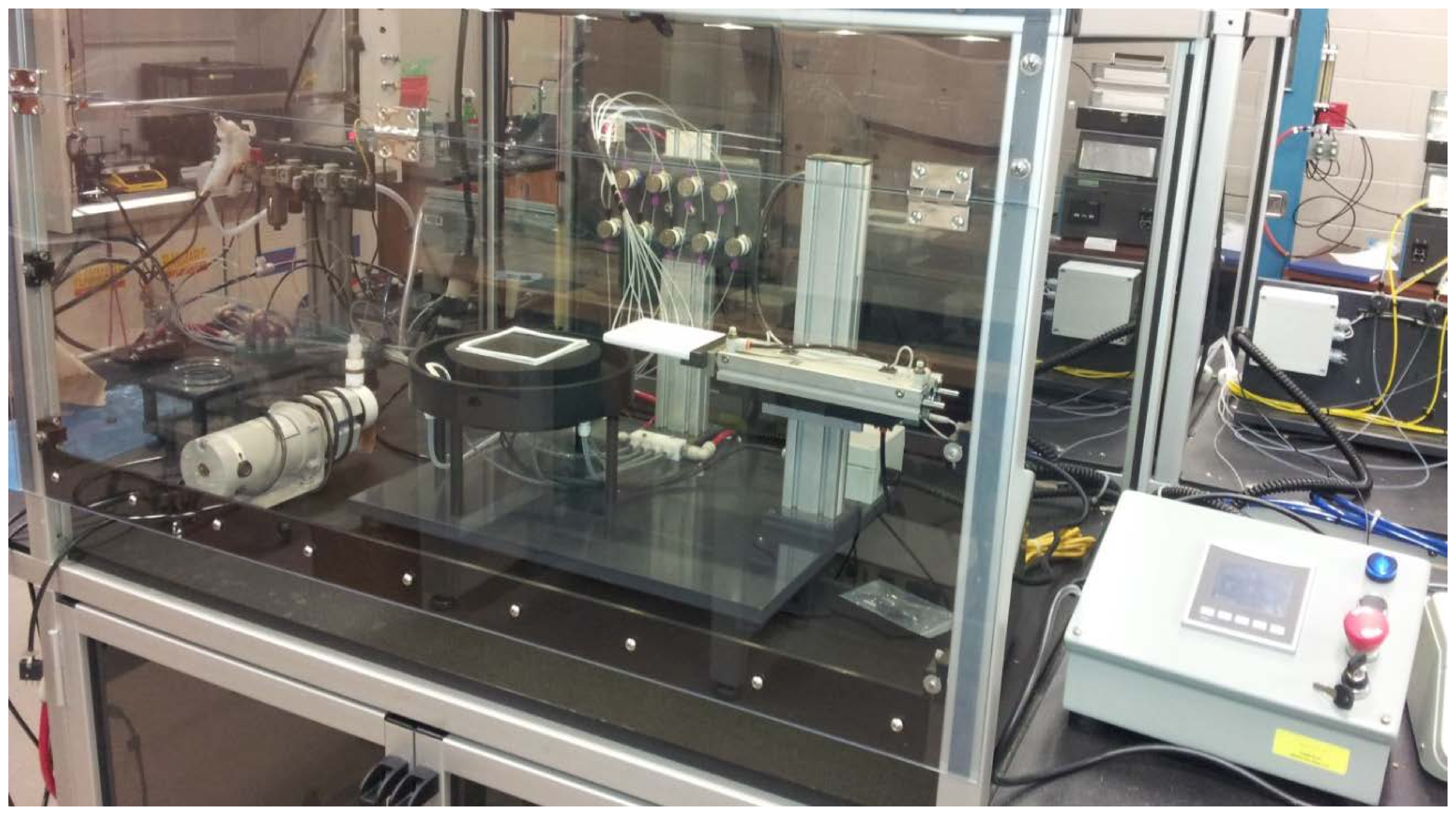
SISOM THIN FILMS

The new ferroelectric oxide $[KNbO_3]_{1-x}[BaNi_{1/2}Nb_{1/2}O_{3-\delta}]_x$ or "KBNNO" offers potential for unprecedented solar cell efficiency. Usual ferroelectric photovoltaics have been uncompetitive due to large band gaps, which poorly absorb the solar spectrum, while KBNNO features an alloy-tunable band gap as low as 1.1 eV, so that its absorption can be tailored to match the solar spectrum.

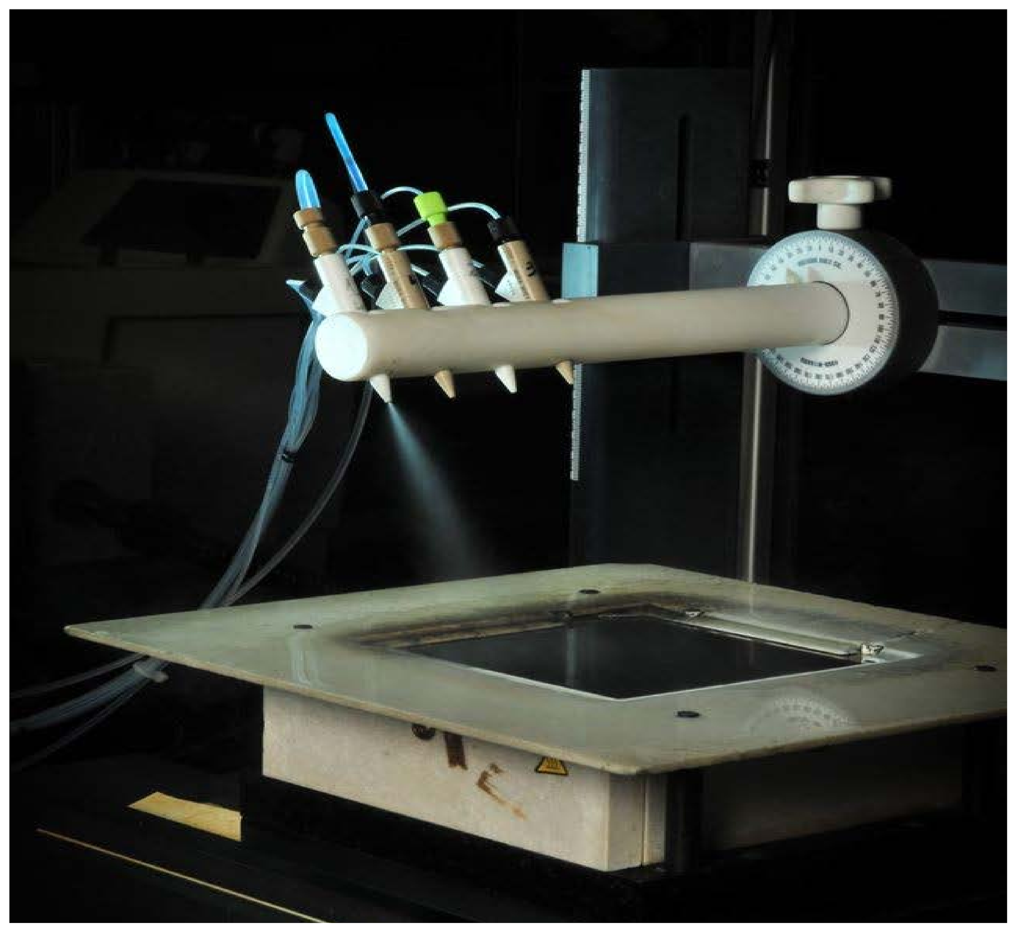


Ferroelectrics have recently attracted attention [1] due to their spontaneous polarization P, which provides Bulk Photovoltaic Effect (BPVE), where a bulk electric field separates photogenerated charge carriers. KBNNO has a reasonably large polarization allowing for charge separation across the bulk. Open-circuit voltages V_{oc} exceed the band gap, potentially leading to efficiencies that exceed those possible for standard pn-junction cells if the current collection can be improved using suitable contacts.

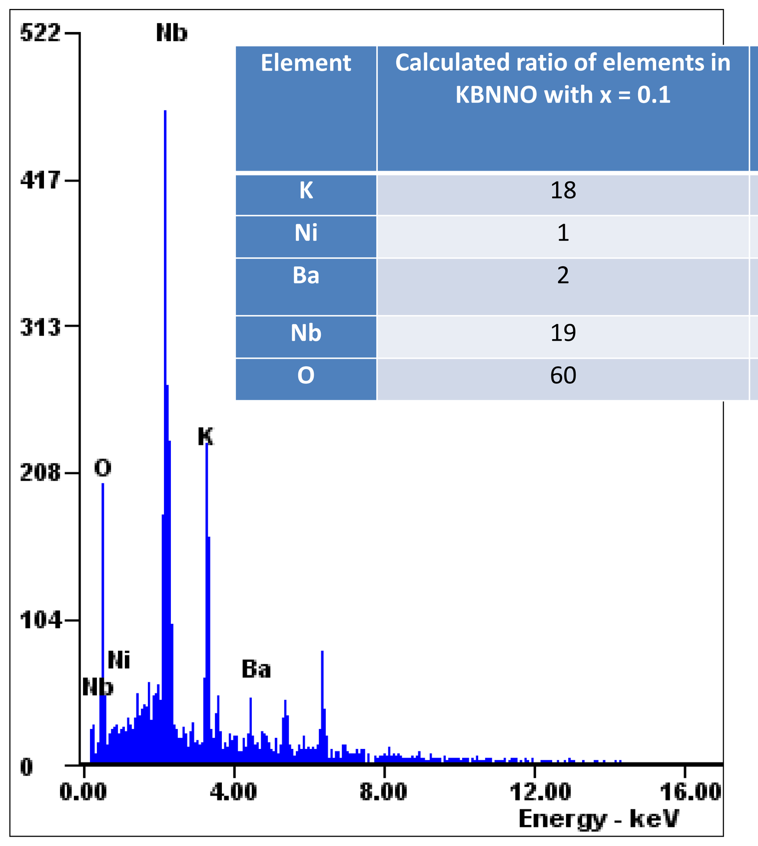




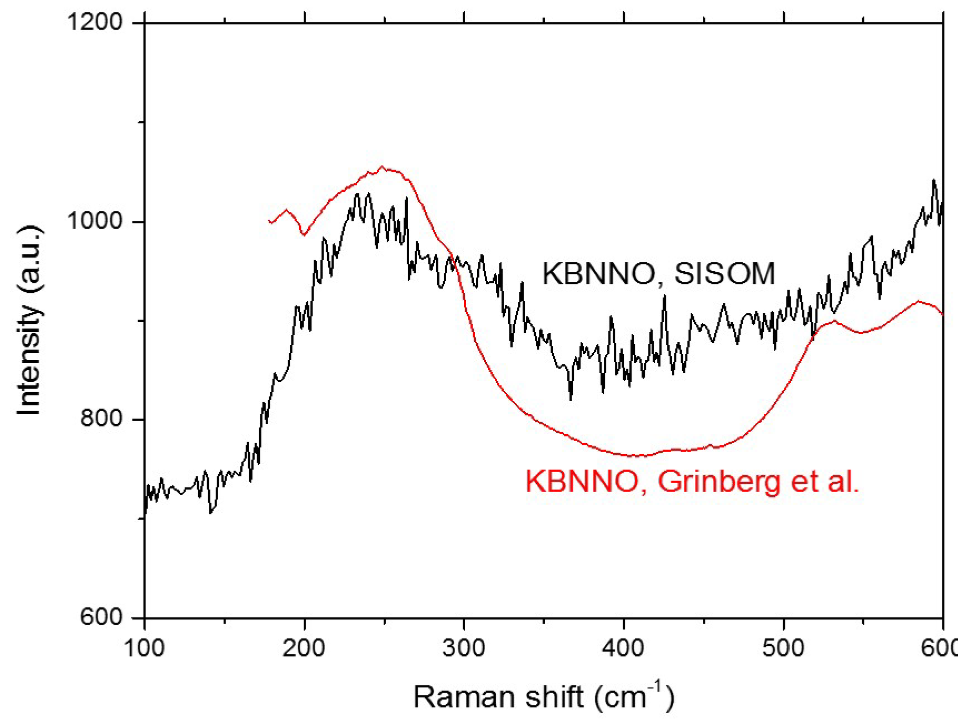
KBNNO films are grown by SISOM's innovative acqueous chemical spray method on hydrophilic substrates, known as SPEED. Hydrophilic substrates attach hydroxyl ions (OH^-) from the precursor solution in a high-density monolayer (>10^{12} sites/cm^2), forming reaction nucleation sites. Heterogeneous reactions form the desired molecules if the substrate temperature supplies at least the activation energy of reaction, usually in the range 125 – 300 C. The films consist of densely packed 50-100 nm grains. Recrystallization is accomplished by post-growth annealing at 400 – 700 C.



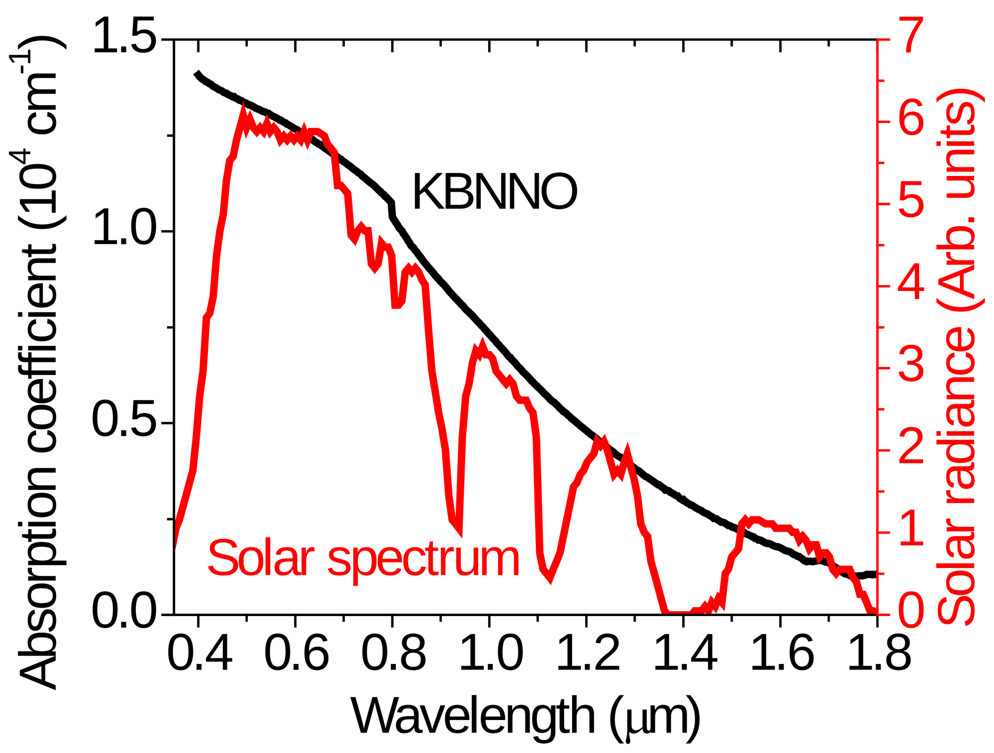
The correct concentrations of Nb, K, Ni, Ba, and O in the grown films was confirmed by Energy Dispersive Spectroscopy (EDS), and the Raman spectrum agrees with literature results for sintered KBNNO.

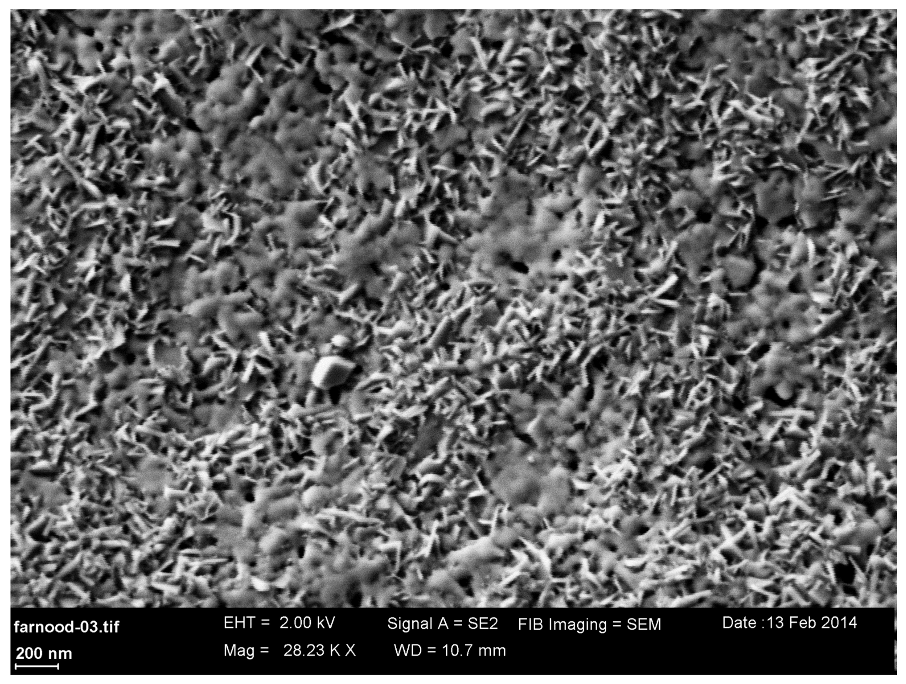


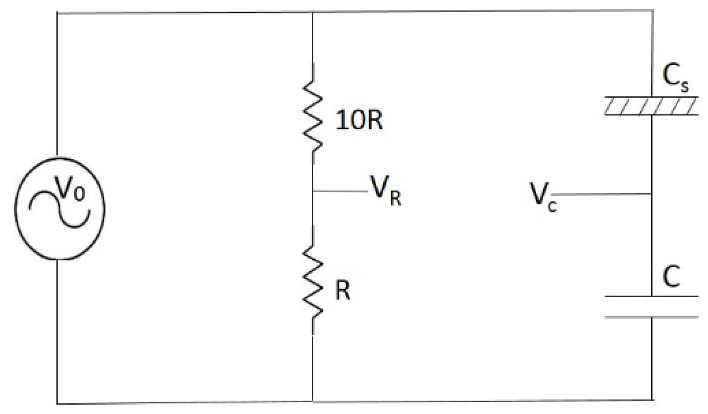
Element	Calculated ratio of elements in KBNNO with x = 0.1	EDS ratio of elements in preliminary SISOM KBNNO film
K	18	15.6
Ni	1	2.6
Ba	2	2.0
Nb	19	22.3
O	60	57.5



The optical absorption spectrum of the KBNNO film matches the solar emission spectrum. Film thickness of just ~ 1 μm suffices to absorb most of the light.

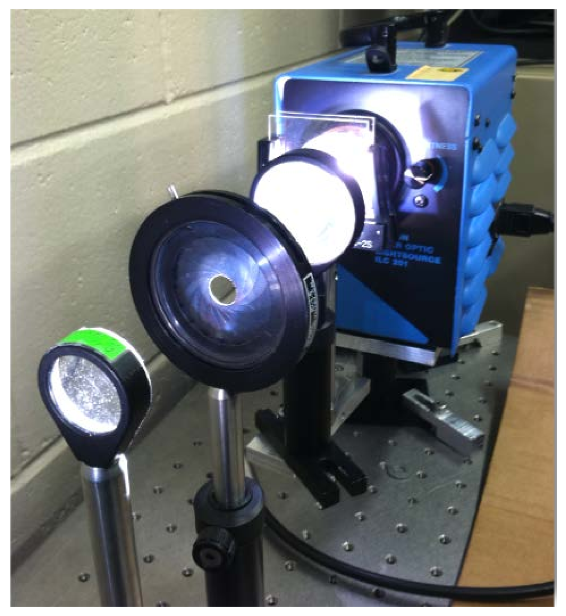






Ferroelectric hysteresis (Polarization P vs. electric field E) is measured by the Sawyer-Tower method.

Characterization of the photovoltaic IV curve will be measured using a filtered Xenon arc lamp



References

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