High Efficiency, Low-Cost Perovskite Solar Cell Modules

Los Alamos NATIONAL LABORATORY EST. 1943

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High-efficiency (>15%) hybrid perovskite 3”x3” solar-cell modules with moisture stability

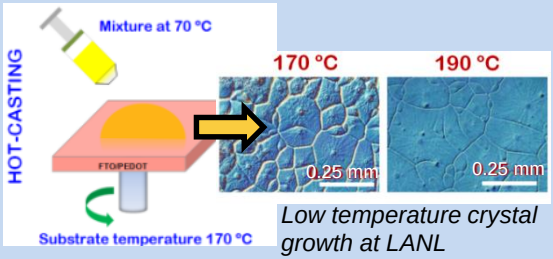
BACKGROUND & MOTIVATION

The problem: Need for high-efficiency low-cost solar-cell technology, that meets DOE SUNshot goal of producing electricity at 0.6c/kWh.

- State-of-the-art solar cell efficiency ~20% use high-purity, single-crystalline semiconductors like Silicon & GaAs grown using high-cost crystal growth techniques.
- In contrast, efficiency of solution processed thin-film technology limited to 6-9% due to poor crystalline quality.
- No current technology offers high-efficiency at low-cost

INNOVATION

Discovery of solution-processed mm-scale single-crystal growth of hybrid perovskites



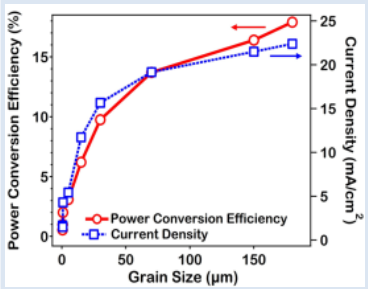
Low temperature crystal growth at LANL

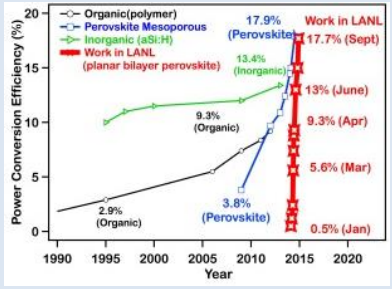
- Ability to make mm-scale grains of single-crystal perovskite films with controlled thickness.
- Crystalline quality comparable to high quality semiconductors like Si & GaAs.
- Earth abundant material, with low-cost & easy to process

DESCRIPTION

Initial Results:

- Proof-of-concept perovskite solar cells with high-efficiency approaching ~18% demonstrated by team





Perovskite solar cell work at LANL (Nie-Mohite)

Enabling Technology:

- Ability to make inch-scale thin-films for Perovskites solar cell modules. (moisture stability not yet demonstrated)

Engineer Approaches:

(A) Development of 3”x3” solar module temperature controlled thin-film coating

- **Dr. blading technique:** Drag solution on hot-substrate with controlled speed using 4” ultra-smooth blade
- **Dip-coating:** Pull substrate from solution maintained at desired temperature
- **Spray coating:** Use ultrasonic spray coater to deposit ultra-smooth films on hot-substrate

(B) Long-term moisture stability (encapsulation schemes)

- Hydrophobic polymer coatings e.g. PMMA, PDMS, etc.
- Use glass-bonding encapsulation schemes.
- Multilayer Graphene/reduced-Graphene Oxide films.

Current Technology Readiness Level (TRL) 3

- Proof-of-concept perovskite solar cells with efficiency approaching 18% demonstrated

ANTICIPATED IMPACT

Perovskite solar cells have the ability to greatly increase the adoption of solar power technology:

- **Low cost** - as much as 75% less than current Si solar cells
- **High efficiency** - equal to and possibly slightly greater than Si solar cell technology
- Realization of solar panels for grid-based electricity generation
- Increased adoption of solar cell technology across the world

PATH FORWARD

Project Goal:

- Achieve perovskite solar cells modules with >15% efficiency & stability

Next steps year 1:

- Develop 3”x3” module thin-films with controlled thickness using Dr. blading, dip-coating & spray coating
- Device performance Optimization: Efficiency >15% on 3”x3” modules

Next steps year 2:

- Encapsulation schemes using PMMA, glass-bonding and/or multilayer graphene
- Test moisture stability & performance outdoor environment

Potential End Users:

- Solar power companies

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