Accelerating a Scalable Clean Energy Future

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Clean Energy: A Global Investment Imperative

The Washington Post

Energy and Environment

Bill Gates: ‘We need to move faster than the energy sector ever has.’
Clean Energy: 
A State Investment Imperative

“This is the right thing to do for the future of our children and health of our planet…”

– Governor Jay Inslee
Foundations for *Scalable* Clean Energy

- Abundant & ubiquitous renewable resources.
- Available when and where it is needed, on the grid or in vehicles.
- Meshes with energy infrastructure, vehicle electrification, markets.
Mission Statement

CEI is accelerating the adoption of a scalable clean energy future by advancing next-generation solar energy and battery materials and devices, as well as their integration with systems and the grid.
CEI’s Objectives

- **Innovation**: Facilitate research discoveries and translation to breakthrough technologies.

- **Education**: Create the next generation of clean energy leaders.

- **Transformation**: Break siloed approaches to clean energy research, education, and partnerships.
Education: Supporting Next-Gen Energy Scholars
Education:
Supporting Leadership through Diversity

UNIVERSITY of WASHINGTON
Innovation: Facilitating Research Discoveries

Impact of microstructure on local carrier lifetime in perovskite solar cells

Dane W. deQuilettes,1 Sarah M. Vorpahl,1 Samuel D. Stranks,2* Hirokazu Nakaoka,1 Giles E. Eperon,2 Mark E. Ziffer,1 Henry J. Snaith,2 David S. Ginger1†
Innovation:
Fostering Research Translation

(54) Title: PHOTOVOLTAIC ARCHITECTURES INCORPORATING ORGANIC-INORGANIC HYBRID PEROVSKITE

(72) Inventors: HILLHOUSE, Hugh; c/o UW Center for Commercialization, 4311 11th Avenue NE, Suite 500, Seattle, WA 98105-4608 (US). BRALY, Ian; c/o UW Center for Commercialization, 4311 11th Avenue NE, Suite 500, Seattle, WA 98105-4608 (US).

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Accelerating scalable adoption demands diverse stakeholder input
What we heard mirrored 2016 Tech-to-Market RFI respondents

1. Affordable Testing, Validation, & Demonstration of Technology
2. Access to Capital
3. Collaboration with Industry
4. Manufacturing Support (contracting and knowledge)
Clean Energy Institute reaction to stakeholder feedback…

Washington Clean Energy Testbeds

- Facilities for scale-up, device testing, and system integration
- Supports our training, research, and technology RD&D mission

Goal: Connect more dots with CESMII
Washington Clean Energy Testbeds Opened Last Week

RD&D scale-up tools – solution processed devices

- “Ink” chemistry scale-up
- Freeform printing tools
- Coating and printing (nano-to-macro)
- Roll-to-Roll RD&D tools (in two months, best in U.S.)

Characterization tools

- “Ink” rheology, structure, and properties
- Real-time process diagnostics
- Materials structures & properties
- Device performance
CEI Scale-up & Characterization Testbed Layout

- **Device & Module Characterization**
- **Sheet and R2R Device Scale-up Processing**
- **Controlled Environment Lab for Sensitive Materials and Device Processing**
- **Dedicated Pilot Scale R2R Print Processing Lab**

- User controlled humidity & temperature
- HEPA filtered hood
- Accommodates equipment exchange

Clean Energy Institute (CEI) at the University of Washington

Clean Energy Testbeds
3rd generation R2R system design with unique capabilities for perovskite and high resolution print patterning of active materials, electrodes, and encapsulation for PV, sensors, TFTs and thin film batteries. 300mm wide web w/ single pass multilayer deposition & drying.

**FOM Tech Solar X3:**

R&D sheet coater for coating functional materials (OPV, OLED, LEC) on rigid or flexible substrates

**NewLong LS-34GX High Precision Screen Printer**

- High precision/flatness
- Flex or rigid substrates
- Blade coating/Stencil mode

**nScript 3Dn 3D Electronics Printer**

- 10nm resolution, 500nm repeatability, 1 um accuracy
- 300mm+ x, y, z travel with z tracking for conformal printing
- Multiple heads:
  - Electronic materials
  - Structural
  - Biomaterials
- 3-D mapping pre and post prints
# Testbed Processing Capabilities Summary

## Printing and Coating

- **Roll-to-roll devices and functional films**
  - FOM technologies (DK) latest generation 300mm slot die, gravure, flexo, and rotary screen tool with two in line printing/coating stations and ovens, individually controllable and splittable, and lamination system.
  - Benchtop roll coater (slot die) for coating testing with small ink volumes on flex.

- **Sheet-based printing and coating**
  - Sheet based slot die coater for rigid plate and sheet-based substrates.
  - High precision flatbed screen printer (300mm) with alignment cameras for screen and stencil printing of electrodes, battery materials and sensors.
  - Dimatix DMP Inkjet printing system.

- **3D printing and prototyping**
  - nScrypt 3Dn 300mm 3D thermoplastic printing system and 3D conformal nozzle direct write printing of electronic inks.

## Handling and Testing

- **Controlled lab environments**
  - HEPA filtered lab areas and hoods.
  - RH and T-controlled lab bays.
  - N2 and Ar glove boxes and ovens.

- **Solar and optoelectronic device testing**
  - 300mm AAA solar simulator (UV to IR) with temperature stages for cell and module testing.
  - High precision ammeters and electrometers.

- **Energy storage testing**
  - High precision sources, femtoameters and electrometers.
  - 400 channels of battery test capacity.
  - Impedance spectroscopy/EIS.
  - In-situ X-ray, GC-MA of cells.

- **General Analytical**
  - SEM/EDX, Optical, Fluorescence micro.
  - High resolution 300mm profilometry.
  - Access to extensive chemical, surface and structural analysis on campus.
On February 16, 2017 we opened the Washington Clean Energy Testbeds

A new venture to accelerate the translation of research ideas into positive economic and environmental impact
Transformation:
Recruiting Faculty with Diverse Experience

Schlenker  Chu  Subramanian  Zhang

Molecules  Materials & Devices  Prediction & Control  Systems & Operations  Manufacturing  Miles & Markets

Holmberg  MacKenzie
New Spaces for Innovation, Student Training, & Collaboration

WASHINGTON
Clean Energy Testbeds
Research Group Areas

Flexible Electronics

Sensors

Energy Devices

Scalable Manufacturing
Thank you!

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