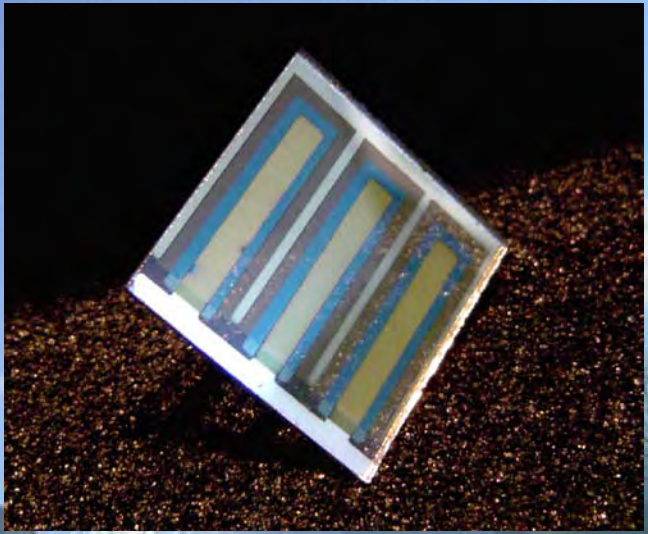
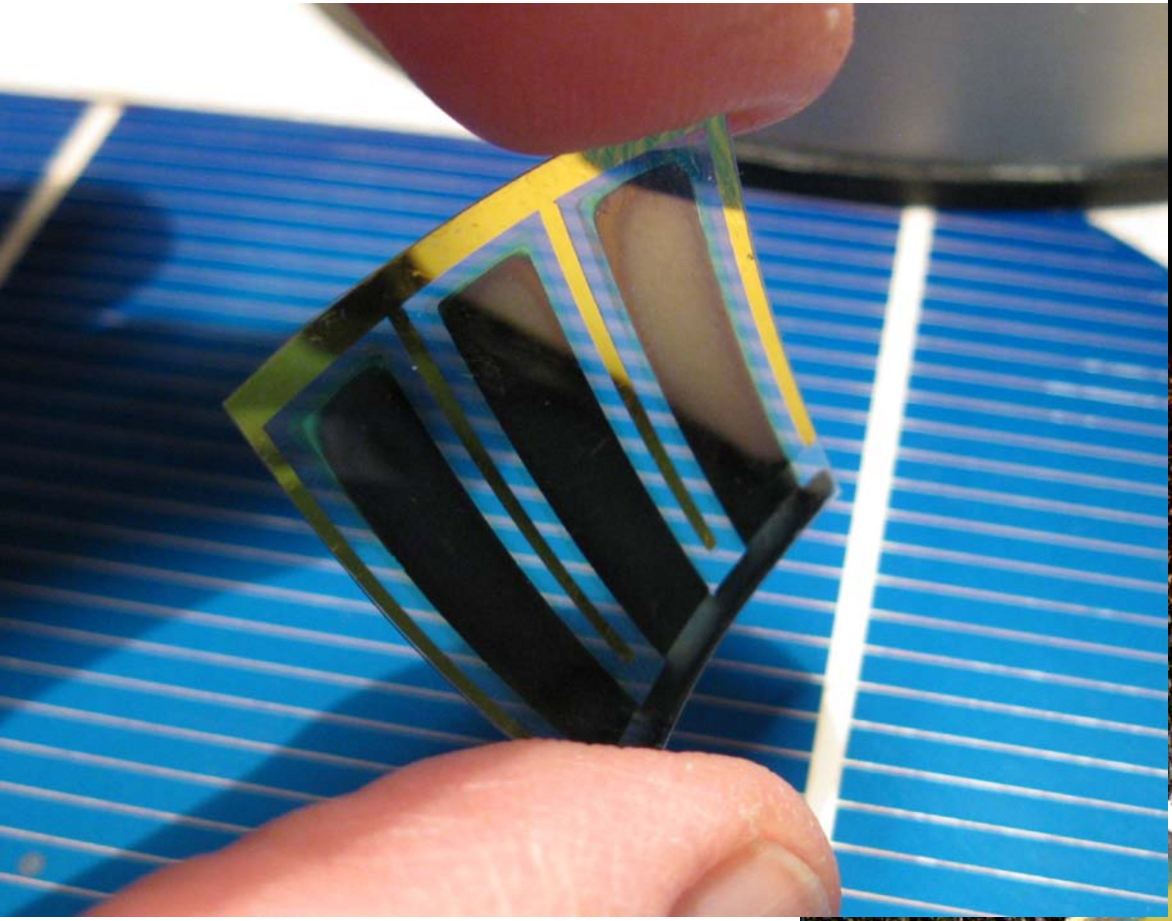
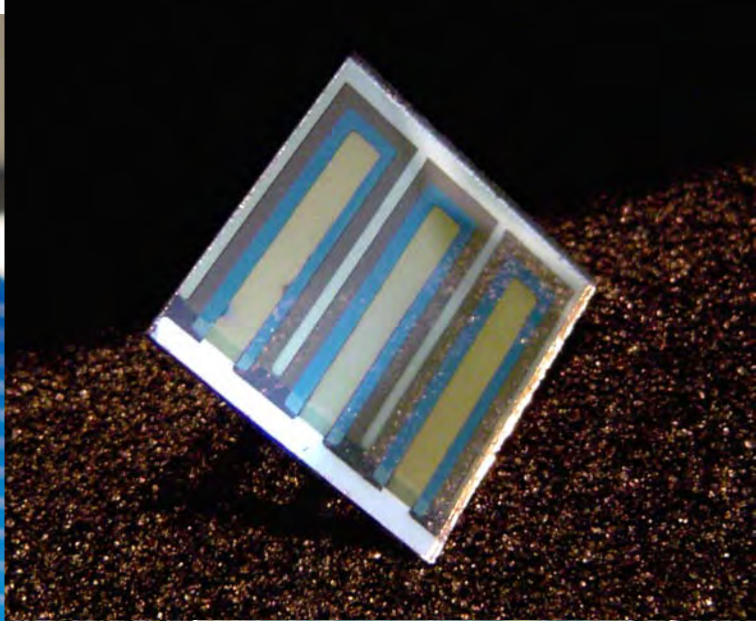


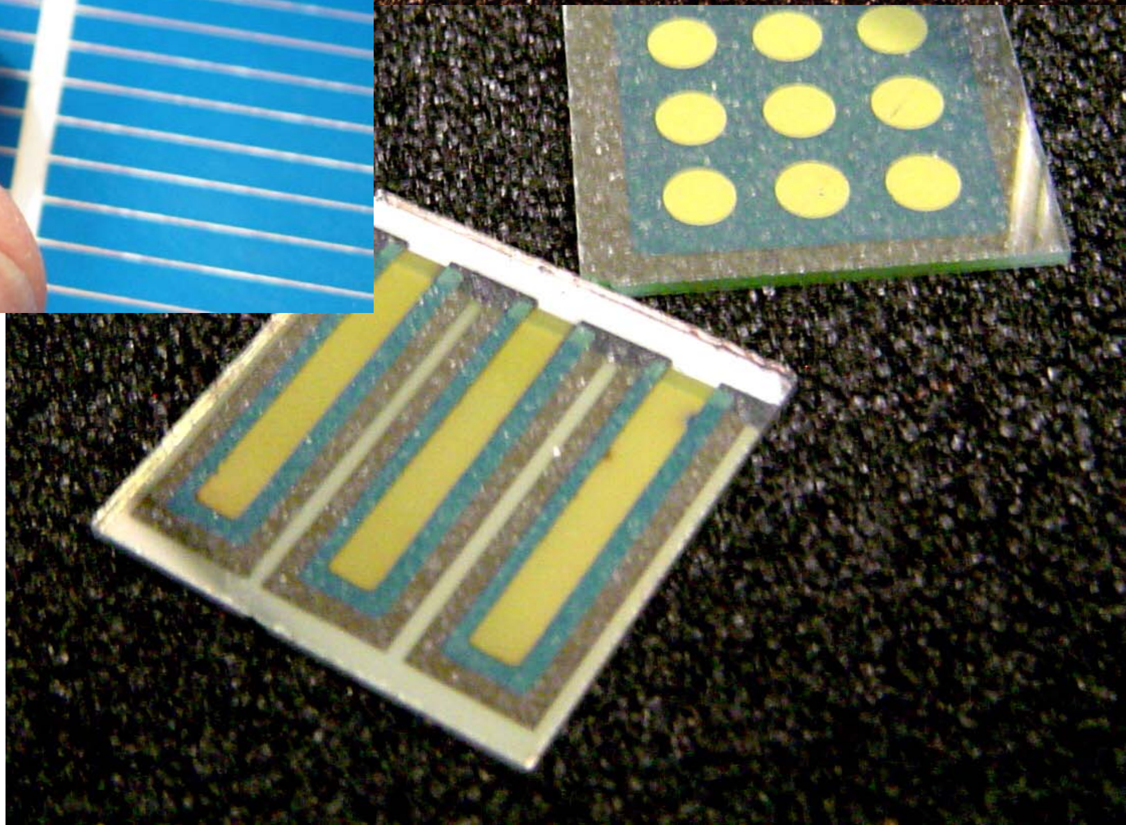
Organic Solar Cells:
A part of "flexible electronics" which have been the focus of this STC

CMDITR 101: Project 4.1
Organic Solar Cells, etc.

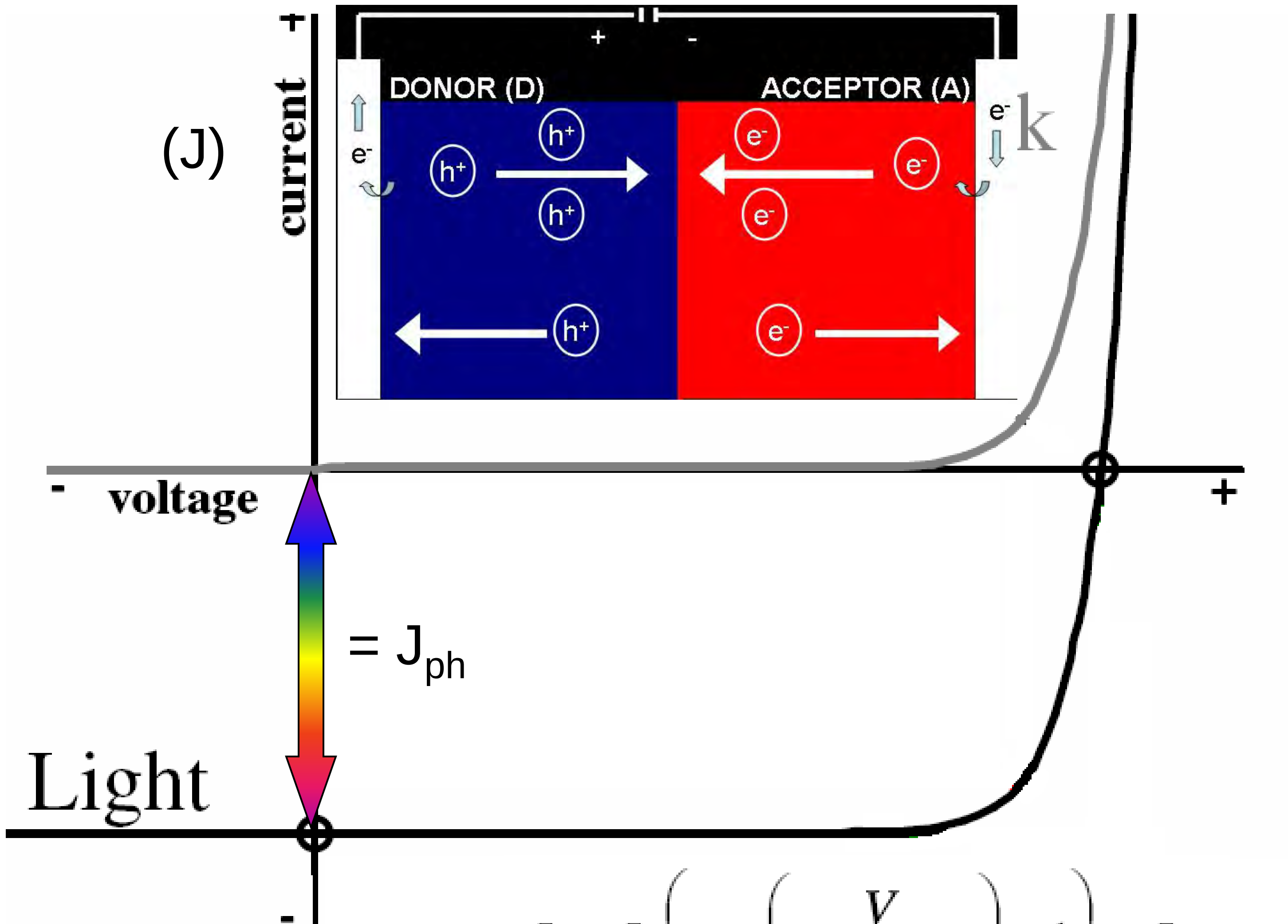
Neal R. Armstrong







Photovoltaic Efficiency



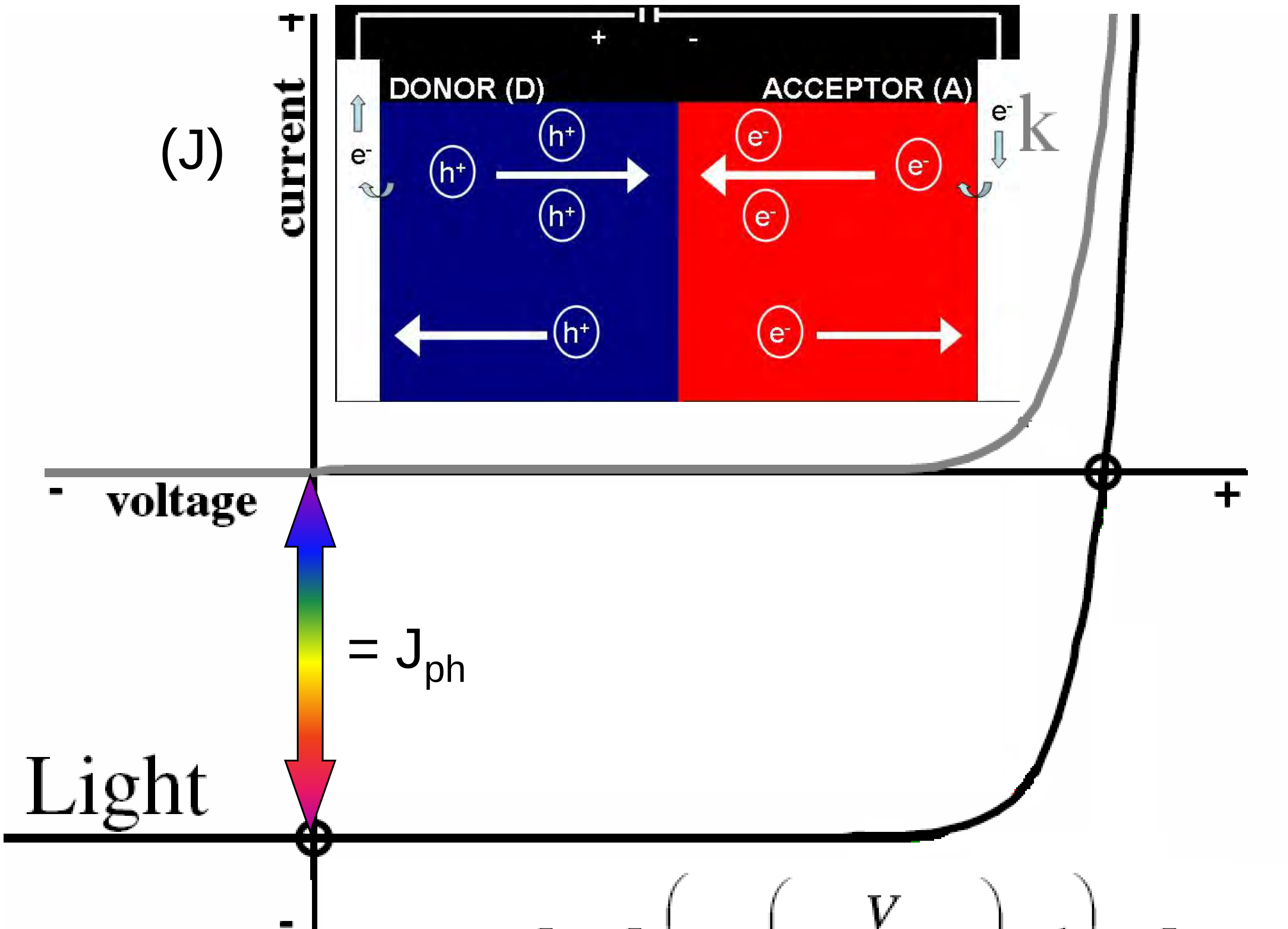
$$J = J_o\left(\exp\left(\frac{V}{n_o k_B T / e}\right) - 1\right) - J_{ph}$$

Key Vocabulary Words

- Open circuit photovoltage (V_{OC})
  - The output potential of the OPV at zero current; controlled by offsets in frontier orbital energies at the D/A interface ($E^D_{HOMO} – E^A_{LUMO}$) and parasitic device parameters
- Short-circuit photocurrent (J_{SC})
  - Maximum current supplied by the OPV at V = 0; controlled by ($E^D_{LUMO} – E^A_{LUMO}$) + molecular orientation, excited state energetics and lifetimes
- Fill Factor (*FF*)
  - Ratio of maximum output power from the OPV (P_{max}) versus the theoretical maximum (P_{theor}) $P_{theor} = V_{OC}*J_{SC}$ (controlled by recombination probabilities, parasitic device parameters
- Power conversion efficiency, η
  - $\eta = [P_{max} * FF]/P_{incident}$

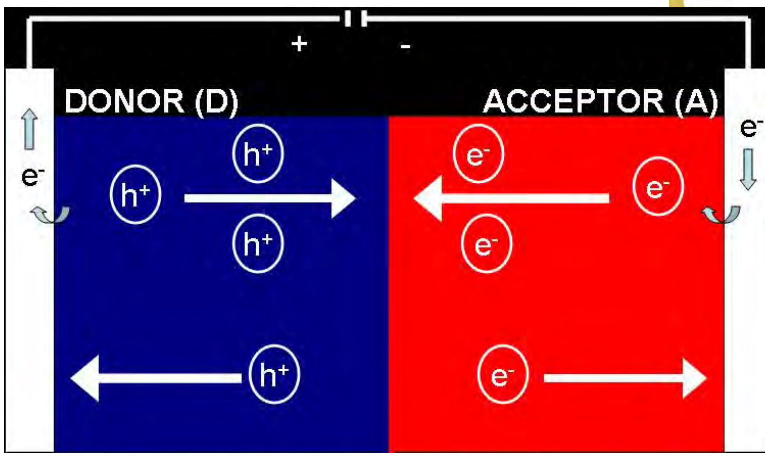
Cost per watt – ($/W) MUST BE LOWER THAN $1!!

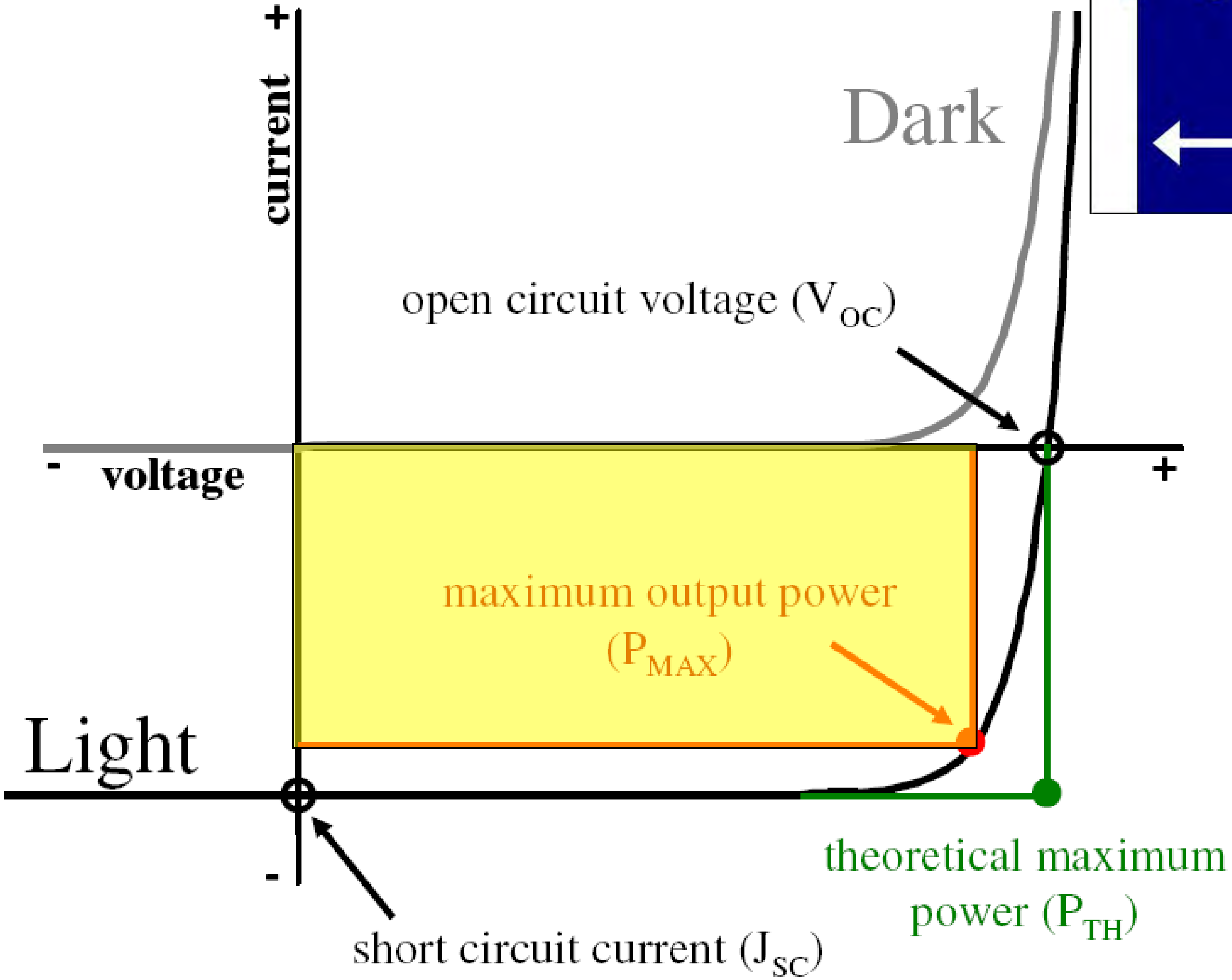
Photovoltaic Efficiency



$$J = J_o\left(\exp\left(\frac{V}{n_o k_B T/e}\right)-1\right)-J_{ph}$$

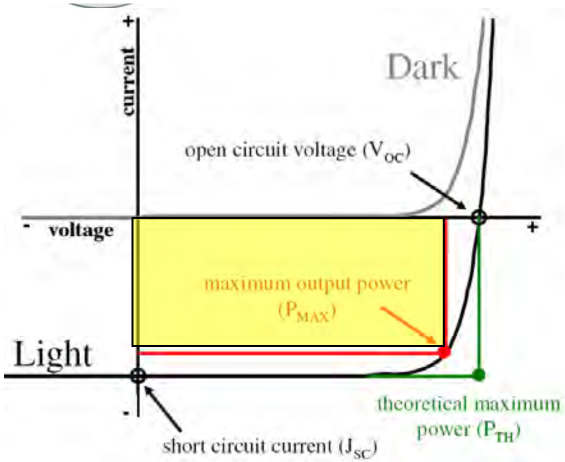
Photovoltaic Efficiency





Fill Factor =

Photovoltaic Efficiency

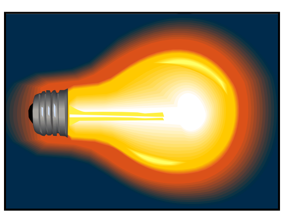


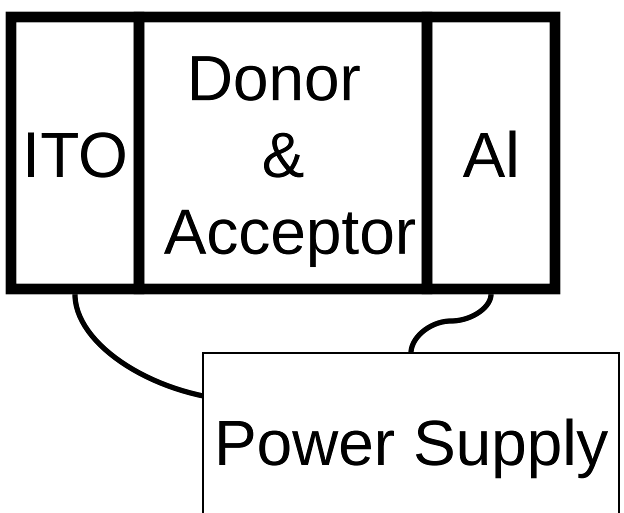
Brumbach Dissertation, U. of Arizona, (2007)

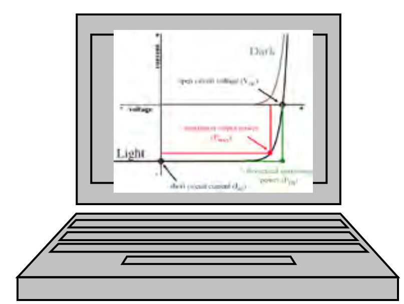
Power Conversion Efficiency:

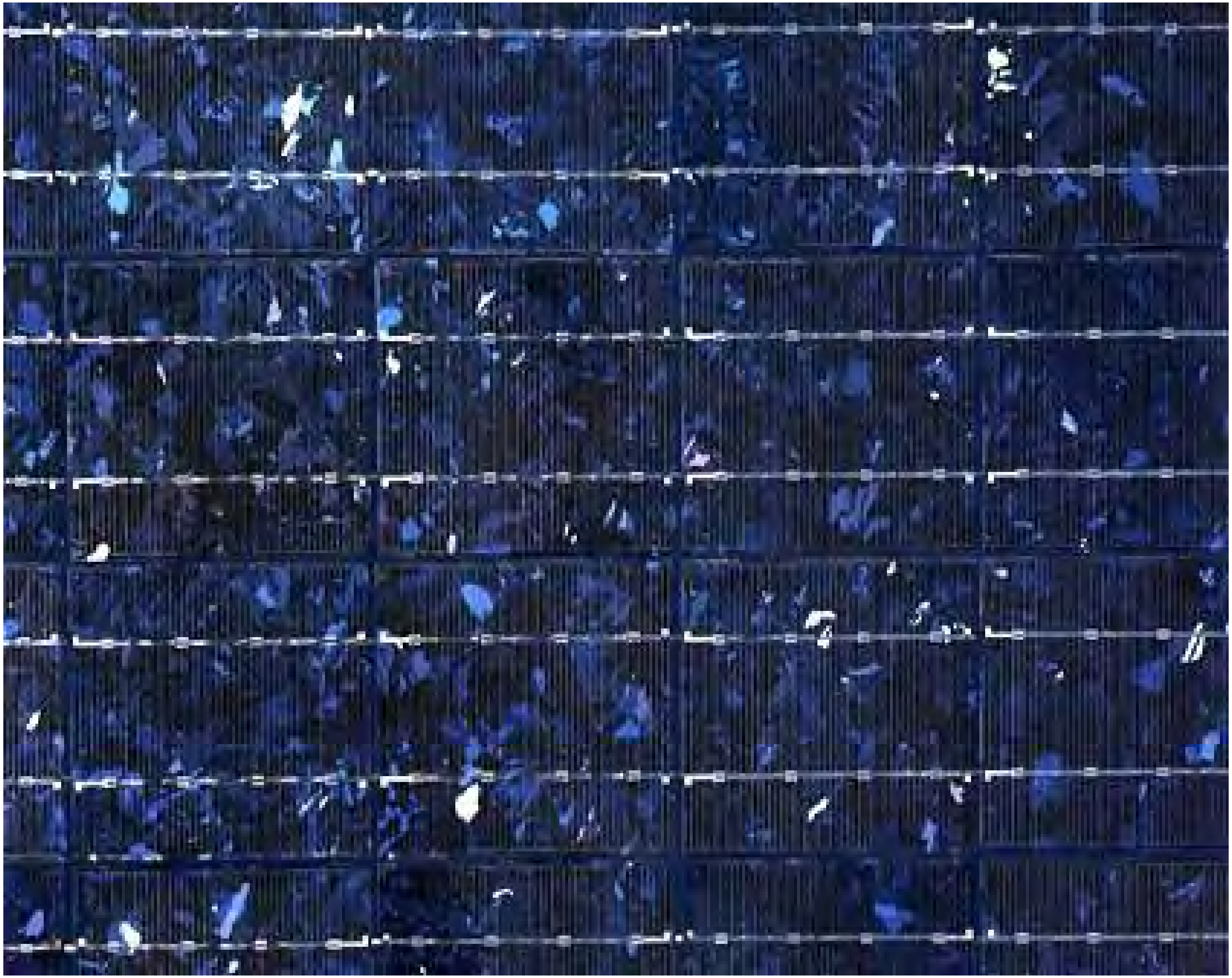
$$\eta = \frac{P_{max}}{P_{solar}}$$

Testing Apparatus: (not to scale!)

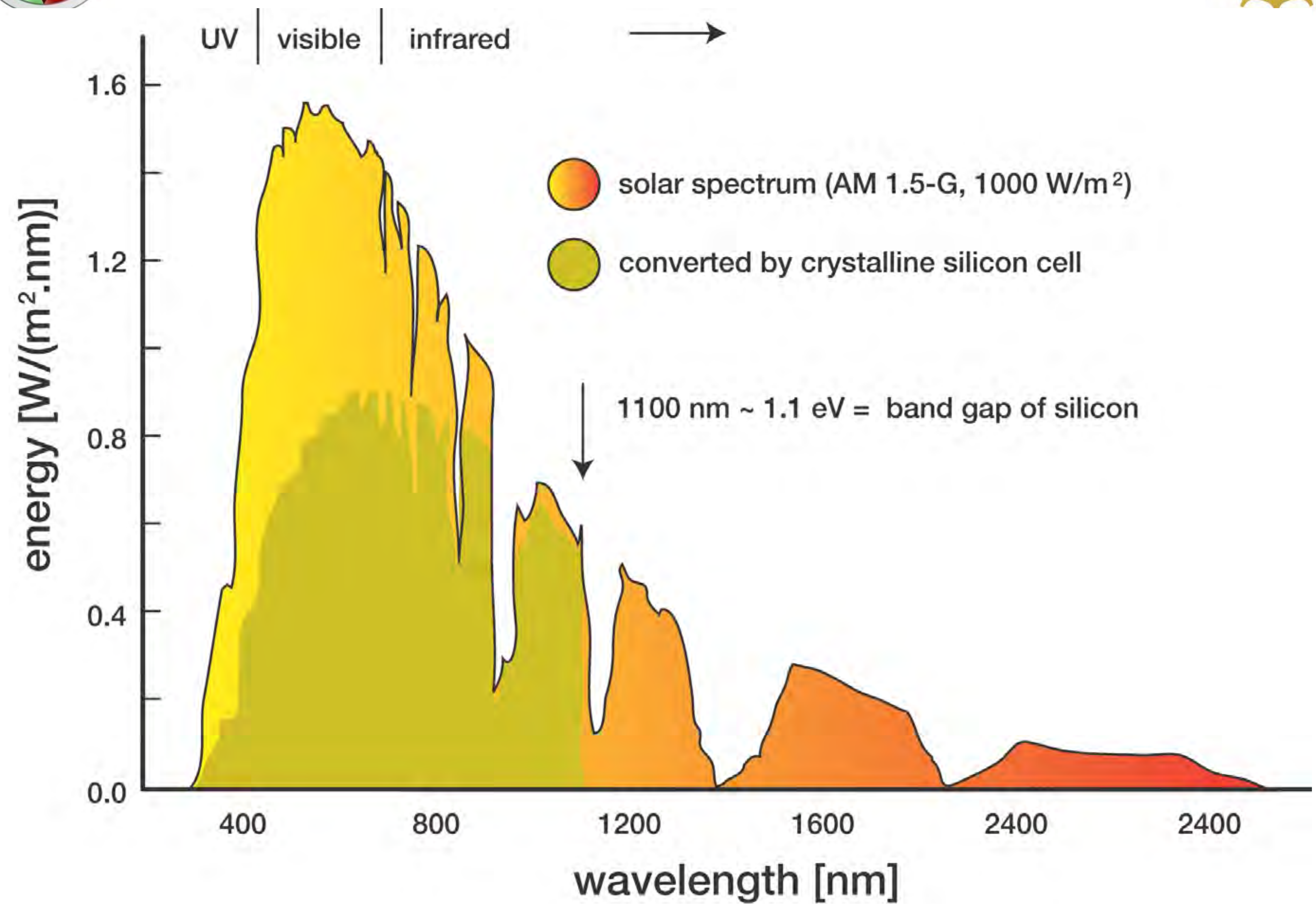




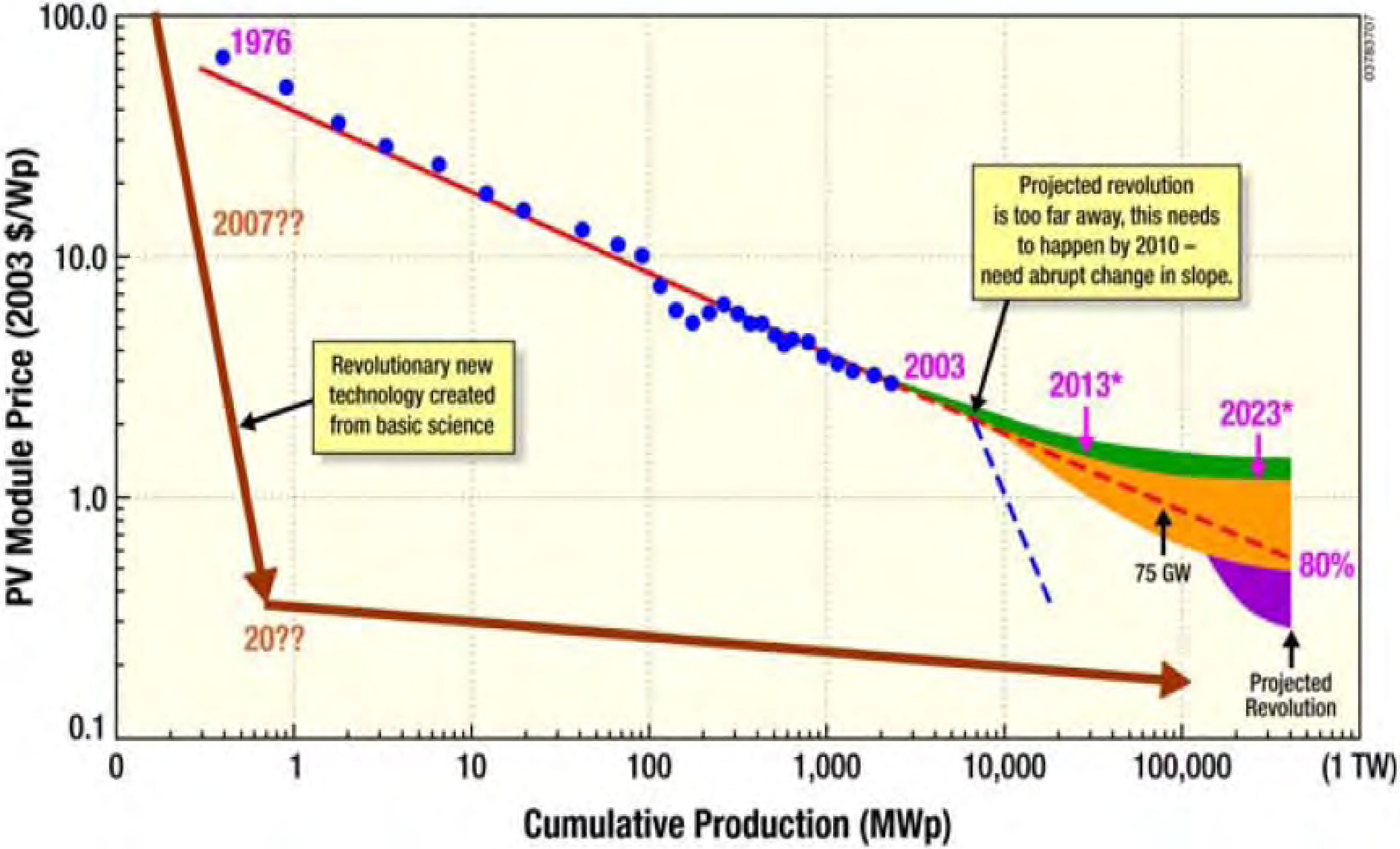




Energy from the Sun:

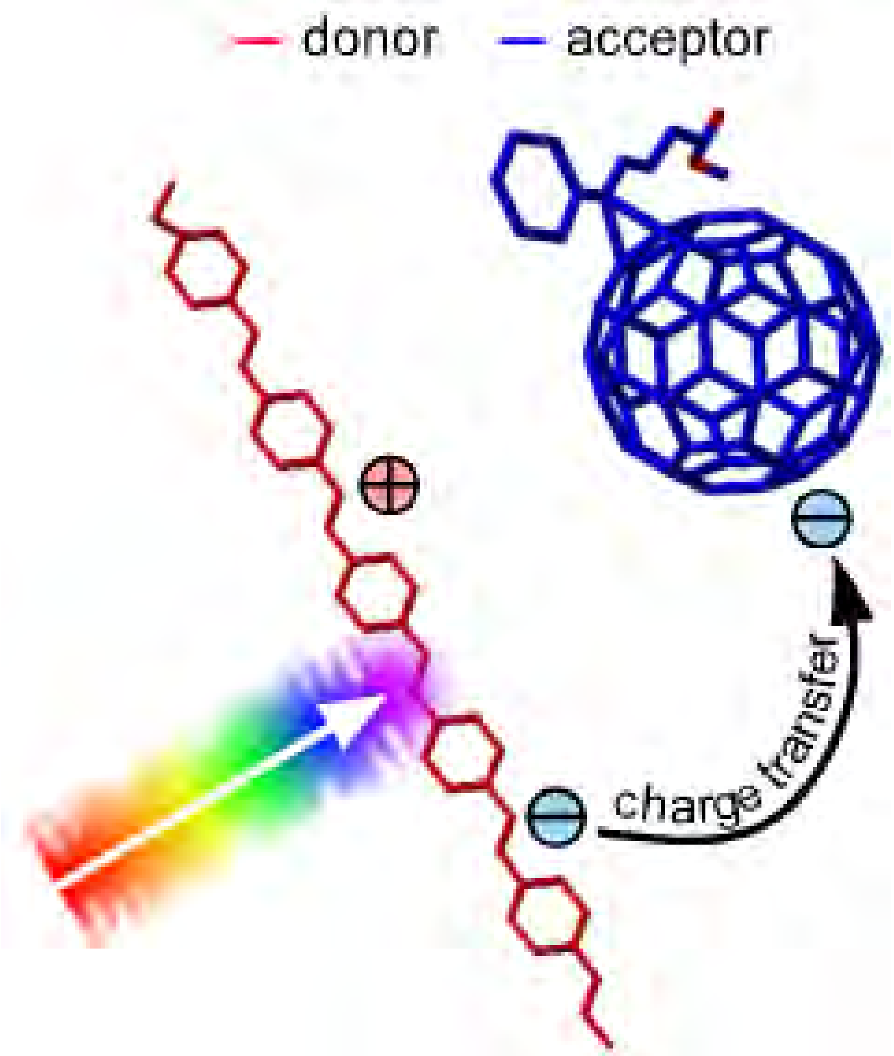


Where Do We Need to Go?

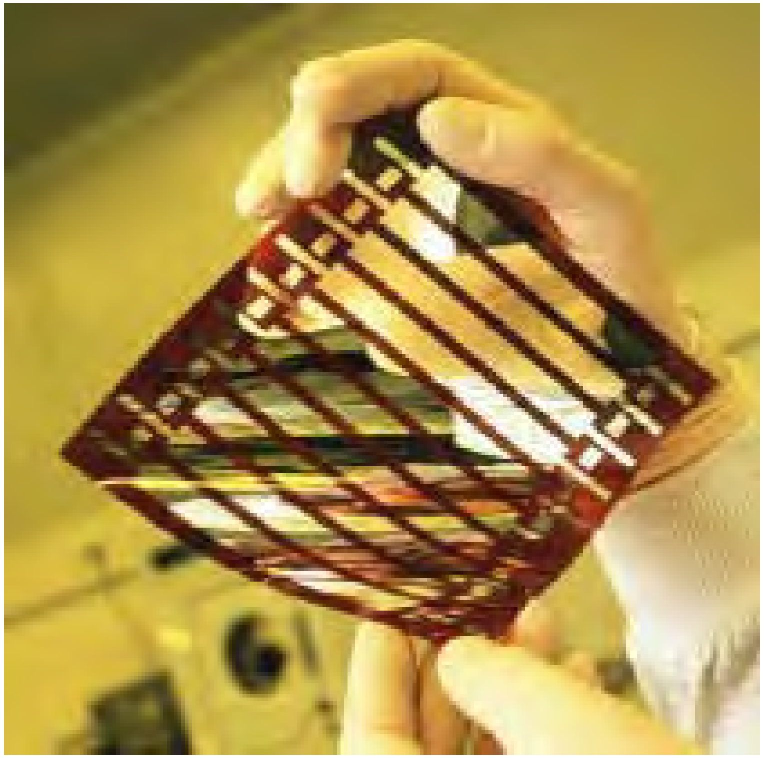


http://www.sc.doe.gov/bes/reports/files/SEU_rpt.pdf

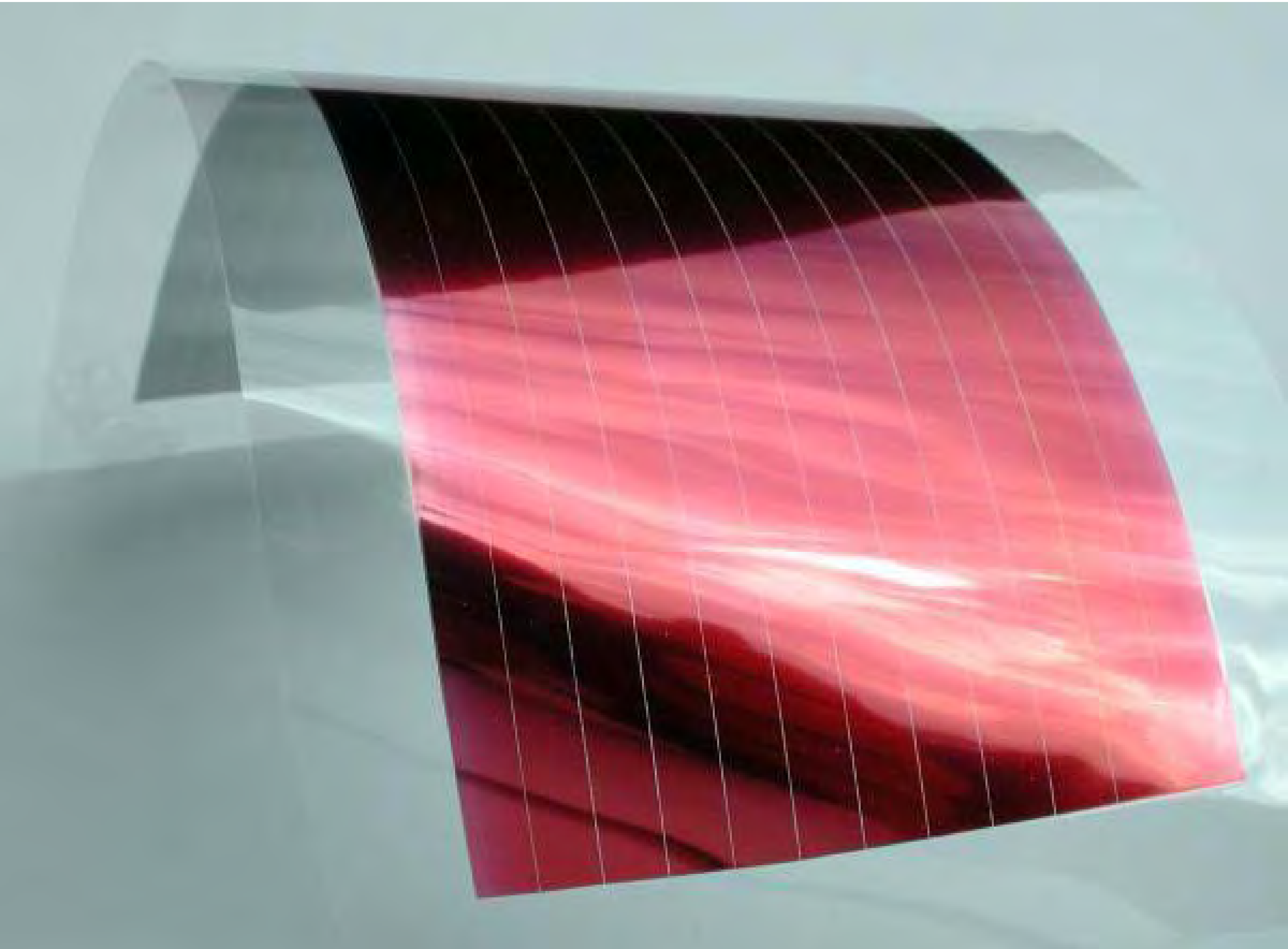
Organic Solar Cells (Photovoltaics)



www.physik.uni-wuerzburg.de/EP6/research-phot...

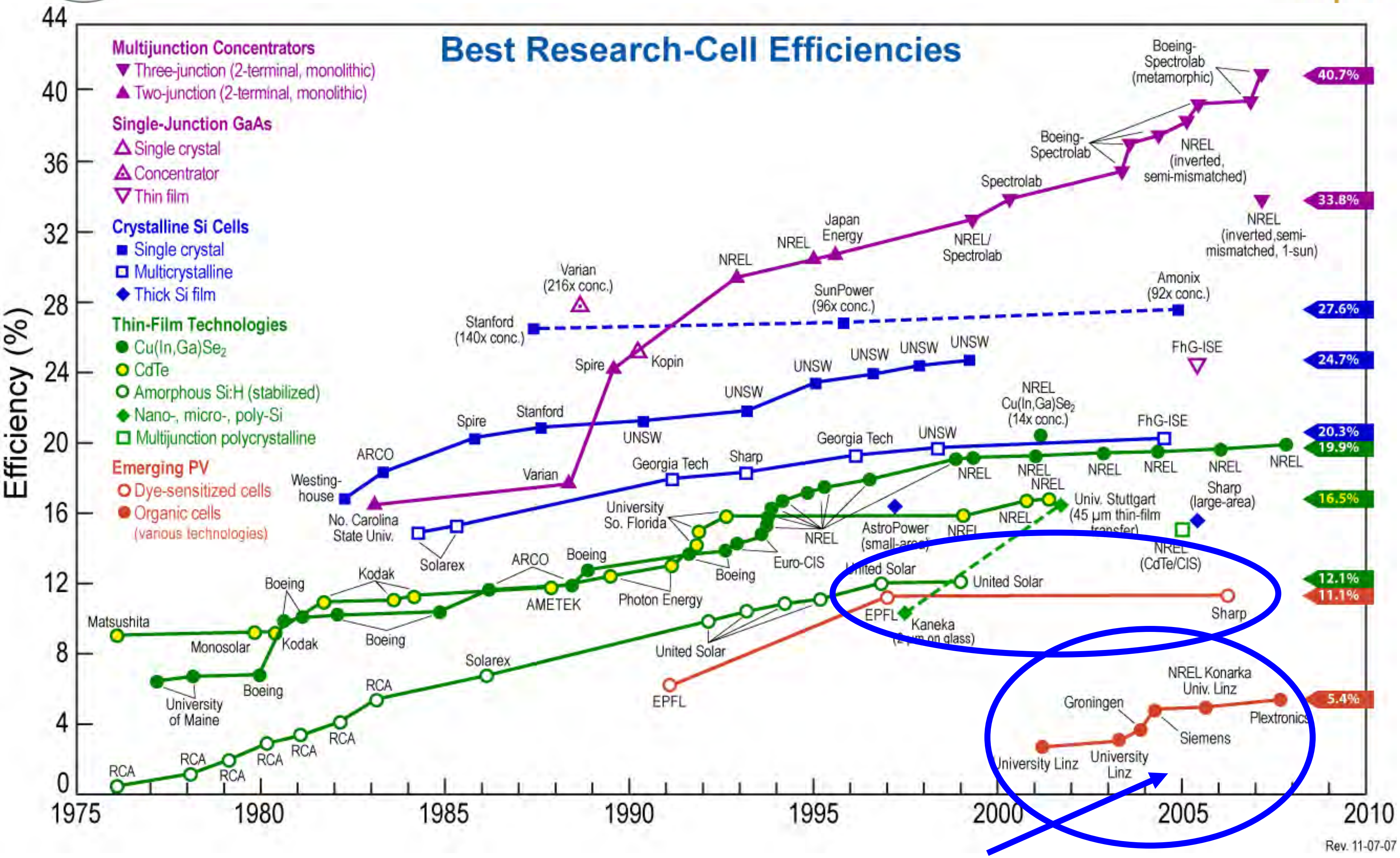


http://www.sc.doe.gov/bes/reports/files/SEU_rpt.pdf



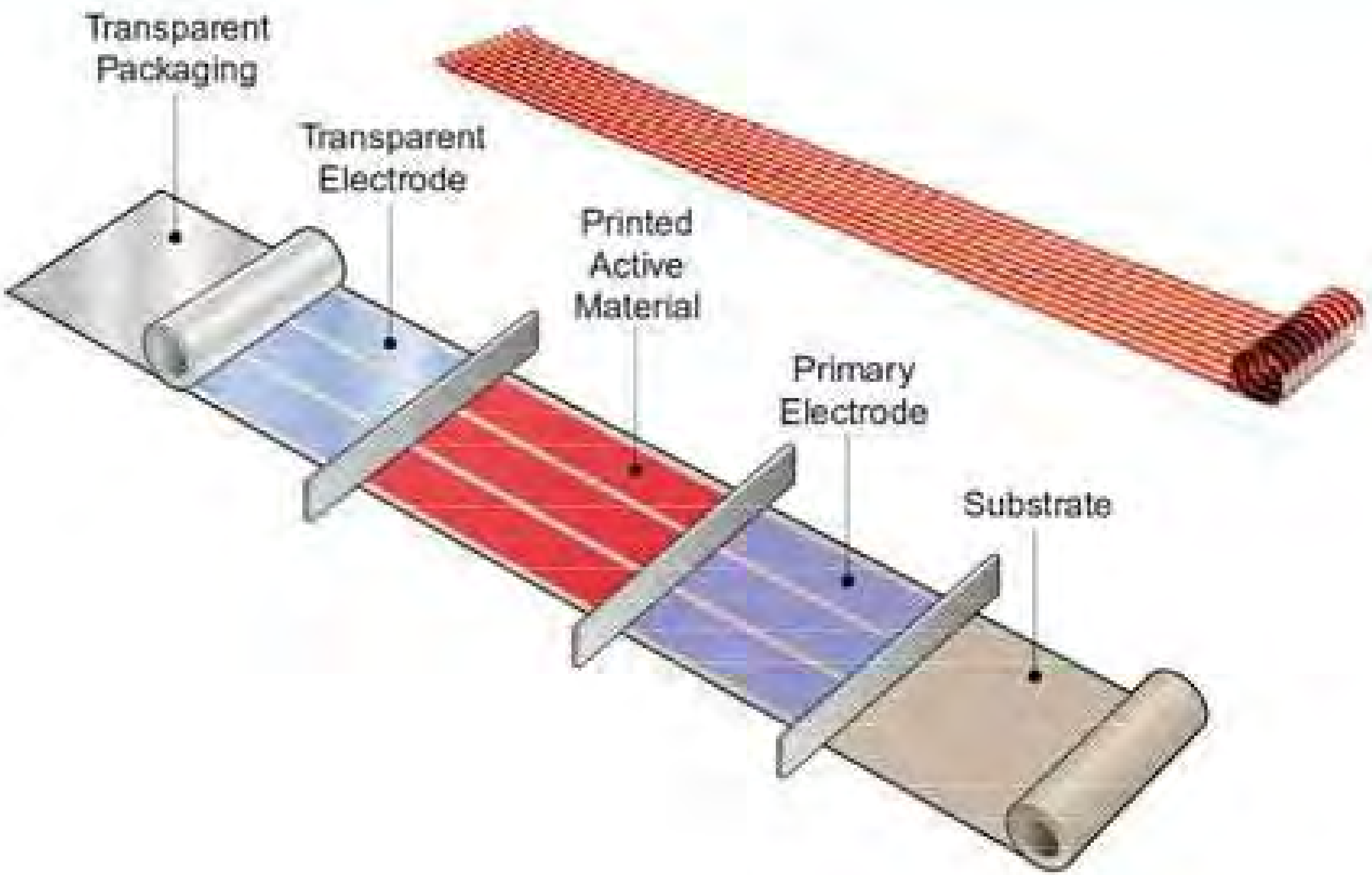
First the good news:

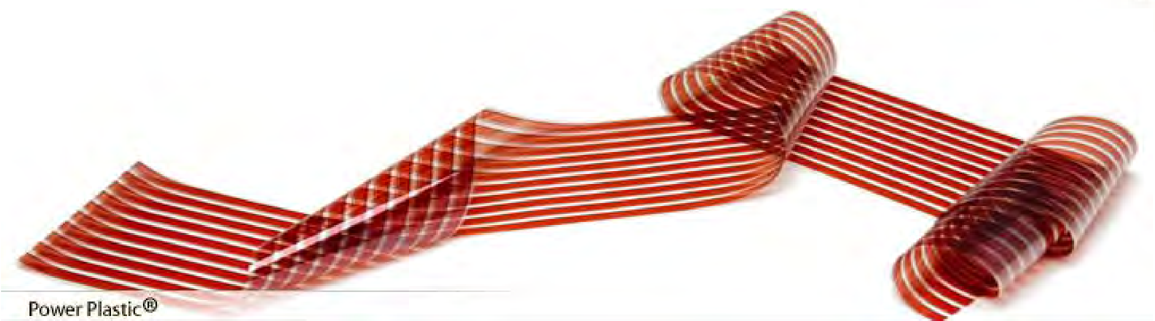
http://www.sc.doe.gov/bes/reports/files/SEU_rpt.pdf



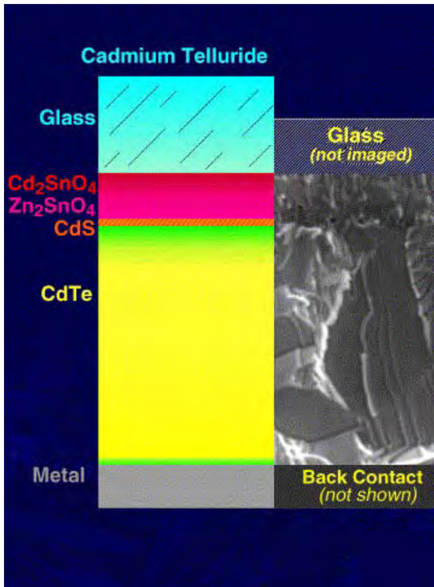
“Organic” Solar Cells

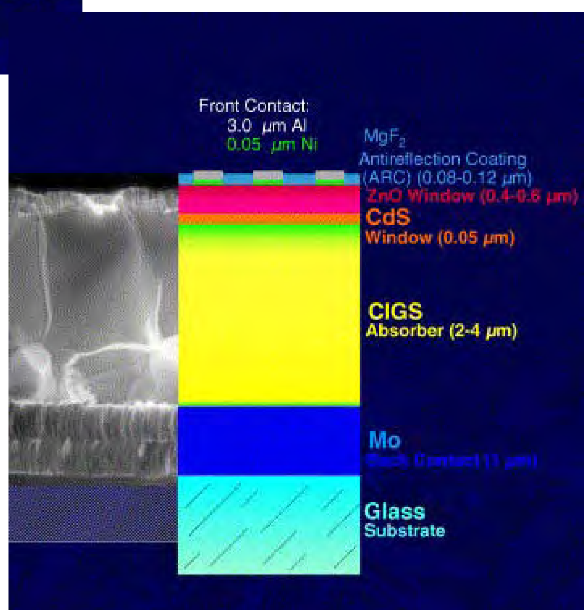
Konarka's OPV Module

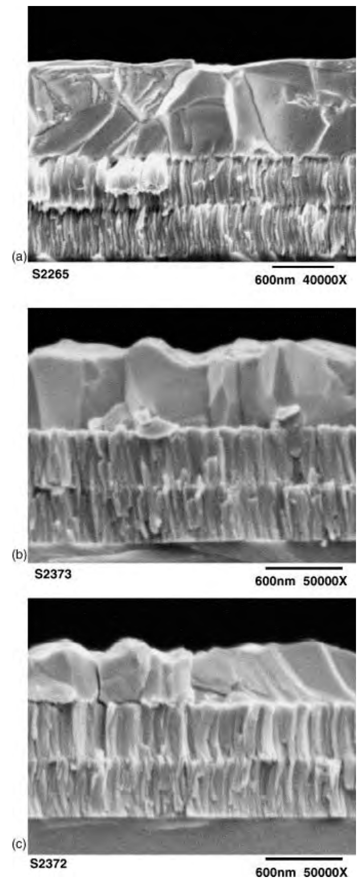




The competition: a-SiH; CIGS, CdTe, etc.
"thin film" solar cells – work pretty good, not as efficient as silicon, but not bad







www.konarka.com

National Solar Technology Roadmap:

Organic PV

Solar Energy Technologies Program

Facilitator: *Dave Ginley*

Participants included:
National Renewable Energy Laboratory
Sandia National Laboratories
U.S. Department of Energy
University and private-industry experts

Metrics

Parameter	Present Status (2007)	Future Goal (2020)
Champion device efficiency	5.2%	12%
Cell degradation	< 5% per 1000 h, research-scale	< 2% per 1000 h, module
Material figure-of-merit efficiency. Identification of candidate materials whose fundamental properties, such as optical absorption, band structure, and carrier mobility, allow for high theoretically attainable efficiencies.	Some material sets with improved figure-of-merit efficiencies exist.	Identification and synthesis of multiple donor-acceptor materials that meet all the fundamental requirements to achieve the Shockley-Queisser limit.

MDITR

NSF

MDITR

CIS:SEM

Center for Interface Science : Solar Electric Materials

THE UNIVERSITY OF ARIZONA

UNIVERSITY OF WASHINGTON

NREL National Renewable Energy Laboratory

Innovation for Our Energy Future

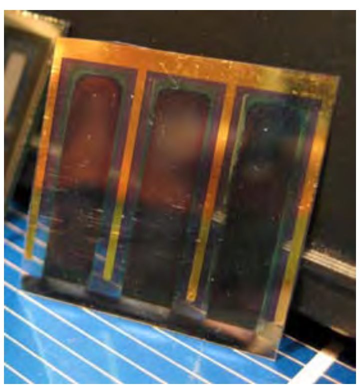
Georgia Institute of Technology

PRINCETON UNIVERSITY

Web site for CIS:SEM about to go "live"

http://solarinterface.org

Solar Energy portal to:
DOE EFRC Programs
UA projects
General interest sites
Upcomiing meetings, etc.



The Solar Interface:
Bi-annual/quarterly Newsletter
(electronic only?)
An "Energy Portal"

CIS:SEM
Center for Interface Science : Solar Electric Materials

Solar Interface

Visit us at:
www.solarinterfaces.org

Volume 1, Issue 1 February __, 2010

Welcome to CIS:SEM!

What's Inside:

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The Unique Tools of Interface Science	3
Upcoming Events	4
Emerging Solar Cell Technologies & Interface Science	4
Links to Critical Department of Energy Sites and EFRC Programs	4

We are pleased to introduce the Department of Energy Frontier Research Center for Interface Science: Solar Electric Materials.

CIS:SEM is one of 46 EFRC programs created in 2009 by DOE, to focus on the basic science of new energy conversion and energy storage technologies — $19M was awarded to the University of Arizona, the lead institution for CIS:SEM, and its partners from the Georgia Institute of Technology, the University of Washington, Princeton University and the National Renewable Energy Laboratories (NREL) in Golden, Colorado, for a five-year effort.

Our vision is to become a nationally and internationally recognized center of excellence for the science of interfaces in photovoltaic devices based on organic and inorganic nanostructured, hybrid materials.

In this first edition of The Solar Interface we will introduce you to our center, to the principle investigators and staff scientists at our five partner institutions, and to the technologies and capabilities which will be of interest to potential research partners of CIS:SEM

Chemical Sciences Building (CSB) at the University of Arizona

The Goals of CIS:SEM :

New theories of charge transfer between organic semiconductors and oxides, metals and emerging non-traditional conductors;

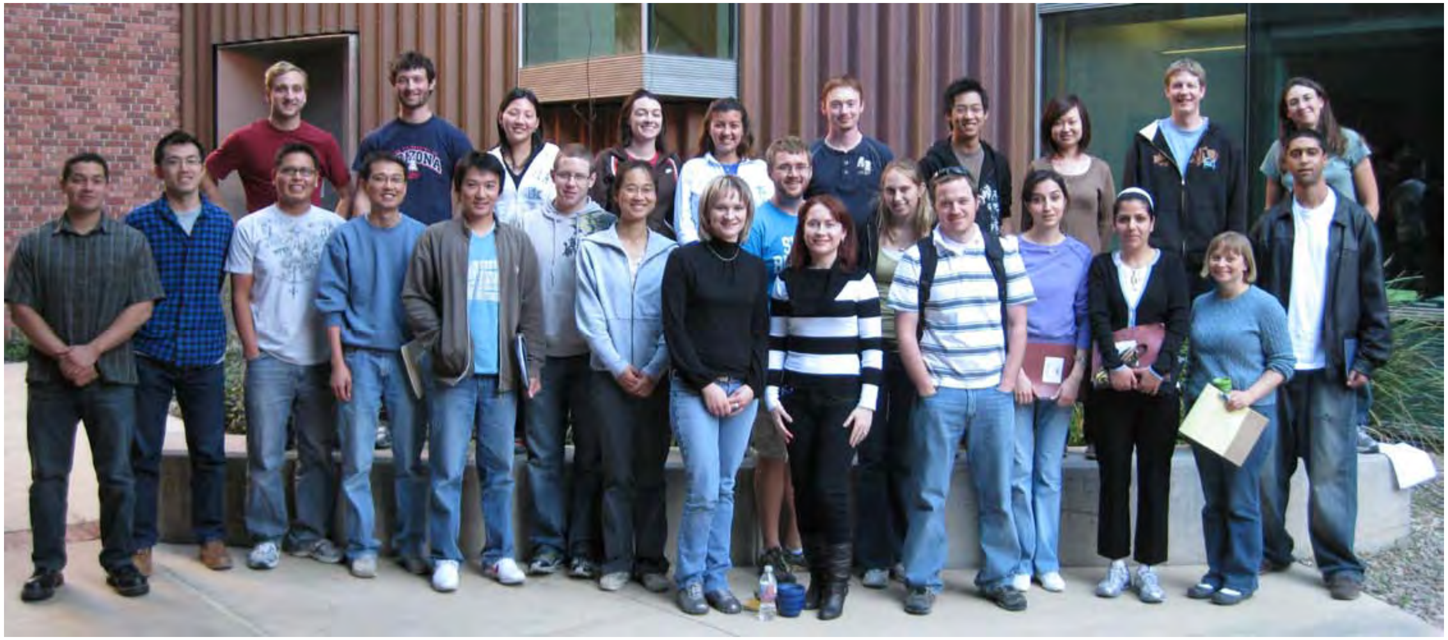
New methodologies for the characterization of atomic and molecular composition, morphology/structure of interfaces

New approaches to the nanoscale characterization of electrical and electrochemical properties of these interfaces;

New nanostructured organic, metallic and oxide hybrid materials leading to the formation of chemically and physically robust interfaces in emerging solar cell systems;

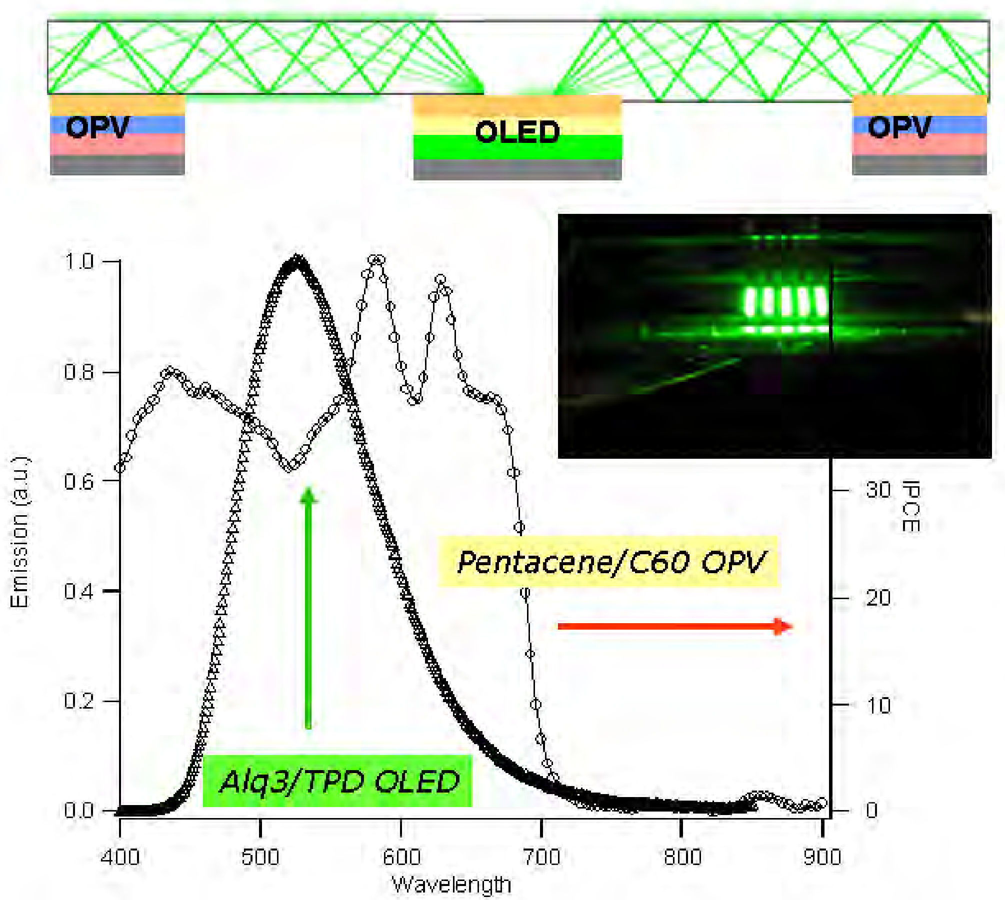
Application of this new basic science to the optimization of existing and future solar energy conversion photovoltaic platforms.

THE UNIVERSITY OF ARIZONA.
Georgia Institute of Technology
NREL National Renewable Energy Laboratory
UNIVERSITY OF WASHINGTON
PRINCETON UNIVERSITY



The Energy Science Group (ESG)
College of Science,
College of Optical Sciences,
College of Engineering

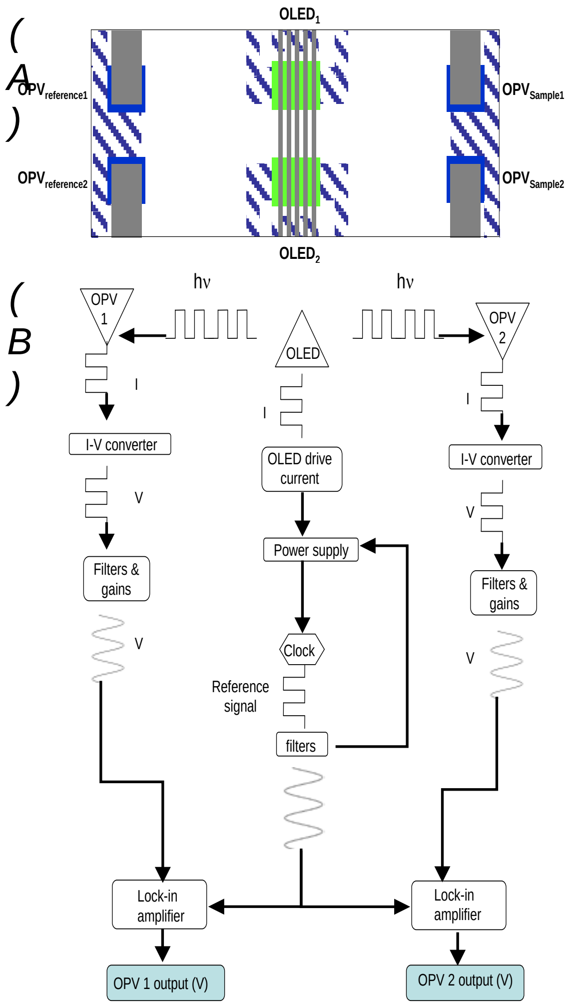
A Planar, Chip-Based, Dual-Beam Refractometer Using an Integrated Organic Light Emitting Diode (OLED) Light Source and Organic Photovoltaic (OPV) Detectors

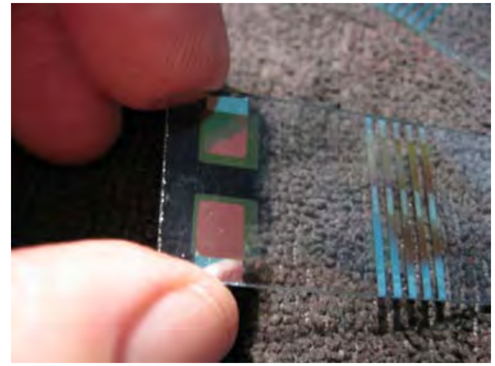


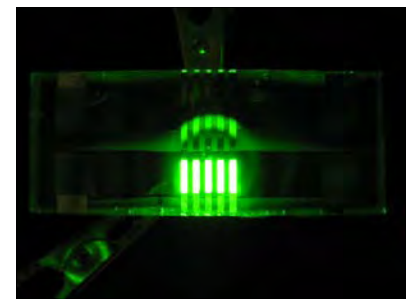
Erin L. Ratcliff, P. Alex Veneman, Adam Simmonds, Brian Zacher, Daniel Huebner,

S. Scott Saavedra, Neal R. Armstrong -- Analytical Chemistry, in press.

The OLED/OPV Refractometer Uses A Segmented OLED Source, True Dual-Beam Operation (Matched OPVs), and Modulation/Demodulation Detection Schemes







Sensitivity to Refractive Index Changes is Less Than ≈ 10^{-4} R.I. Units, and It Appears Possible to Extend This to ≈ 10^{-7} R.I. Units with Optimization of OLED, IRE Platform and OPV Detectors