ACT 3
Self-Assembled Nanomaterials for Energy Generation and Storage

Chris Murray & Zahra Fakhraai (co-leaders)

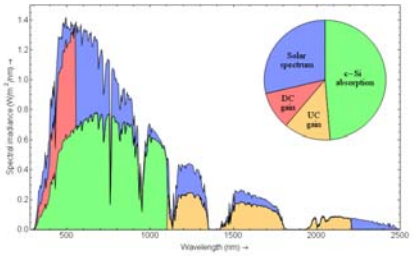
Penn: Russ Composto, Dan Gianola, Rob Riggleman, **Karen Winey**.
Villanova: Gang Feng, Amy Fleischer.
BMC: Xuemei Cheng.
GIANT: **Patrice Rannou (co-leader)**, Bertrand Donnio (CNRS), Trevor Forsyth (ILL/ESRF), Giovanna Fragneto (ILL/ESRF), Didier Gasparutto (CEA), Lionel Picard (CEA), Said Sadki (UGA).
Solvay: Vincent Finsy, Veronique Mathieu.

Electricity is a vital resource following a disaster.

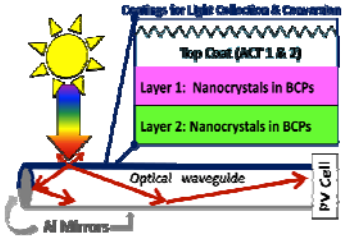
ACT 3: Self-Assembled Nanomaterials for Energy Generation and Storage

- **Objective:** Incorporated solar energy conversion systems and energy storage devices into a flexible shelter.
- **Aim 1:** Increase solar energy conversion by designing multilayered polymer / nanoparticle coatings on optical waveguides to efficiently collect and convert light. Coatings will be compatible with the surfaces from **ACT 1**.
- **Aim 2:** Design and synthesis of new polymers for lightweight, flexible batteries.
- **GIANT**'s expertise in interrogating energy materials *in-situ* and *in-operando* is particularly unique.

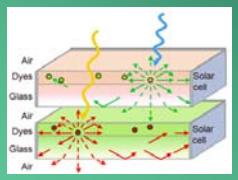
Silicon-based photovoltaic devices convert a limited range of solar wavelengths.



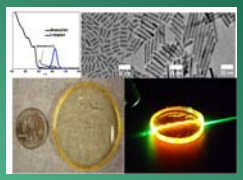
Design nanoparticle / polymer coatings to deliver every photon to the solar cells….



Luminescent Solar Concentrators LSCs

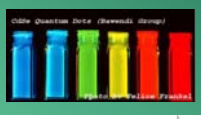


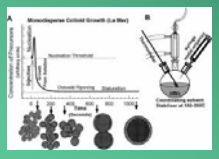
Dyes

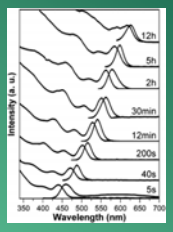


Nanoparticle / polymer (Murray)

Quantum Dot Spectral Converters





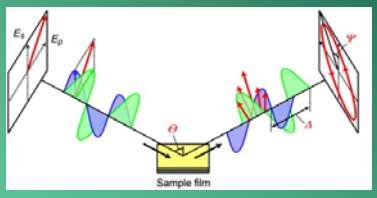


QDs are rapidly being comercialized as down shifting lumophores in displays & solid state lighting

December 7, 2015

In-situ characterization of multi-layer sollar-cell coatings

Spectroscopic Ellipsometry



Yokoyama, D., Sakaguchi, A., Suzuki, M. & Adachi, C. *Org. Electron.* 10, 127–137 (2009).

December 7, 2015

ACT3: ENERGY GENERATION/HYBRID SOLAR CELLS


Bertrand Donnio
CNRS - IPCMS


Patrice Rannou
CNRS - SPrAM


Brigitte Pépin-Donat
CNRS - SPrAM


Didier Gasparutto
CEA, CNRS - SPrAM

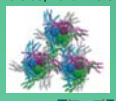
KEYWORDS, CORE COMPETENCES, RESEARCH LINES & APPROACHES

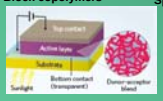
Molecular synthesis
Coordination & Supramolecular Chemistry
Liquid Crystals
Surfactants
Self-assembly
Fulleroïds, Dendrimers

Functional soft matter
Electronic & Energy Transfer
Structure/Property across many length/time scales
Organic (semi)conductors
Block copolymers

Electronic properties
Electron Paramagnetic Resonance (EPR)
Molecular architectures
EPR tracing
Spin trapping

Biorganic synthesis
DNA engineering, self-assembly, conjucation, NP nanohybrids





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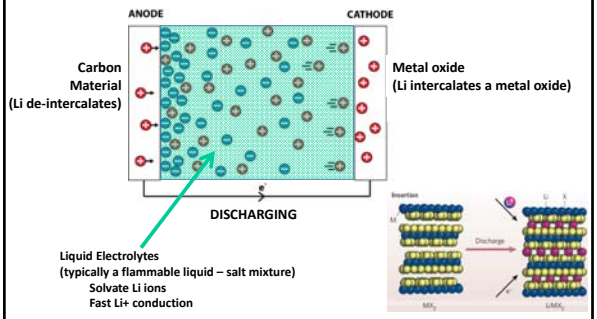
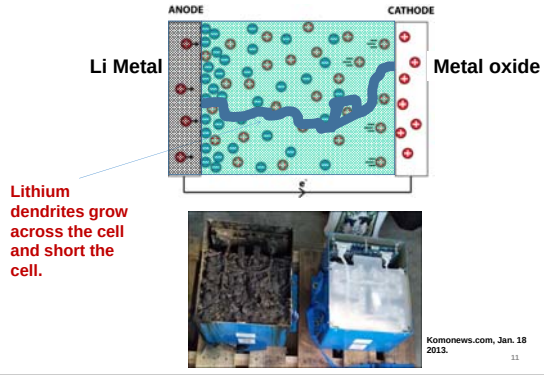
Electrode in a Li-Ion batteries must transport ions, but not electrons.



Armand, *Nature*, 2008.

Higher energy densities are possible with Li-metal batteries, but there is a danger of fire.



Komonews.com, Jan. 18 2013.

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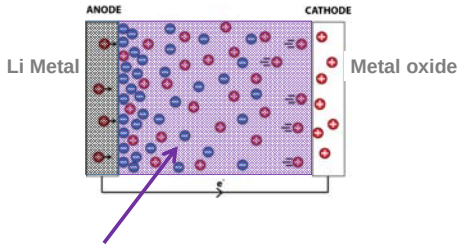
Solid polymer electrolytes could provide a safe and flexible alternative for battery designt



Solid Polymer Electrolytes

- ✓ Less flammable than liquid electrolytes
- ✓ Requires less package (increase energy density)
- ✓ Mechanically robust to avoid dendrites
- ✓ Could be incorporated into fabrics
- o Poor ion conductivity

Connectivity of nanoscale ionic domains may enhance conductivity

Precise copolymers

x = 9, 15, or 21

x = 21

Isolated ionic domains

Ion transport is blocked by nonpolar matrix

Percolated ionic domains

Layered ionic domains

Ion transport may occur without needing to traverse nonpolar matrix

parallel

perpendicular

Buitrago, Bolintineanu, Seitz, Opperk Wagener, Stevens, Frischknecht, Winey, *Macromolecules* **2015**.

In Progress: Structural characterization of layers in COOH precise polymers

Ted Trigg

- B.S., Engineering Physics, Stanford University
- Engineer, Seeo, Inc. (3 y)
- Ph.D. student in Winey group since 2013

Precise copolymers

x = 21

Adjacent reentry structure

One chain

Extended chain structure

One chain

X-ray scattering of strained p21AA

Preliminary fit

PIRE Act 3: Structure-conductivity relationships and structural details of layers

Improved Conductivity

Synthesized 2007

Synthesized 2015

Structure-Conductivity Relationships

- *In situ* EIS and X-ray with %RH and T
- E

Structural Details of Layers

- Nanofocus X-ray beam: single crystal diffraction
- Atomistic MD

ACT3: ENERGY STORAGE/BATTERIES

Trevor Forsyth
ILL, ESRF

Giovanna Fragnetto
ILL

Patrice Rannou
CNRS - SPrAM

Said Sdki
UJF, CNRS - SPrAM

Lionel Picard
CEA - Liten

KEYWORDS, CORE COMPETENCES, RESEARCH LINES & APPROACHES

Bio/Soft matter

***in situ* and/or operando, multiscale characterization**

Neutron Scattering
X-Ray Scattering

Functional soft matter
multiscale ionic transport

***in situ* and/or operando characterizations**

Single-Ion block Copolymers

Electrochemistry, electronically and Ionically conducting polymer

Electron transfers
Si NWs & Nanotrees
Supercapacitors
Battery

(Macro)Molecular Enginnering
ionically conducting Polymer

Controlled polymerization
Single-Ion block Copolymers
Battery

Active compound
Current collector
Substrate
Solid electrolyte

SiNWs

reAct

December 7, 2015