



Excitonic Solar Cells

and the NINT Solar Energy Collaboration

Dr. Ken Harris, NRC-NINT
Clean Tech Seminar
September 28th, 2009

The Collaborative Team

- The NINT solar energy project is staffed from both the Materials & Interfacial Chemistry Group and the Engineered Materials for Energy Group



- Materials & Interfacial Chemistry
- Led by Dr. Jillian Buriak
- Primarily chemists



- Applied Materials for Energy
- Led by Dr. Michael Brett
- Primarily engineers

- MIC Personnel: Jillian Buriak, Ken Harris, Dave Rider, Sean McClure, Brian Worfolk
- AME Personnel: Mike Brett, Mike Fleischauer, Mike Taschuk, Jaron Van Dijken, Mike Thomas
- Technician Support: Al Lalany, Kevin Shahbazi, Ben Bathgate, Jen Bruce
- NINT is a **research lab** which aims to create **intellectual property**.

Motivation

- Five times more electricity will be required globally in 2050 than in 1995 (total E = ~30 TW).
- Photovoltaics (PV) currently produce ~0.01% of global electricity.
- For wider-acceptance, **low cost** fabrication techniques must be considered.
- Our goal is to develop technologies for inexpensive, solution-processible solar cells.

- C. Wadia, et al., Environ. Sci. Tech., 43, 2072-2077, (2009).
- N.S. Lewis, D.G. Nocera, PNAS, 103(43), 15729-15735, (2006).

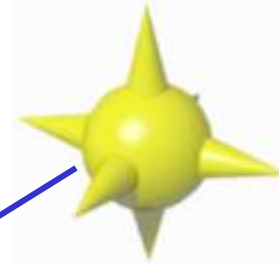
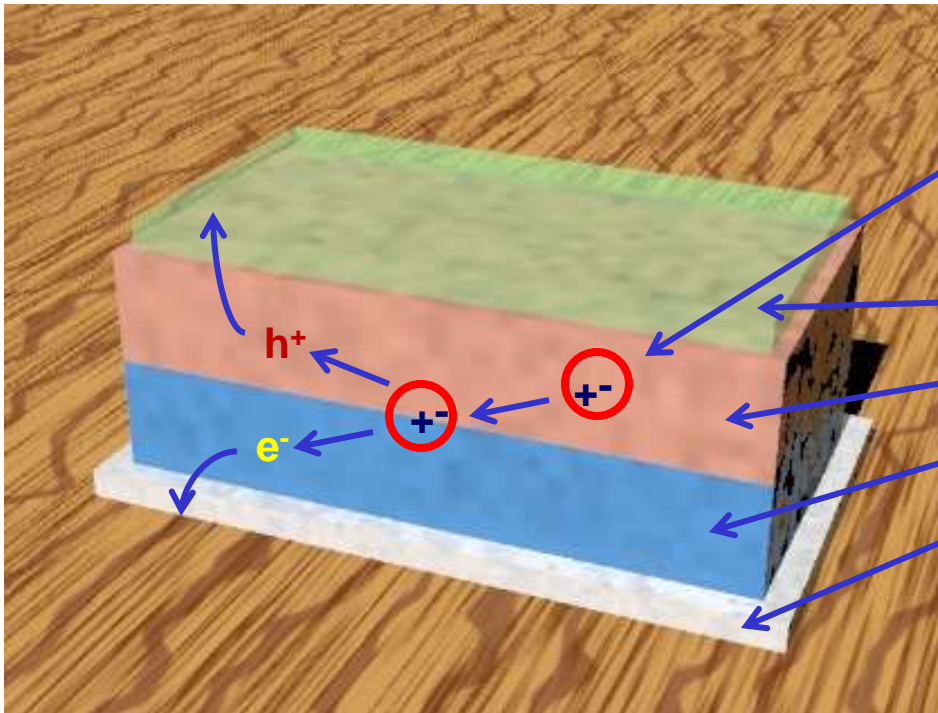


A Canadian Opportunity:

City	Annual PV Potential
Cairo	1635
Mexico City	1425
Regina	1361
Sydney	1343
Calgary	1292
Winnipeg	1277
Edmonton	1245
Toronto	1161
Beijing	1148
Yellowknife	1094
Halifax	1074
Vancouver	1009
Tokyo	885
Berlin	848

Generation III – Excitonic Solar Cells

- Solar cells convert light energy into electrical energy



Transparent Electrode

h^+ Transport Layer (“Donor”)

e^- Transport Layer (“Acceptor”)

Metallic Electrode

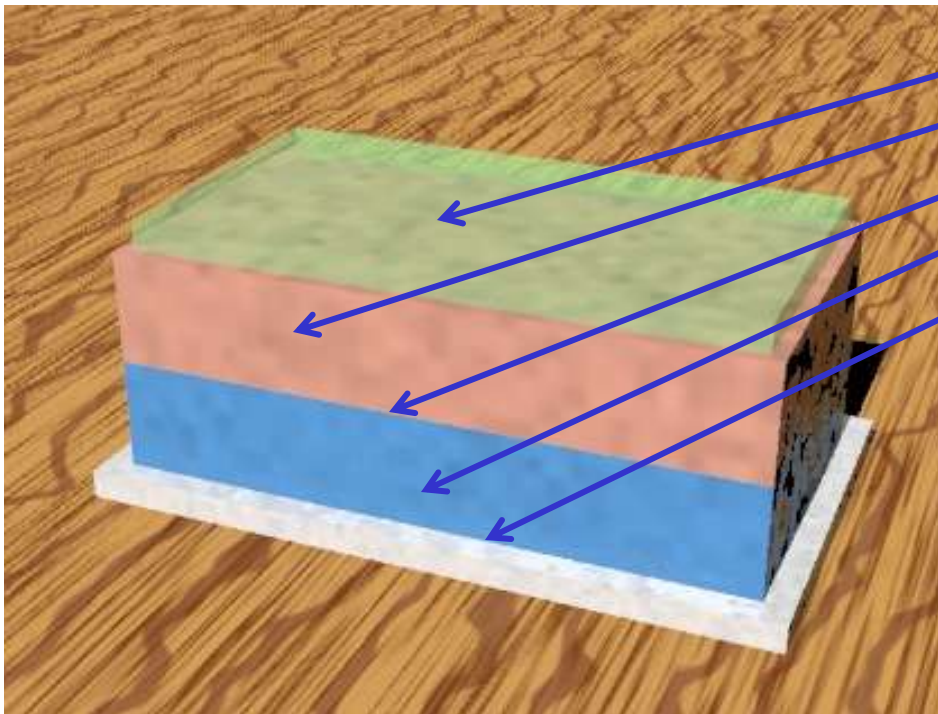
Materials include:

Conducting polymers,
semiconductor nanoparticles,
metallic nanoparticles, carbon
nanotubes/ C_{60}

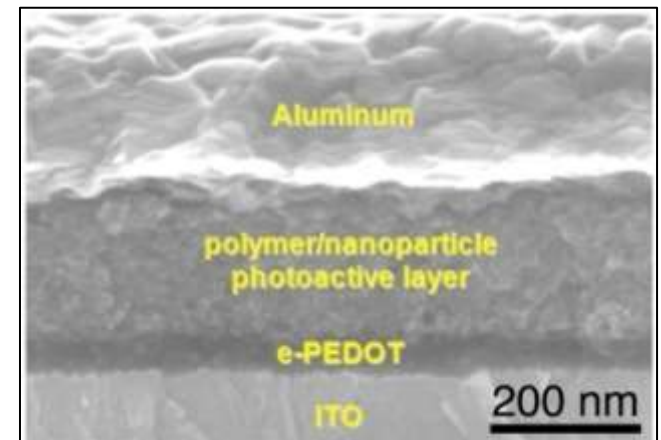
1. Photon absorption creates an exciton
2. Excitons diffuse
3. Charge separation occurs at an interface
4. Electrons and holes transported to electrodes

Properties of an Ideal Solar Cell

- For the best performance, a number of parameters must be optimized:

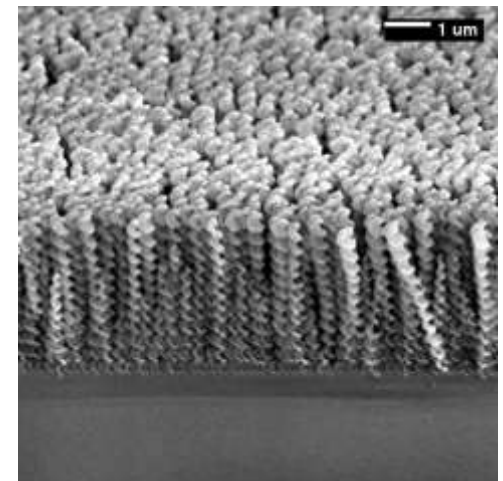
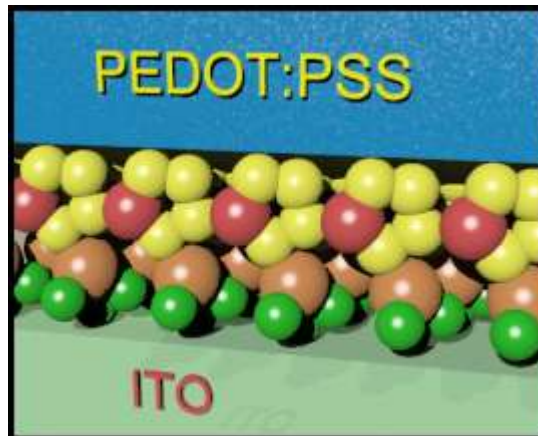
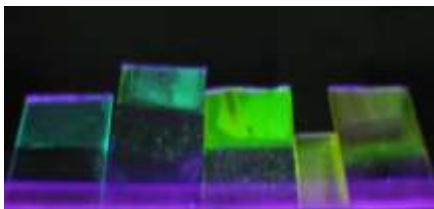


- High transparency
- High absorbance
- Maximum interfacial area
- Direct path for charge extraction
- No energy barriers at interfaces



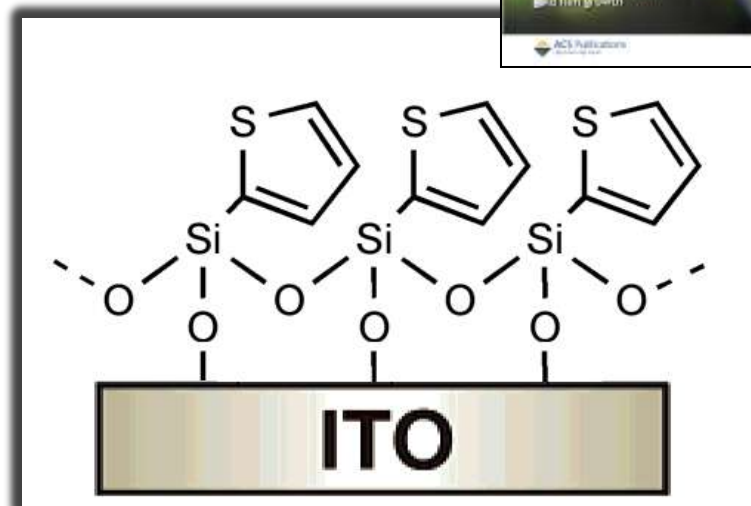
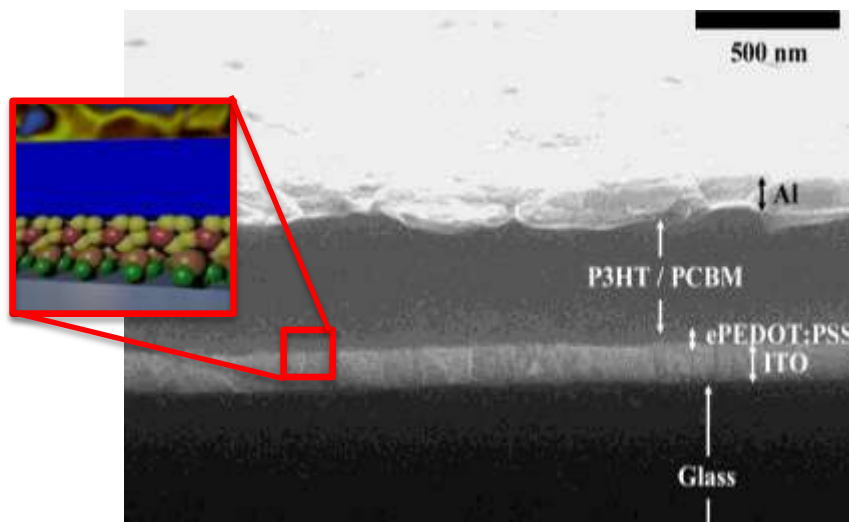
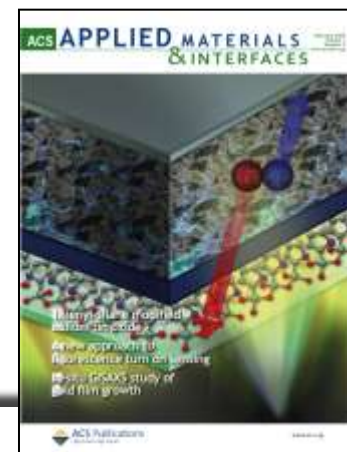
Multi-Pronged Research

- New photoactive materials – better light absorption, better charge transport
- Columnar structures by glancing angle deposition – increased interfacial area for charge separation
- Layer-by-layer deposition – a fabrication technique favourable for water-soluble materials and scale-up
- Inorganic nanoparticles – better stability, tunable properties combined with solution-processing

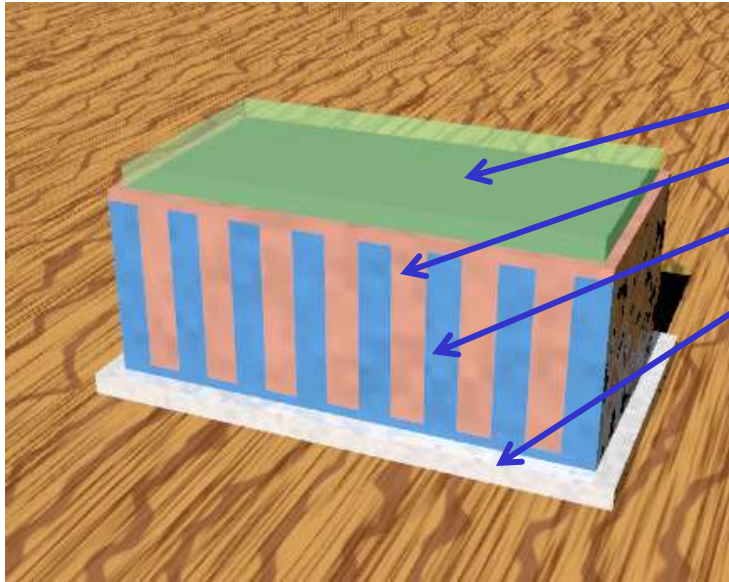


Approach One: Interfacial Modifiers

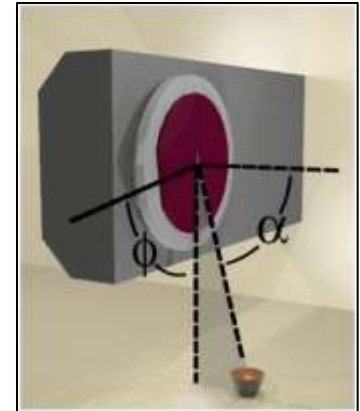
- An energy barrier is often present between the hole transport material and the anode.
- We have used various organic molecules to reduce this energy barrier and extract additional charge.
- In one case, performance of thienylsilane-modified solar cells was 30% better than unmodified cells.



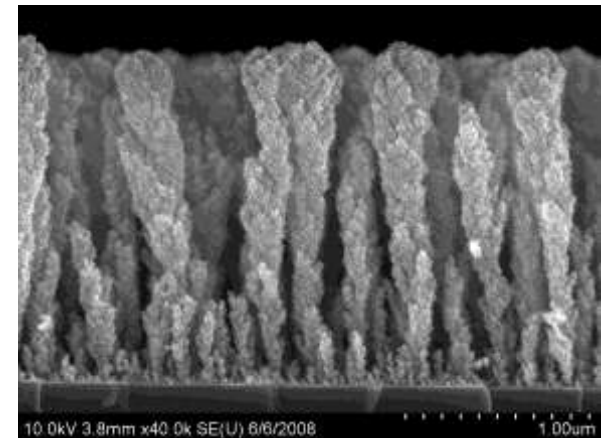
Approach Two: Glancing angle deposition



Transparent Electrode
Hole Transport Layer
Electron Transport Layer
Reflective Electrode



- An interdigitated structure has a large interfacial area, and charges are directly transported to the appropriate electrodes
- Using the GLAD technique, columnar structures can be formed and filled with photoactive materials
- Materials: ITO, TiO₂, CuPc, Al and others



Acknowledgements

