# 2008 Solar Annual Review Meeting

**Session: Organic Photovoltaics**
**Company: Konarka**
**Funding Opportunity: $3.6M (DOE)**
**$8.7M (total)**

**Jeremiah Mwaura (jmwaura@konarka.com)**
**Presenter's Name, Contact Information**

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# Budget and Solar America Initiative Alignment

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| Project Start Date | FY07 Budget | FY08 Budget | Total Proj Budget |
|---|---|---|---|
| June 1, 2007(calendar) | $1.3M | $2.9M | $8.6M |
| June 1, 2007(12 months) | $2.7M | $3.0M | $8.6M |

This project supports the Solar America Initiative by:

- Grid parity by 2015
- 7% module efficiency (2010)
- 10 year Life (2010)

This project does not support manufacturing of solar modules

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# SAI – Konarka Program Objectives

**Objectives/Approaches/Tasks**

**1] Stability**

**Objective: lower water vapor transmission rate**

**Approaches:**

**- adhesives for over laminate with plate-like fillers**

**- adhesives for perimeter with rod-like fillers**

**Tasks:**

**- Develop procedures for suspending fillers in adhesives**

**Partners:**

**-NREL (Rod-like Fillers)**

**- University of Delaware (Stability)**

**2] Performance**

**Objective: improve cell efficiency by increasing absorptivity of electron carrier**

**Approaches:**

**- develop n-type polymers (high absorptivity)**

**- develop n-type small molecules (high absorptivity)**

**Tasks:**

**- synthesis**

**Partner:**

**- NREL, Measurements and Characterization Division**

**3] Performance**

**Objective: improve cell efficiency by replacing TCO**

**Approach:**

**- metal grids**

**Tasks:**

**- develop silver printing ink formulations**

**- print grids using screen, gravure or inkjet printing**

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# Stability

**1] Stability**

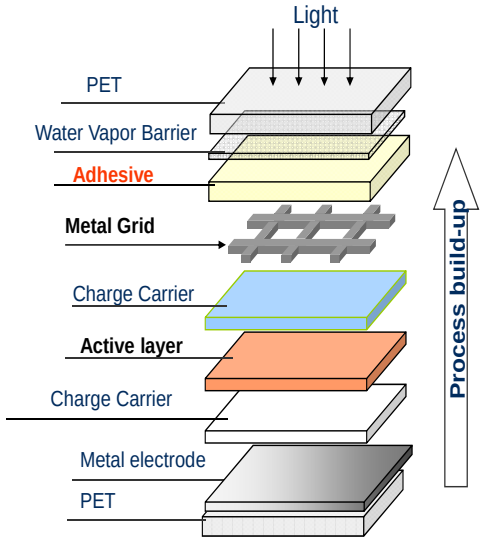
**Objective: lower water vapor transmission rate**

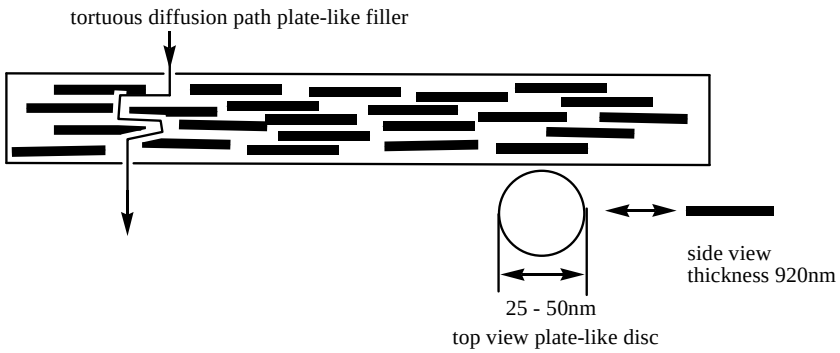
**Approaches:**

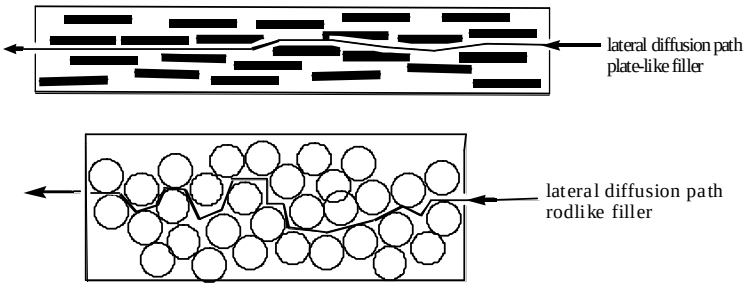
- **adhesives for over laminate with plate-like fillers**
- **adhesives for perimeter with rod-like fillers**

**Tasks:**

- **Develop procedures for suspending fillers in adhesives**




**Current Stability on <u>glass</u>:**

**<5% degradation in performance at 1000 hours testing with various conditions of temperature and humidity:**

**1.3 suns, 40°C, 500 hours (efficiency changes <5 %)**

**85°C, 1 sun 500 hours (efficiency changes <5%)**

**65°C/90% humidity, 1000 hours (efficiency changes <5%)**

**85°C, dry atmosphere, 1000 hours (efficiency changes <5%)**

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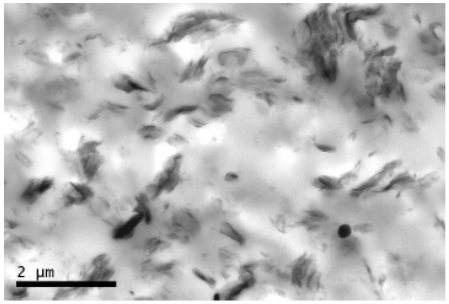
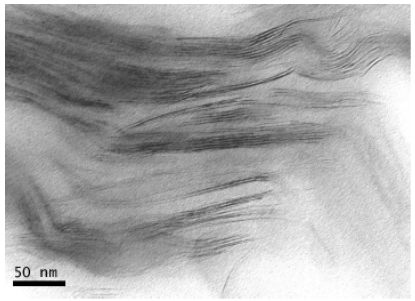
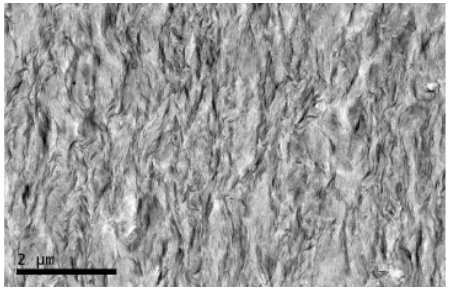
# TEMs of Cloisite Clay in Butvar

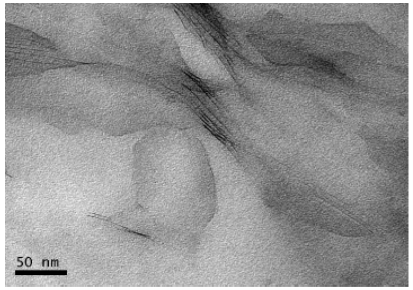
**18% wt Clay B / Butvar**



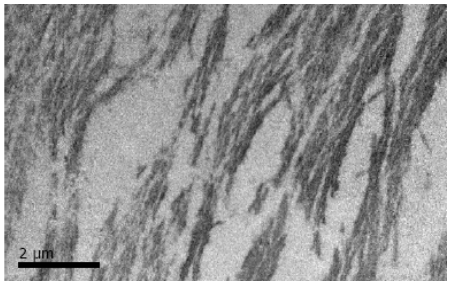



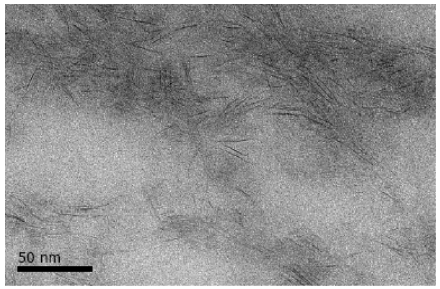

**40% wt Clay B / Butvar**




**70% wt Clay C / Butvar**




**WVTR of 70% clay is 4x improved over Butvar control**

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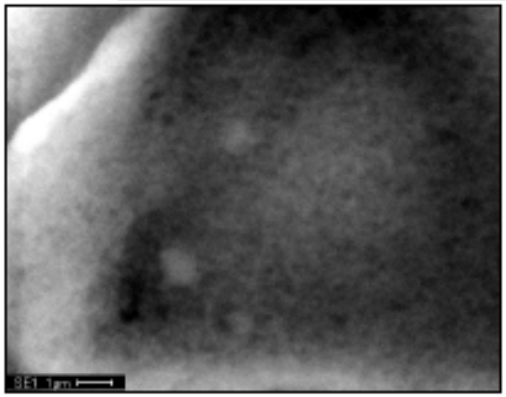
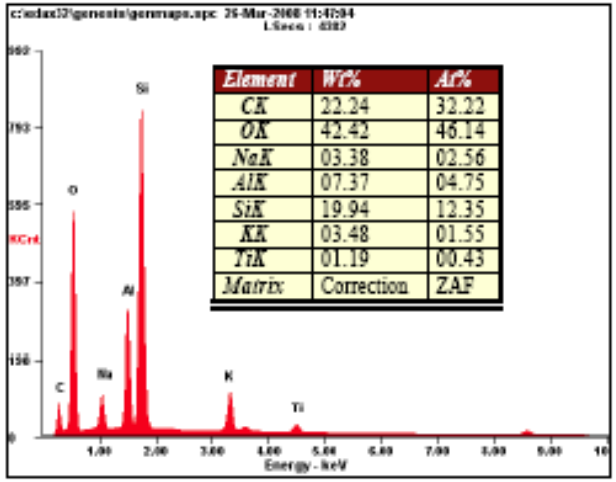
# Boehmite Fibers

**SEM data of Boehmite in DYMAX films**

1-butanol coated Al(O)OH : 0.5 g
DYMAX : 1 0 g
UV cured (RAYONET) between cover glass slides (20 min)



mapping resolution: 100 nm




**Element map shows uniform distribution of Al across the sample**

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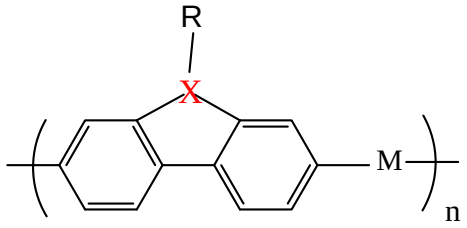
# Performance – N-type

**2] Performance**

**Objective: improve cell efficiency by increasing absorptivity of electron carrier**

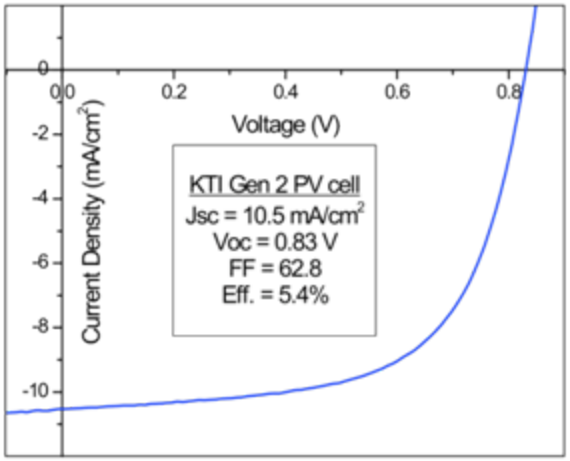
**Approaches:**

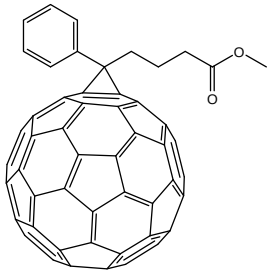
- **develop n-type polymers (high absorptivity)**
- **develop n-type small molecules (high absorptivity)**



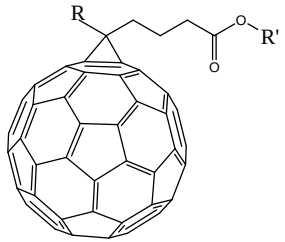

Polymer Target

Where X and M are a very strong electron acceptors




PCBM




R, R' = self-associating groups

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# New Fullerene Derivatives

| Sample | $V_{oc}$ ( V) | $I_{SC}$ (mA) | FF | Efficiency (%) | LUMO (eV) (CV solution) |
|---|---|---|---|---|---|
| P3HT/PCBM | 0.62 | -11.17 | 0.67 | 4.7 | -3.70 |
| P3HT/#16 | 0.63 | -11.80 | 0.51 | 3.82* | -3.70 |
| #15 | - | - | - | - | -3.53 |
| #19 | - | - | - | - | -3.32 |

*un-optimized

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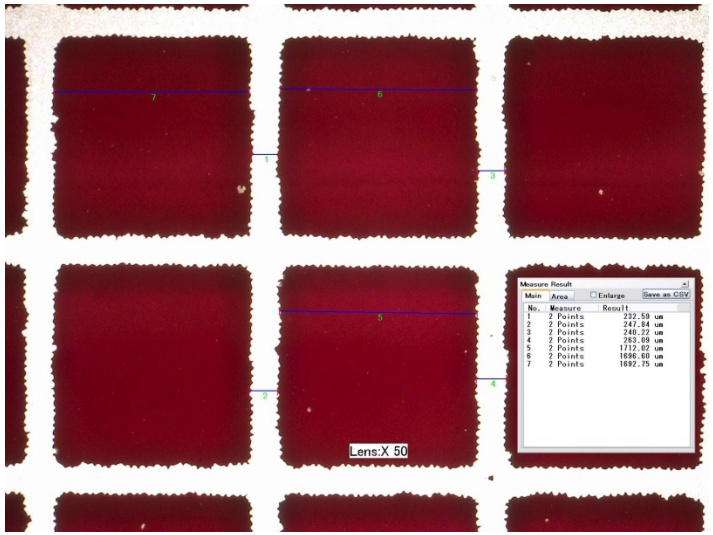
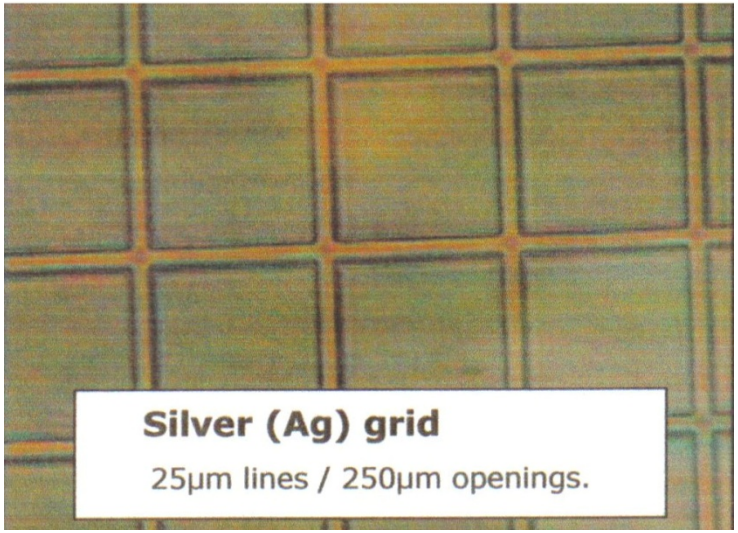
# Printed Grid in Development




Grid printed with silver ink  88% open, 232um wide lines

Conductivity = $2.6 \times 10^4$S/cm (bulk silver conductivity = $6 \times 10^5$S/cm)

Ideal grid structure - lithographic technique

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# Project Alignment with Technology Roadmap

**Need**

**Efficiency: 10% cell by 2010**

**10% module by 2015**

**Stability ≥20 year life (2015)**

**High Yield Manufacturing**

**Significance**

**Energy cost on par with electric grid (2015)**

**Anticipated Production >>3MW by 2010**

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# Project Update

| Objectives/Tasks | Status |
|---|---|
| **1] Stability** | |
| **Objective: lower water vapor transmission rate** | |
| **Tasks:** | |
| **- Develop procedures for suspending plate-like and rod-like fillers in adhesives** | **- Procedure developed (March, '08)**<br>**- WVTR testing underway (current)** |
| **Future: a] continue to explore new adhesives**<br>**b] simultaneously test existing materials and optimize processes**<br>**c] make and test adhesives with commercial barrier films in modules** | |
| **2] Performance** | |
| **Objective: improve cell efficiency by increasing absorptivity of electron carrier** | |
| **Tasks:** | |
| **- synthesis of n-type polymers** | **- Stop work (April, '08)** |
| **- synthesis of n-type small molecules with higher absorptivity** | **- Redirect to voltage (Jan. '08)**<br>**- Accelerate effort (current)** |
| **Future: a] continue to pursue new fullerene derivatives for improved cell voltage** | **- Current** |
| **b] optimize performance in cells and modules** | **- Current** |
| **3] Performance** | |
| **Objective: improve cell efficiency by replacing TCO** | |
| **Tasks:** | |
| **- develop silver printing ink formulations** | **- Work proceeding** |
| **- print grids using screen, gravure or inkjet printing** | **- Screen printing demonstrated** |
| **Future: continue to pursue silver ink formulations with higher conductivity** | **- Current** |

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# Obstacles Discussion

**Task 1 - Fillers**

**- Barrier encountered : procedure for dispersing nano-particulates of clay in adhesive binder**

**Probably solved**

**Task 2 – n-Type materials**

**a] n-Type polymer:**

**Barrier encountered: synthesis of monomer comprising strong electron accepting groups**

**Stopped work April after 9 months (down select scheduled for July, '08).**

**b] n-Type small molecules:**

**Barrier encountered: increase in absorptivity**

**Developing small molecules with increased Voc**

**Task 3 - Grids**

**- Barrier encountered: silver formulations with good conductivity and proper rheology for screen printing**

**screens with small features to reduce the size of the metal lines to ≤100um**

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