NOVEL APPROACH TO HARNESS THE FULL POTENTIAL OF DIRECT SOLAR TO ELECTRICITY CONVERSION

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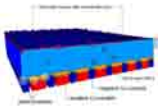
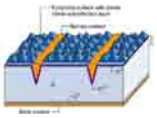
BACKGROUND

- Abundance of solar radiation
- Direct conversion of sunlight into electricity: the photovoltaic effect (PV)
- Photons with enough energy may generate electron-hole pairs that provides useful power.
- The energy of low energy photons is lost as heat.
- The efficiency of semiconductor based PV cells decreases with increasing temperature.


SunPower A-300

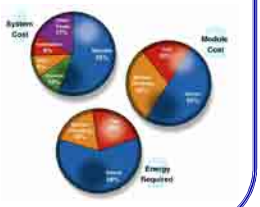

Sanyo "HIT"


BP Solar Saturn

High cost of PV systems due to:

- Increase of material cost (significant increase in demand for silicon)
- High manufacturing expenses that ultimately drive up the PV-module cost per generated Watt ratio

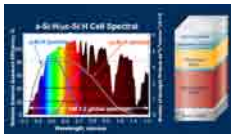
- Electricity from PV cannot yet compete with the price from fossil fuel generated utility. (UE - Japan)
- Further reduction of turn-key system prices is needed.



SCOPE OF WORK

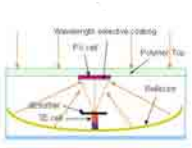
MOTIVATION

- Our hybrid system belongs to a family of alternative developing paths for the realization of the next generation solar cells.
- We wish to demonstrate the potential of our approach in improving the overall efficiency of conventional systems while maintaining the module price affordability

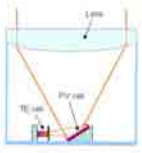


MAIN OBJECTIVE

Develop prototype hybrid PV and TE devices that have the potential of low-cost and high efficiency


Reflection Type Unit Cell

(a) reflective type


Transmission Type Unit Cell

(b) transmissive type

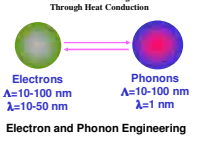
SOLAR THERMOELECTRIC ENERGY CONVERSION

Nondimensional Figure of Merit

Joule Heating — Seebeck Coeff. Electron Cooling

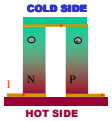
$$ZT = \frac{\sigma S^2 T}{k}$$

Reverse Heat Leakage Through Heat Conduction



Electron and Phonon Engineering

- Solar-thermoelectric technology first converts solar energy into thermal energy and then into electricity through solid-state thermoelectric devices.



CONTRIBUTION TO THE MISSION OF MIST

This proposed project contributes to the mission of MIST in several ways:

1. It focuses on alternative clean-energy.
2. Solar thermal utilization technology developed can have further applications in other areas such as water desalination.
3. The proposed project will help establish experimental infrastructure at MIST ranging from materials synthesis to micro-fabrication.

PRELIMINARY RESULTS

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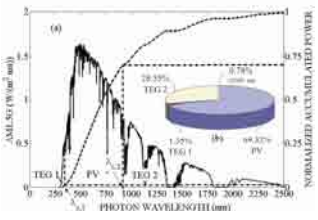

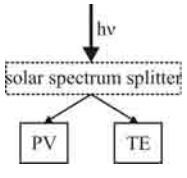

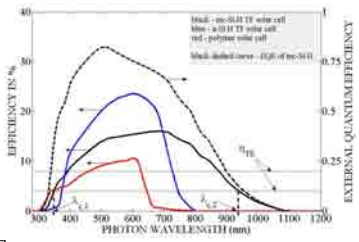

$$\eta_{PV,\lambda} = \frac{P_\lambda}{P_{ph,\lambda}} = \frac{I_{SC,\lambda} \cdot V_{OC} \cdot FF}{P_{ph,\lambda}} = EQE \cdot \frac{q \cdot V_{OC} \cdot FF}{h\nu_{ph}}$$

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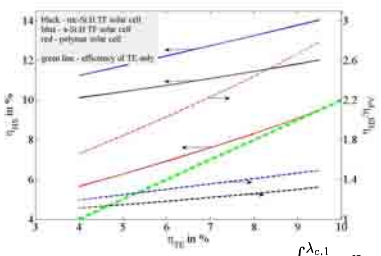
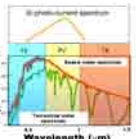


	mc-Si:H TF solar cell		a-Si:H TF solar cell		polymer TF solar cell	
$\eta_{PV,c1}/\eta_{PV,c2}$	9.5 % / 9.09 %		9.47 % / 9.4 %		3.52 % / 3.4 %	
η_{TE}	4 %	8 %	4 %	8 %	4 %	8 %
$\lambda_{c,1}$	349 nm	393.5 nm	374 nm	386 nm	338.5 nm	460 nm
$\lambda_{c,2}$	939 nm	875 nm	745 nm	727 nm	645 nm	627 nm
η_{HS}	10.13 %	11.45 %	11.24 %	13.26 %	5.66 %	8.32 %
SRE	1.11	1.26	1.20	1.41	1.66	2.44
PV power fraction	69.32 %	62.11 %	50.25 %	47.32 %	39.45 %	25.24 %
TEG power fraction	29.90 % (1.35%)* (28.55%)*	37.11 % (4.13%)* (32.98%)*	48.97 % (2.82%)* (46.14%)*	51.90 % (3.62%)* (48.28%)*	59.77 % (0.85%)* (58.92%)*	73.98 % (12.48%)* (61.50%)*

$$\eta_{HS} = \frac{\int_{\lambda_{s,min}}^{\lambda_{c,1}} \eta_{TE} \cdot P_{s,\lambda}\, d\lambda + \int_{\lambda_{c,1}}^{\lambda_{c,2}} \eta_{PV,\lambda} \cdot P_{s,\lambda}\, d\lambda + \int_{\lambda_{c,2}}^{2500nm} \eta_{TE} \cdot P_{s,\lambda}\, d\lambda}{\int_{\lambda_{s,min}}^{\infty} P_{s,\lambda}\, d\lambda}$$

OBSERVATIONS & FURTHER WORK

Our modeling results show that the PE-TE hybrid system performs better that a tandem system in harnessing the entire phonon energy spectrum. This in line with the original motivation of our project



Ongoing activities:

1. Design of hybrid systems
2. Design and fabrication of frequency selective surfaces
3. Solar TE Modeling and Cell Fabrication
3. Hybrid system performance

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