News
The Society of Plastics Engineers
ENGINEERING PROPERTIES & STRUCTURE DIVISION
September 2010

Chairperson's Report

Welcome To Our New and Returning Board Members

Chairperson Pierre Moulinié

Dear EPSDIV Members,

Our Board of Directors had its annual face-to-face board meeting at ANTEC-2010 in Orlando, Florida, giving us an opportunity to personally welcome our newest board members. Again, welcome to Luyi Sun, who is currently co-chairing our Technical Program Committee for ANTEC-2011, Ashish Batra and Jason Lyons, who both did an outstanding job coordinating the ANTEC-2010 Technical Program, Daniel Liu, who now chairs the Awards Committee, and Daniel Schmidt. With this rejuvenation of the EPSDIV Board I'm convinced we'll re-energize our discussions on programming and help support SPE's future directions. On the subject of programming, EPSDIV has continued to enjoy high-quality contributions in which we were happy to recognize at our ANTEC Awards Reception. The "Best Paper" was contributed by Zhiyong Xia, Daniel Cunningham & Jay Miller from BP Solar and is reprinted at the end of this newsletter. The John O'Toole Award sponsored by Honeywell Specialty Materials was awarded to Matthew Bernasconi from the University of Massachusetts-Lowell for his student presentation.

This brings me to our Abstract and Paper Submission Period. The deadline for submissions is just around the corner, November 19th, so be sure to submit your paper for ANTEC-2011 soon. You just might attract attention from our Awards Committee!

A constant in today's world seems to be the difficulty in which some colleagues have in making the trip to a conference. In addition to the challenge that many students are experiencing, this challenge has presented itself as more prevalent lately, among our industry employed members. Addressing this challenge, our Division continues to develop its internet-based technical program in an effort to accommodate those who are unable to make a trip, keep the time commitments small and hopefully broaden our audience to colleagues in other continents. We're grateful for SPE's coaching, which will aid our growth in this sector. Several innovative ideas were discussed during our last board meeting and we will be following-up on these with firm plans in the near future. Stay tuned!

— *Pierre Moulinié*

Boston, Massachusetts

INSIDE THIS ISSUE

ANTEC 2011 Call for Papers

EPSDIV CALL FOR PAPERS ANTEC 2011, Boston, MA

Proposed Topics:

- Structure & Property Relationships in Engineering Resins and Blends
- Recent Developments in Polyolefins
- Polymer Nanocomposites
- Films and Packaging
- Fracture Mechanics of Polymers
- Biodegradable and Biomass Plastics
- Polymeric Materials from Renewable Resources/
- Medical Device Polymers
- Polymeric Materials for Environmental, Biomedical, and Bioengineering Applications
- Polymers for Energy Related Applications
- Smart Materials
- Nanotechnology in Electronic and Biological Devices
- Sustainable Plastics
- And more……

***Abstract/Paper Deadline*: 11/19/2010** ***Revision Deadline:* 2/1/2011**

*Information and Online Submittal at **www.4spe.org…and select Division D26-EPSDIV !***

Contact: Luyi Sun at luyi.sun@txstate.edu *-OR-* **Hoang Pham at hoang.pham@dow.com**

SOCIETY OF PLASTICS ENGINEERS
The International Plastics Society

EPSDIV ANTEC 2011 TPCs
Luyi Sun and Hoang Pham

EPSDIV Keynote Speakers – ANTEC 2011

Confirmed Keynote Speakers:

- Mr. Rob Cotton - Frito-Lay (Plastics Packaging)
- Prof. Satish Kumar – Georgia Institute of Technology (Nano-structured Materials in Energy Related Applications)
- Prof. Robert Langer – MIT (Polymers for Biomedical Applications)
- Prof. Yuezhong Meng – Zhongshan University, China (Degradable Polymers From Carbon Dioxide)
- Prof. Hung-Jue Sue – Texas A&M University (Scratch Behavior of Polymers)
- Prof. Brian L. Wardle – MIT (Polymer Nanocomposites)

Financial Report
from July 1, 2009 to June 30, 2010

BALANCE as of July 1, 2009 (cash, checking, savings, investments)	**$**	**38277.61**
INCOME		
SPE Rebate	$	711.49
Interest		714.31
Award Sponsorships		1000.00
ANTEC Sponsorships		6000.00
Misc.		41.59
TOTAL INCOME	$	8467.39
EXPENSES		
Newsletter Production	$	1591.00
Awards		2382.39
Councilor Travel		2260.82
ANTEC		680.17
ANTEC TPC		2856.00
BOD Travel		500.00
Teleconferences		299.39
TOTAL EXPENSES	$	10569.77
CASH FLOW	$	-2102.38
ENDING BALANCE as of June 30, 2010	**$**	**36175.23**

-Submitted by Emmett Crawford, EPSDIV Treasurer 2009-2010

SPE Celebrates Excellence by Honoring Three Leaders in Technology and Education with Lifetime Achievement Awards

ORLANDO, FL, U.S.A.-During ANTEC 2010, the Society of Plastics Engineers (SPE) presented three of its most prestigious awards to honor the lifetime achievements of three individuals. Presentations took place at the SPE Celebrates Banquet on Sunday, May 16, 2010.

The honorees were:

Dr. L. James Lee (center in photograph below), Ohio State University, received the International Award for lifetime achievement in plastics engineering, science, or technology.

Dr. Murali Rajagopalan (left in photograph below), Acushnet Company / Titleist Golf. received the Research/Engineering Technology Award for lifetime achievement in plastics research or engineering.

Dr. Sadhan C. Jana (right in photograph below), University of Akron, received the Education Award for lifetime achievement in plastics or polymer education, sponsored by SPE's Detroit section in honor of Fred Schwab, a founding member of SPE.

Dr. L. James Lee is the Helen C. Kurtz Professor and Distinguished Scholar at the Ohio State University. He is internationally known for his work in polymer and composite engineering. During his industrial tenure and early career at OSU, he built strong programs to develop thermoset polymers and composite manufacturing processes. His research in reactive processing, low profile additives, sheet molding compounds, and liquid composite molding is the most comprehensive program in the United States for automotive and infrastructure applications. In 1997, he established the National Science Foundation (NSF) Center for Advanced Polymer and Composite Engineering, a university-industry consortium. In 2004, he led 35 OSU faculty and collaborators from a number of universities in the establishment of the prestigious NSF Nanoscale Science and Engineering Center at OSU, the largest polymer nano-manufacturing research program in the U.S. And in 2005, the Center for Multifunctional Polymer Nanomaterials and Devices was founded. Dr. Lee has published more than 400 technical papers, serves on the editorial boards of 5 well-known technical journals, and is a Fellow of SPE and of the American Institute for Medical and Biological Engineering.

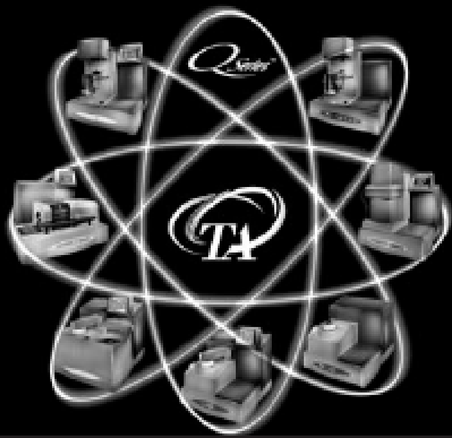
Dr. Murali Rajagopalan is Director of Materials Research, Golf Ball R&D, at Acushnet Company / Titleist Golf. He studied polymer science at McGill University, and then joined BF Goodrich Company as an R&D scientist for Geon Vinyl. There he invented and commercialized heat resistant PVC alloys and blends for HVAC applications and contributed to the commercialization of gamma-sterilizable PVC for medical devices. He moved to Acushnet in 1993, where he has become one of the most prolific inventors of new concepts in golf balls. He developed several new technologies using novel ionomers, reactive blends, and castable polyurethane for various golf ball components. The breadth, quality and sheer quantity of his intellectual work has been vital to Acushnet Company and its growth from $300-million in sales in 1993 to over $1.3-billion in 2007. Dr. Rajagopalan has over 170 U.S. Patents and 50 patent applications pending, most involving developments in golf ball materials and design. He is a Fellow of SPE.

Dr. Sadhan C. Jana is Chair of the Department of Polymer Engineering at the University of Akron. He received a Ph.D. in chemical engineering from Northwestern University and worked at the General Electric Corporate Research Center for four years prior to joining the University of Akron in 1998. Dr. Jana has raised $2-million in research funding over the past eleven years, more than 80% of it from federal sources such as the National Science Foundation, NASA, and the US Army Research Center. His current research focus is on shape memory polymer nanocomposites, polymer nanocomposites produced by self-assembly, and polymeric bipolar plates for fuel cells. **(Continued on page 5)**

(Continued from page 4)

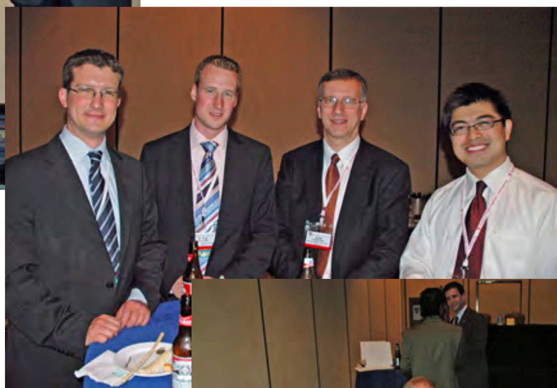
Dr. Jana led the development of a ten-year strategic plan in 2007 to address national needs in health, environment, alternative energy, and a broadened material base utilizing sustainable resources. Within two years of its execution, new faculty have been hired in the areas of photovoltaics, implant biomaterials, and biosensors and devices. Current faculty research focuses on nanomaterials, solving problems related to alternative energy, the issues of cleaner environment, and work on biological materials for orthopedics and implants. Prof. Jana is author of over 90 articles in peer-reviewed journals and refereed conference proceedings, has applied for ten patents, is a Fellow of the SPE, and is an associate editor of Polymer Engineering & Science.

THANKS to our corporate sponsors for their support of our Technical Program during ANTEC-2010.



Encourage Others to Join EPSDIV, By visiting: www.4spe.org/membership

Images from ANTEC 2010 in Orlando, FL



To PAOM or Not to PAOM? That Is The Question!

Councilor Brian Landes

Have you heard of PAOM? If not, don't worry. Your council has been hard at work developing a Proposed Alternative Operating Model (PAOM), which would transform both the "form" and "function" of SPE – to better serve you – our membership!

The initial motivation for looking at alternative operational models was to better address the growth of the Society internationally. However, it was soon realized that some of the proposed changes could also greatly benefit the Society as a whole. The model is built around the idea that SPE is a community of member groups (Divisions, Sections, and SIG's) that function cooperatively, and allow members the flexibility to participate in any Member Group or Groups of their choice. In contrast with our current "top to bottom" organizational structure, the proposed PAOM turns this model upside down. Instead of funds and decisions filtering down from SPE international, Member Groups would directly receive funding and make decisions that would filter up to SPE international.

"Governance" would be replaced with "facilitation," to share best practices among member groups. The Member Group success would be based on the interest, quality, and performance of the group.

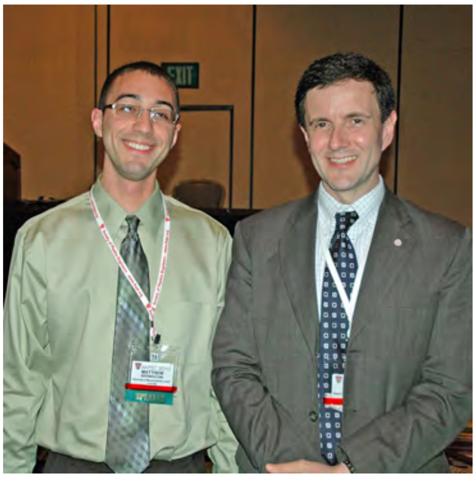
The result would be a more decentralized organization with greater mobility, flexibility and creativity. The majority of the member dues would go to the Member Groups, with smaller portions devoted to sustaining the regional and global support operations of the Society. This frees Member Groups to design responsibility, accountability, and compliance structures that are suited for their geographies, interests and individual vision. SPE international would serve as a conduit for best practices, SPE branding as well as financial reporting.

If adopted, this would represent a marked change in the structure and operation of SPE. The PAOM has been presented to the Executive Committee, staff, and key leaders for reaction and input. A strategic Planning Committee has been formed to consider the suitability of the PAOM for implementation.

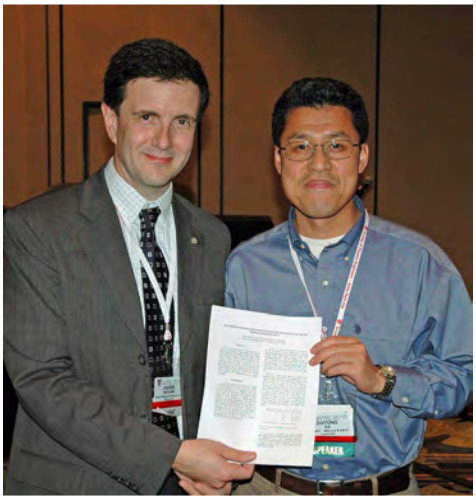
Now would be a great time to give us your thoughts and ideas about this model. Drop me an email (bglandes@dow.com). Your ideas will help to strengthen the Society as we move forward. We are SPE! Let's all make it the best it can be.

- Brian Landes

The John O'Toole Award sponsored by Honeywell Specialty Materials was awarded to **Matthew Bernasconi** (on left in photograph below) from the University of Massachusetts-Lowell. The award was presented by Pierre Moulinié. His paper will be featured in our next newsletter.



The "Best Paper" was contributed by **Zhiyong Xia** (on right in photograph below), Daniel Cunningham & Jay Miller from BP Solar and was presented by Pierre Moulinié. This paper is reprinted on page 9 of this newsletter.



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POLYMER PACKAGING SOLUTION TO INCREASE PHOTOVOLTAIC SOLAR MODULE POWER OUTPUT

Zhiyong Xia, Jay Miller and Daniel Cunningham
BP Solar International Inc. Frederick, MD 21703

Abstract

Silicon solar cells lose 0.45% of power for every 1°C increase in temperature. If solar modules could dissipate heat more efficiently, the operating cell temperature would be lowered, increasing the module power output. In this paper, we present findings in using encapsulants with improved thermal conductivity to increase the heat transfer from solar cells into the environment. The outdoor performance of solar modules built with the improved encapsulant shows that 1-2% power gain can be achieved compared with the standard encapsulant. Further, modules with the improved encapsulant are anticipated to have better long-term reliability as compared with the standard encapsulant.

Introduction

To ensure the reliability and longevity of crystalline silicon photovoltaic (PV) modules, a variety of polymers have been employed in the encapsulation of solar cells. Among the different polymers, ethylene vinyl acetate (EVA) based cell encapsulants, and polyester/Tedlar based module back sheets are two important polymer categories. These polymers have excellent physical, mechanical and barrier characteristics and long term durability. The EVA formulations used in commercial c-Si PV modules is a block copolymer of ethylene and vinyl acetate (VA) with 33% of VA by weight. This chemical formulation makes EVA fall under the polyolefin family. The higher VA content ensures the cross-linking of EVA during lamination and high light transmission into the encapsulated solar cell. Figure 1 shows the chemical structure of an EVA random copolymer [1].

Just like other polyolefin polymers, EVA has poor thermal conductivity. In solar modules this poor thermal conductivity prevents the heat resulting from unconverted sunlight energy and circuit resistance losses from dissipating efficiently. Poor heat dissipation tends to increase the operating temperature of the encapsulated solar cells, which in turn reduces the cell energy conversion efficiency. In BP Solar multicrystalline silicon solar cells, for every 1°C increase in cell junction temperature, the cell loses about 0.45% of power output [2].

Therefore, if one could reduce the operating cell temperature by a few degrees, then roughly half of that reduction would represent the expected percentage gain in module power output. There are various approaches in current practice towards lowering the operating temperature of solar modules. For example, using open rack mounting for modules improve the air circulation and convective heat transfer to the ambient air. Reducing the cell packing density increases the module surface area available for heat transfer [3]. To our knowledge, there has not been significant effort devoted to designing new packaging materials with the goal of improving the thermal conductivity of the module, thus reducing the module temperature and increasing the module power output.

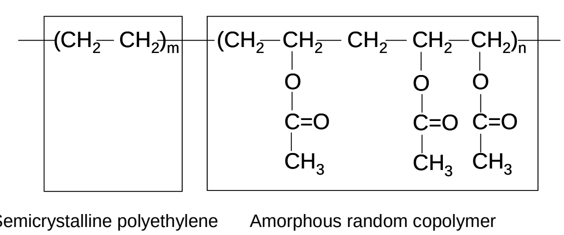

Figure 1. The chemical structure of an EVA block copolymer.

In this paper, we present our efforts towards improving the heat dissipation from solar modules through the application of a more thermally conductive encapsulant. Our main objective was to explore the effect of increased EVA thermal conductivity on module operating temperature, and to confirm improvement of module power output.

Experimental

Three EVA materials were formulated with standard curing, UV packages and peroxide additives. Among them, sample 1 was our standard EVA without added thermal conductive fillers, while sample 2 and sample 3 were formulated with 15wt% filler A and filler B. The base EVA resin used was a standard PV grade with 33wt% vinyl acetate.

Three samples of 72 cell solar modules were built using these EVA formulations. The modules were deployed for outdoor testing at the test site at Frederick, MD. The module outdoor performance data were collected by a Daystar multitracer, an instrument which is a combined maximum power point tracker and data acquisition system. STC performance data for each module was collected using a Spire 480i sun simulator.

Results and Discussion

1. Theoretical Heat Transfer Modeling

To understand the impact of encapsulation on the heat transfer of the solar module, the thermal resistance of each layer across the module thickness was calculated. Figure 2 shows the cross-sectional configuration of the modules built in this study.

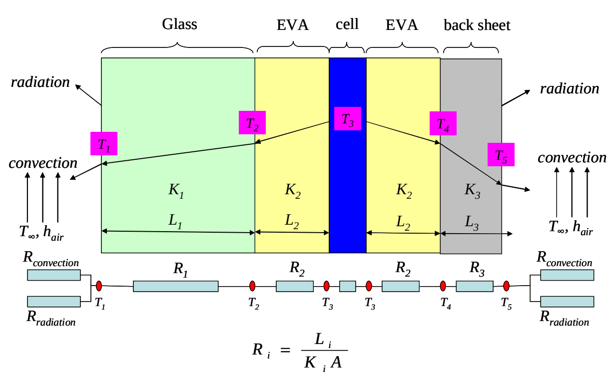

Figure 2. Module component configuration.

The calculated results are shown in Table 1, from which one can see the highest thermal resistance comes from EVA encapsulant and back sheet. Although the glass has a much higher thermal conductivity (1.4W/mK) as compared with the EVA and back sheet, the thermal resistance of the glass is the highest due to it having the greatest thickness of all of the packaging components.

Table 1. Calculated thermal resistance of each layer at wind speed of 1m/s (ignoring the surface convection and radiation heat transfer).

Material	K (w/mK)	ρ (g/cm3)	Cp (J/kg.K)	thickness (mm)	Thermal resistance (K/W)
Glass	1.4	2.225	750	3.2	1.85E-03
EVA	0.25	0.961	2058	0.4572	1.48E-03
Si cell	148	2.33	712	0.2	1.09E-06
EVA	0.25	0.961	2058	0.4572	1.48E-03
Back sheet	0.1463	1.35	1317	0.127	7.02E-04

Due to the necessity of preserving the light transmitting properties of the glass and EVA on the front side of the cell, it was decided to focus only on modifications to the materials on the back side of the cell., and specifically on the EVA layer.

The potential increase in thermal conductivity by addition of two filler components to the EVA was modeled. Figure 2 shows the modeling results using equations 1-3[4].

$$\frac{K_c}{K_m} = \frac{1 + AB\phi}{1 - \varphi B\phi} \quad (1)$$

$$B = \frac{\left(\frac{K_f}{K_m}\right) - 1}{\left(\frac{K_f}{K_m}\right) + A} \quad (2)$$

$$\varphi = 1 + \frac{(1 - \phi_{\max})\phi}{\phi_{\max}^2} \quad (3)$$

Where

Km: thermal conductivity of encapsulant matrix

Kf: thermal conductivity of filler

ϕmax: max. packing factor. For random packed spheres, ϕmax=0.637

A: filler geometry factor=1.5;

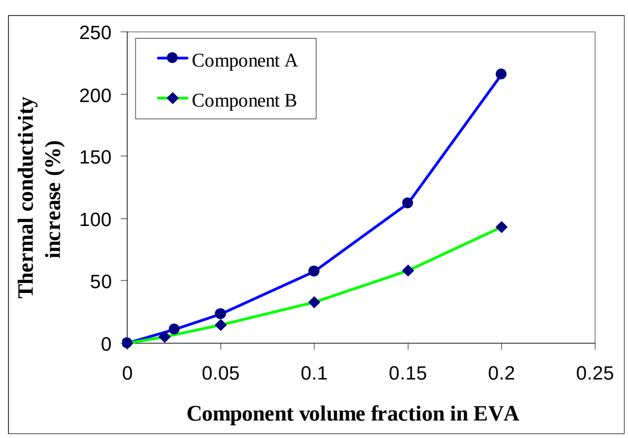

Figure 2. Thermal conductivity increase vs. filler component volume fraction.

Based on Figure 2, at 5vol% loading level, filler A would be able to increase the thermal conductivity of the EVA by 20%. At 10vol% loading level, a 57% increase in thermal conductivity of the EVA would be observed.

Using the Fourier heat transfer law, and lumping together the thermal resistances of all of the back side layers as *R*, we can see that in order to remove the same amount of heat (Q) from the cell, the relationship between the cell temperatures of a cell encapsulated with standard EVA (old) and that of a cell encapsulated with improved EVA (new) is given by equation (6) below.

$$T_{old} - T_{environment} = \frac{Q}{\sum R_{old}} \tag{4}$$

$$T_{new} - T_{environment} = \frac{Q}{\sum R_{new}} \tag{5}$$

$$T_{new} = T_{environment} + \frac{\sum R_{old}}{\sum R_{new}}\left(T_{old} - T_{environment}\right) \tag{6}$$

For example, take the case of a cell encapsulated with standard EVA and operating at a cell temperature of 50C with an ambient temperature of 23C. If that cell were instead encapsulated with an improved EVA having a thermal resistance decrease (conductivity increase) of 23%, the operating cell temperature would be reduced by 5°C. This 5°C decrease in cell temperature would translate to an approximate increase in power output by 2.5%.

2. Outdoor testing results

The outdoor performance of sample modules built with improved EVA formulations was compared to that of a control module built with standard EVA. Figure 3 shows the layout of the three sample modules at the outdoor testing site in Frederick, MD. The control module was built using standard EVA while sample modules 1 and 2 were built with improved EVA formulations.

Performance Factor (PF) was used to compare the outdoor performance of the sample solar modules [5]. Closely related to module efficiency, PF is dimensionless and is equal to the DC energy output of the module (W hr) divided by the module STC power (W/Sun) and divided by the normalized insolation (Sun hr) measured in the plane of the module. The differences in PF as compared with the control (standard EVA) modules were calculated and plotted throughout the day.

A chart of the difference in PF versus the control is shown in Figure 4. The maximum differences in PF for the two sample modules made with improved EVA formulations range from 2 to 3%.

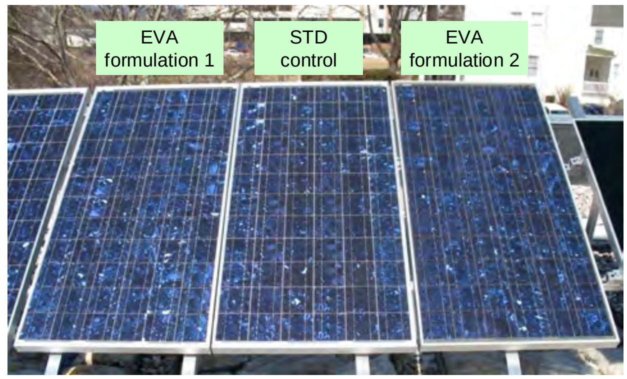

Figure 3. The layout of the outdoor testing array in Frederick, MD.

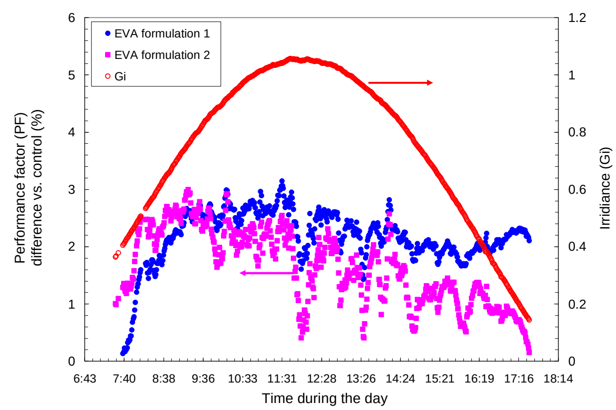

Figure 4. Change of performance factor versus the control module plotted with the time of the day. Irradiance during the day is also plotted.

Conclusions

This study clearly showed that the power output of modules built with encapsulants with improved thermal conductivity can run up to 5°C cooler than modules built with the standard encapsulant. The 5°C decrease in module temperature translated into a module power gain of between 2-3% over control and correspondingly greater energy production over the course of the day. Over time, the lower module operating temperatures also will reduce the rate of degradation of the module components, improving the long term durability of the module assembly.

Acknowledgement

This work has been partially supported under the Department of Energy (DOE) Solar Energy Program - Cooperative Agreement # DE-FC36-07GO17049.

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Key Words: Solar module, solar energy, encapsulant, packaging material.