

# **Encapsulant based solution to Potential Induced Degradation of** Photovoltaic Modules \*

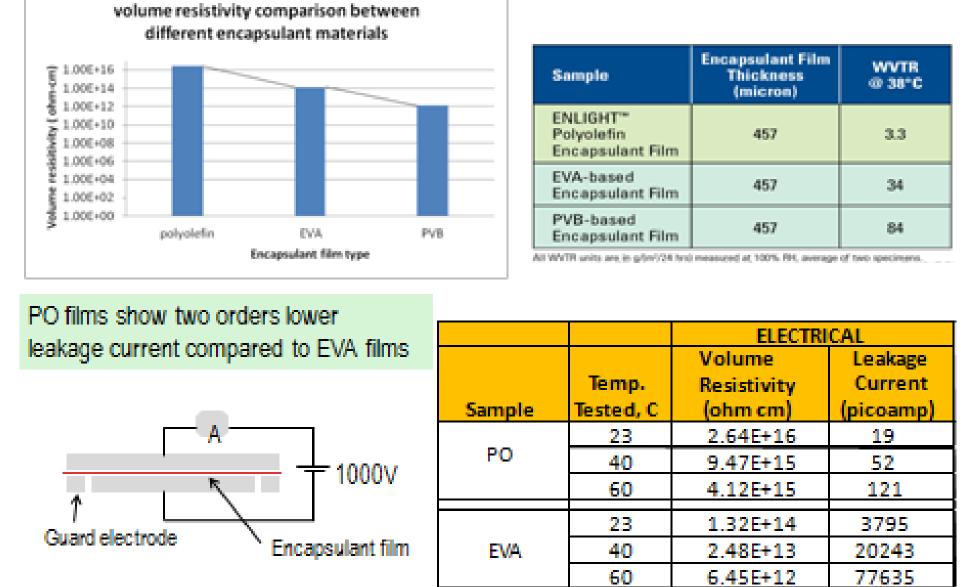
Kumar Nanjundiah, John Naumovitz, Michael White, Nichole Nickel, Tom Burns

The Dow Chemical Company 1605 Joseph Drive, Midland, MI 48642, USA

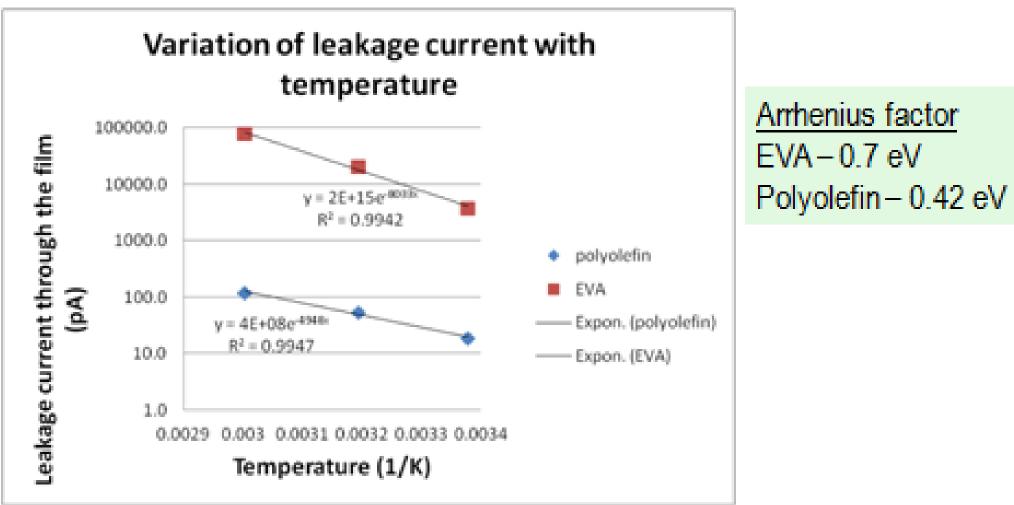
#### Introduction

In solar power installations, modules made of individual solar cells are connected in series to achieve desired supply voltage. The module frames are also grounded to prevent electrical shock hazards. The large potential created by this architecture between the ends and ground has been shown to cause small leakage currents across the insulators protecting the cells. This leakage current over time has been associated with reduced power output from the system. This phenomenon has been called potential induced

### Electrical properties

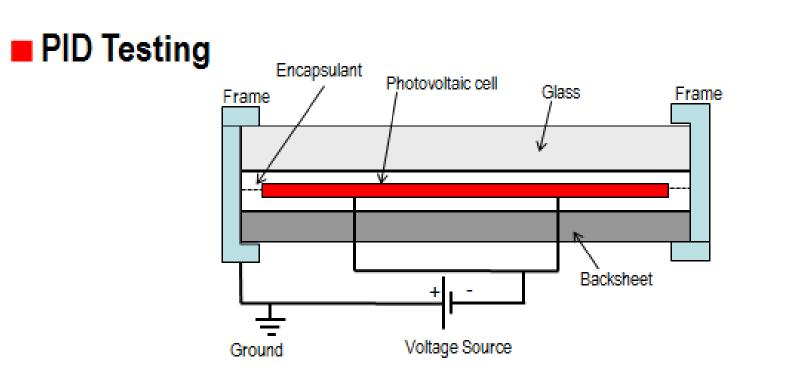


# Arrhenius factor for Leakage Current



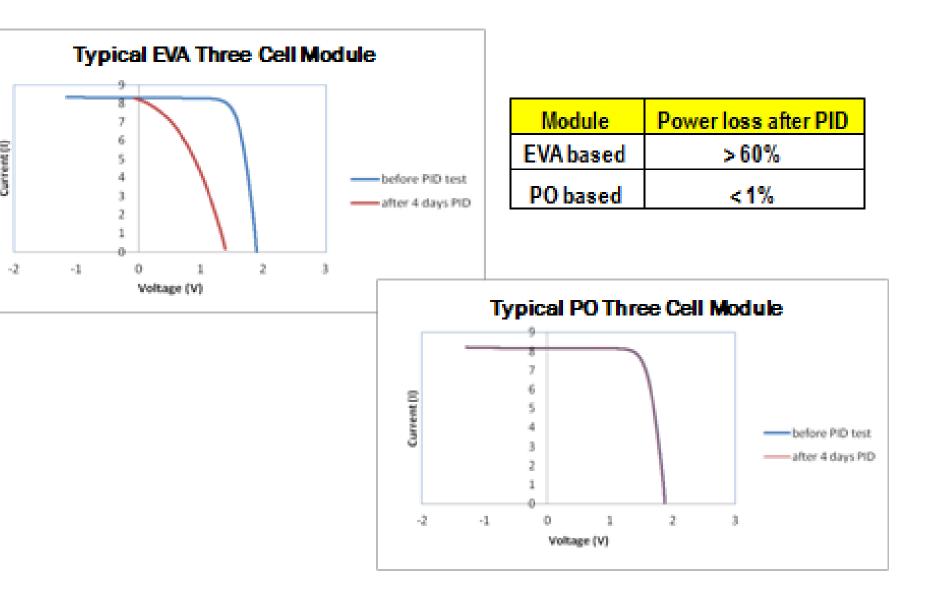
degradation (PID). Accordingly, materials used as the insulators protecting the cells become extremely important in designing PID resistant modules. In this study, electrical properties of encapsulants (insulators) made from ethylene vinyl acetate (EVA) and polyolefins (ENLIGHT<sup>™</sup>) are evaluated and compared. Accelerated testing of PID on single and multiple cell modules made with different encapsulant films at elevated temperatures are related to the electrical properties of the films. ENLIGHT<sup>™</sup> films show orders of magnitude higher volume resistivity compared to EVA films. It is also seen that the resistivity over broad temperature range is essential to minimize the effect of PID.

The slope is 1.5X higher for EVA suggesting EVA film is more prone to current leakage than PO film through the encapsulant with increase in temperature

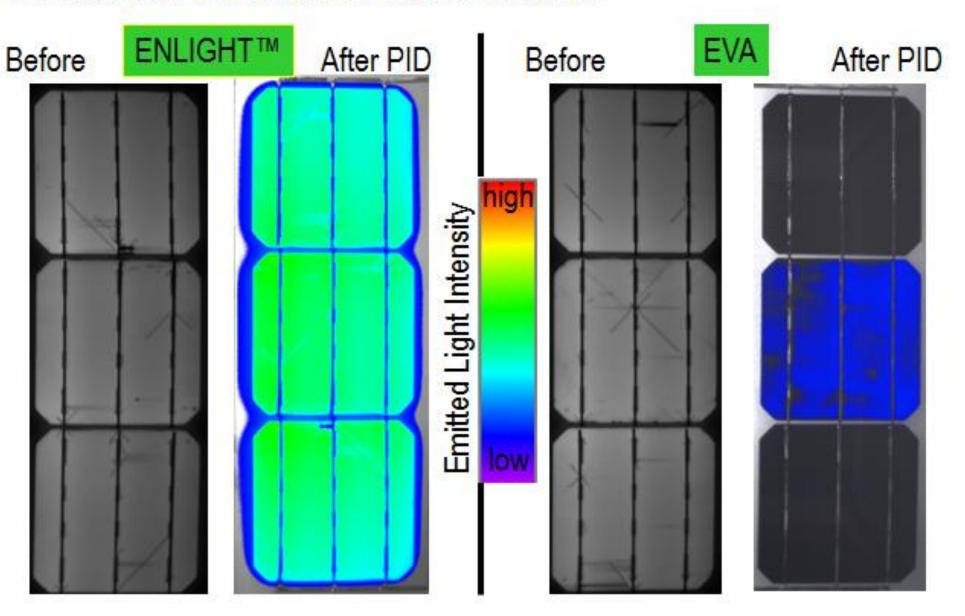


- Prepare single cell modules with MC 4 connectors and junction boxes
- Flash them to get baseline power, IV data and get electroluminescence image of the module
- Place them in the oven at 60C and 85% RH and apply -1000V to the cells with respect to the frame
- Age for 96 hours with voltage applied
- Flash the modules to check for loss of power and do EL measurements to look for failures.

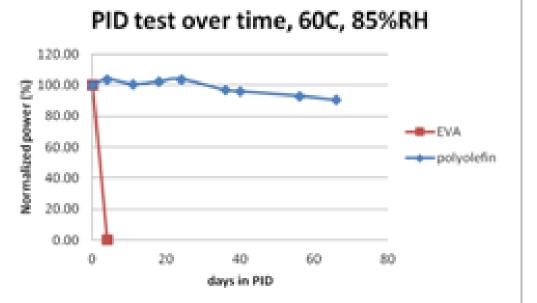
## PID Test Results

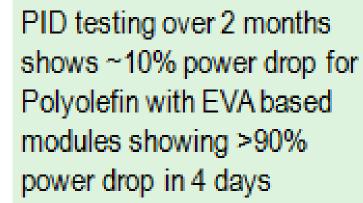


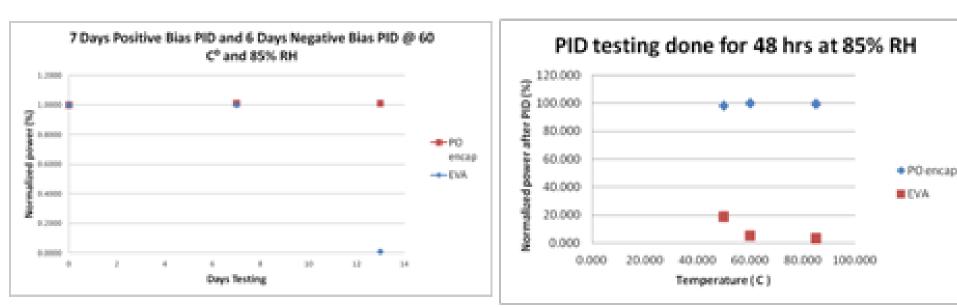
#### Electroluminescence Measurements



#### PID continued...





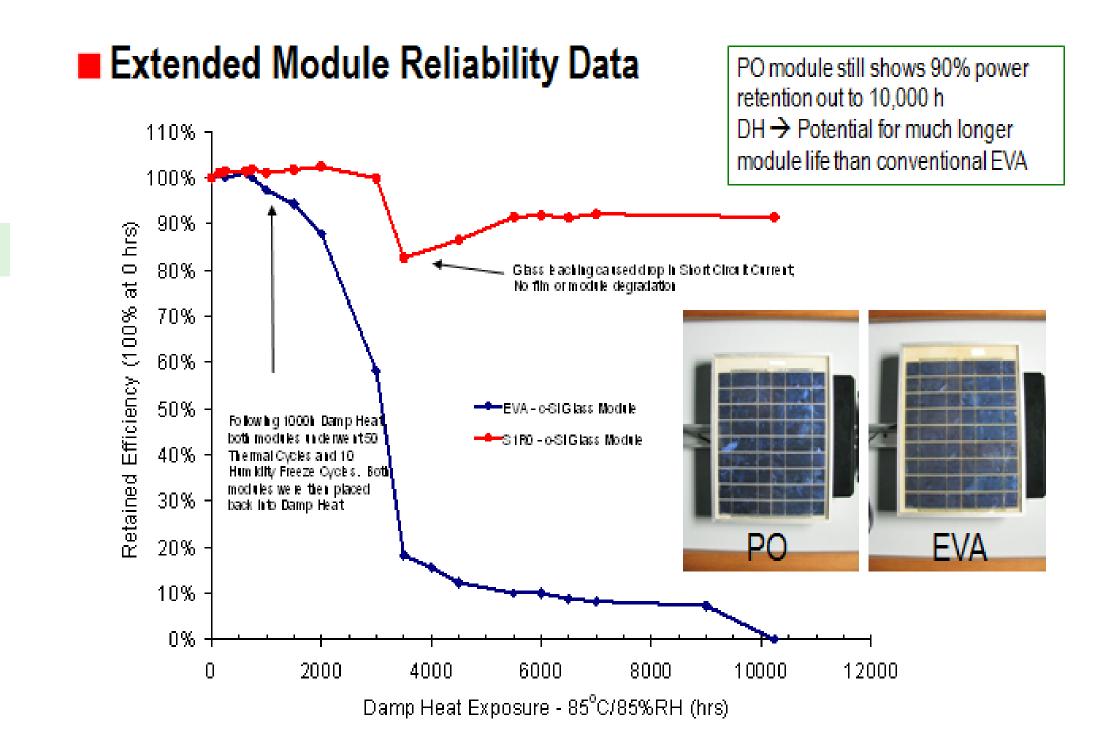


# PID continued...

Even with PID resistant cells – severe conditions can lead to power drop

Encapsulant film	7 days under water @RT		85 C, dry, 7 days
$ENLIGHT^{TM}\ PO$	-0.9%	-0.7%	-1.8%
EVA	-2.3%	12.0%	7.5%

Negative sign means power gain compared to before PID test



### Exposure to QUV and Damp Heat testing

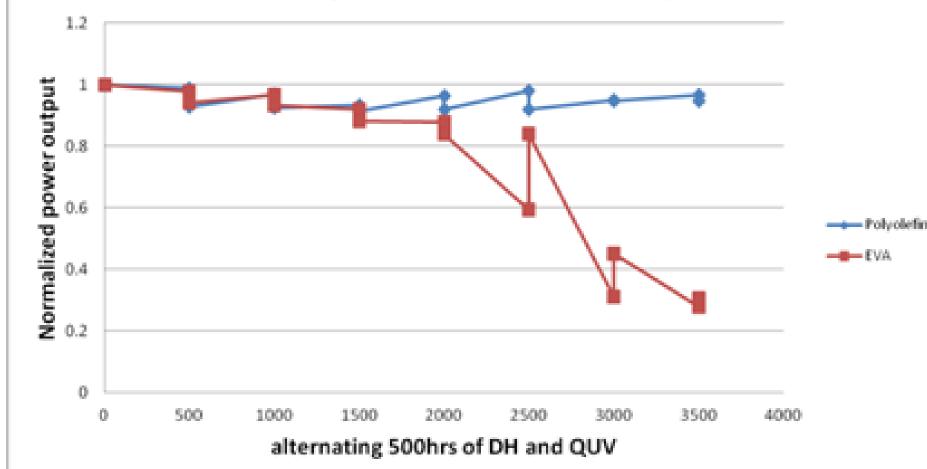
#### Long term module weathering

#### Long-term Durability of Modules with Dow Encapsulant films

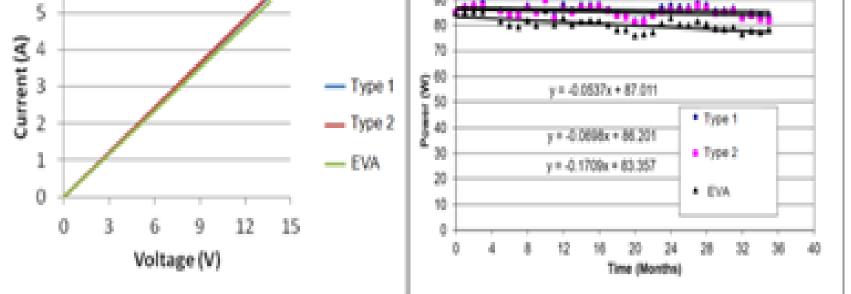
# 100 ;

#### Summary

PID has been shown to be a significant issue in crystalline silicon



PO based module retains power during alternative cycling of damp heat and UV exposure over 7000hrs of total exposure



Module type →	Dow Prototype 1	Dow Prototype 2	EVA
Degradation	0.74	0.97	2.46
Rate (%/ year)			

The power of EVA modules drop 2X compared to the PO film modules

- modules in the field
- There have been solutions suggested to the solve the issue by changing the coating on solar cells or changing the grounding configuration
- In this work, we present an approach by using polyolefin based encapsulant in place of EVA which does not lead to any change in the type of cells used or the installation process
- It was found that electrical insulation resistance and lower water vapor transmission are required to prevent ion migration and PID
- The ENLIGHT<sup>™</sup> Polyolefin encapsulant film provides two orders higher volume resistivity and one order lower water vapor transmission rate which in turns helps modules resist PID.

#### ™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow

- The principles of Responsible Care<sup>®</sup> and Sustainable Development influence the production of printed literature is produced in small quantities and on paper containing recovered/post-consumer fiber and using 100 percent soy-based ink whenever possible. \* NOTICE: Any photographs of end-use applications in this document represent potential end-use applications but do not necessarily represent current commercial applications, nor do they represent current commercial applications, nor do they represent an endorsement by Dow of the actual products. Further, these photographs are for illustration purposes only and do not reflect either an endorsement or sponsorship of any other manufacturer for a specific \* potential end-use product or application, or for Dow, or for specific products manufactured by Dow. \*
- NOTICE: No freedom from infringement of any patent owned by Dow or others is to be inferred. Because use conditions and applicable for determining whether products and the information in this document are appropriate for the Customer's use and for ensuring that the Customer's workplace and disposal practices are in compliance with applicable laws and other governmental enactments. Dow assumes no obligation or liability for the information in this document. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED. \*
- NOTICE: If products are described as "experimental" or "developmental": (1) product specifications may not be fully determined; (2) analysis of hazards and caution in handling and use are required; (3) there is greater potential for Dow to change specifications and/or discontinue production; and (4) although Dow may from time to time provide samples of such products, Dow is not obligated to supply or \* otherwise commercialize such products for any use or application whatsoever. \*