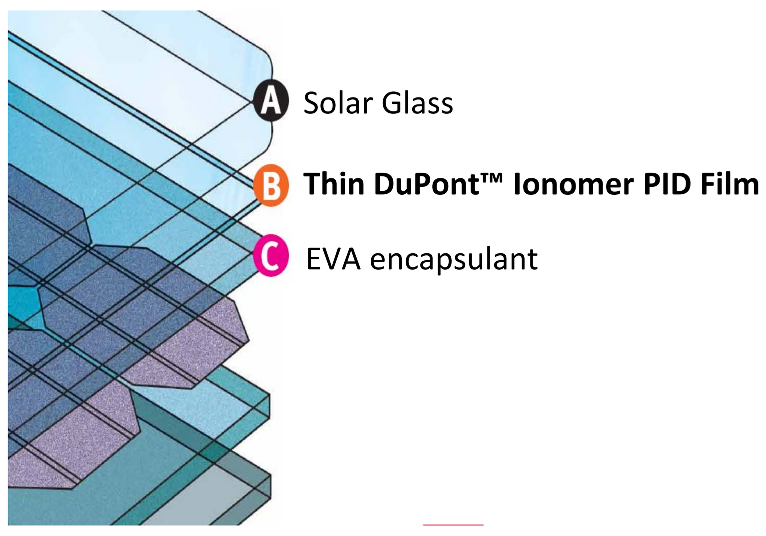
Prevention of Potential Induced Degradation with Ionomer Film

Jane Kapur[1], Jennifer Norwood[1], Alison Bennett[1], Babak Hamzavytehrany[1], Katherine Stika, Craig Westphal[1], Ingo Kueppenbender[2]

[1] E. I. DuPont de Nemours & Co., Inc., Wilmington, DE 19880 U.S.A.
[2] DuPont de Nemours (Deutschland) GmbH, Germany

1. Objective and Performance Goals

Ionomer encapsulants have been shown to prevent potential induced degradation of PV modules. To be more cost effective, thin films of ionomer were used in conjunction with EVA and tested under PID conditions. Both film thickness and ionomer type were optimized to obtain a robust solution.



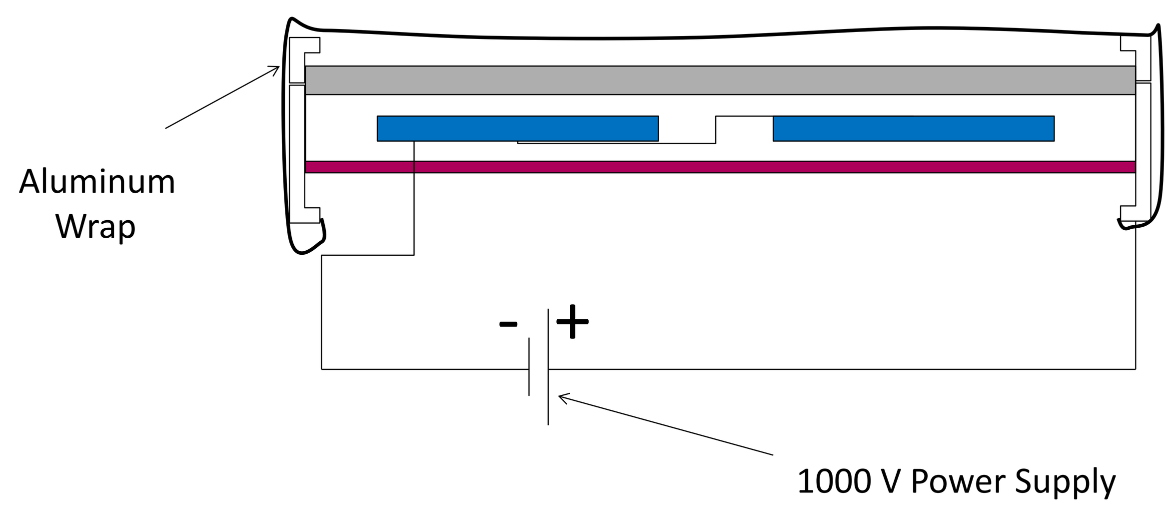
- Prevent PID under stringent test conditions
- Minimal change to module materials
- Minimal change to module manufacture
- Low added cost

Product Concept:
A thin ionomer film between glass and cells, adjacent to front EVA encapsulant

2. PID Method & Criteria

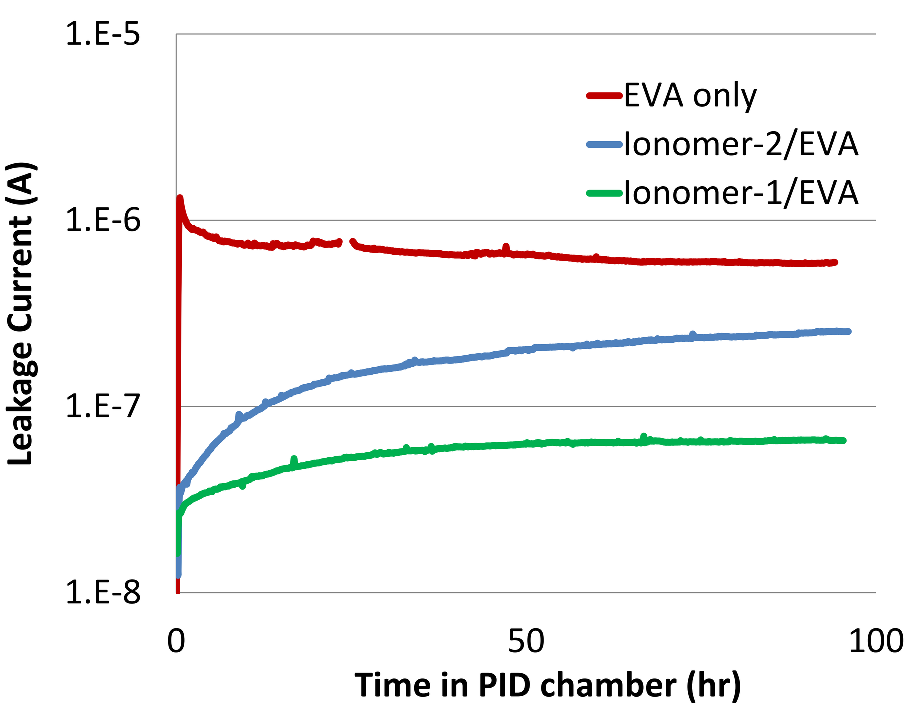
PID:	> 95% Power Retention
Voltage:	- 1000V
Temp/RH:	60 ºC / 85%RH
Time:	96h - 500h
Glass Surface:	no treatment, Al **foil**
Solar Cell:	Mono c-Si, not optimized for PID resistance

- Foil accelerates PID
- Provides reproducible results



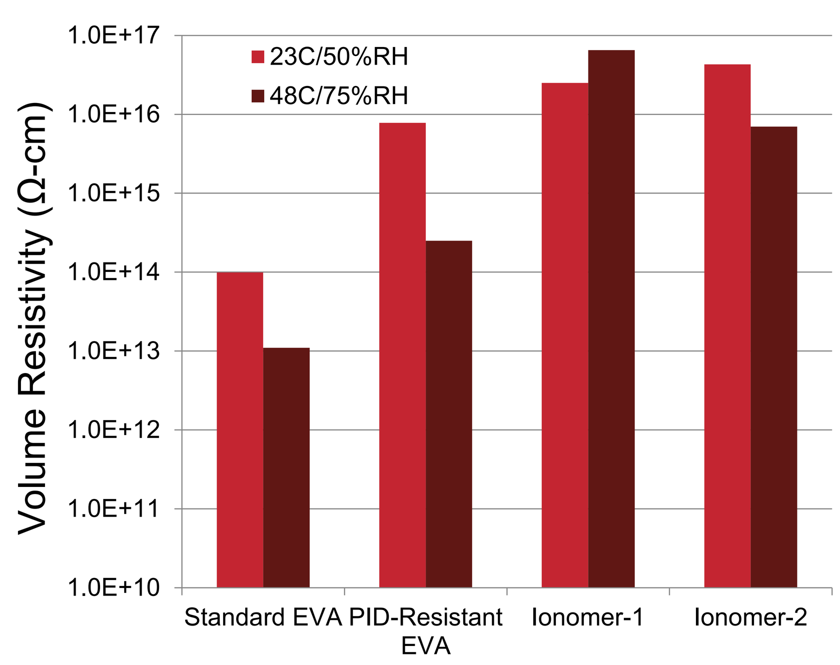
3. Why Use Ionomer?

Low Current Leakage



Higher Leakage Current contributes to PID. The leakage current of EVA is approx. 10x higher than that of Ionomer-1 combined with EVA.

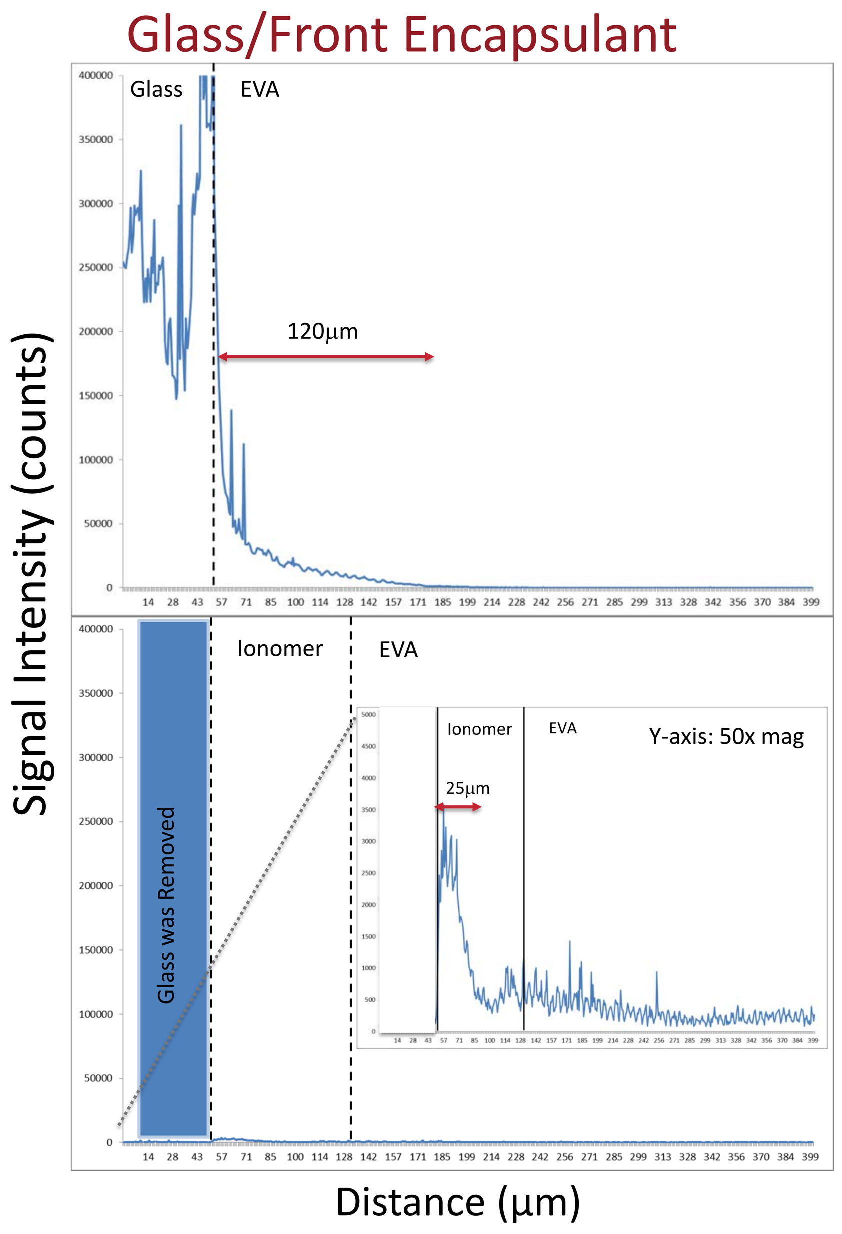
High Volume Resistivity



The volume resistivity of ionomer remains high while that of EVA drops 1-2 orders of magnitude with a temperature increase of 25° C.

Na Ion Migration Profile Measured Using LA-ICP-MS in Module

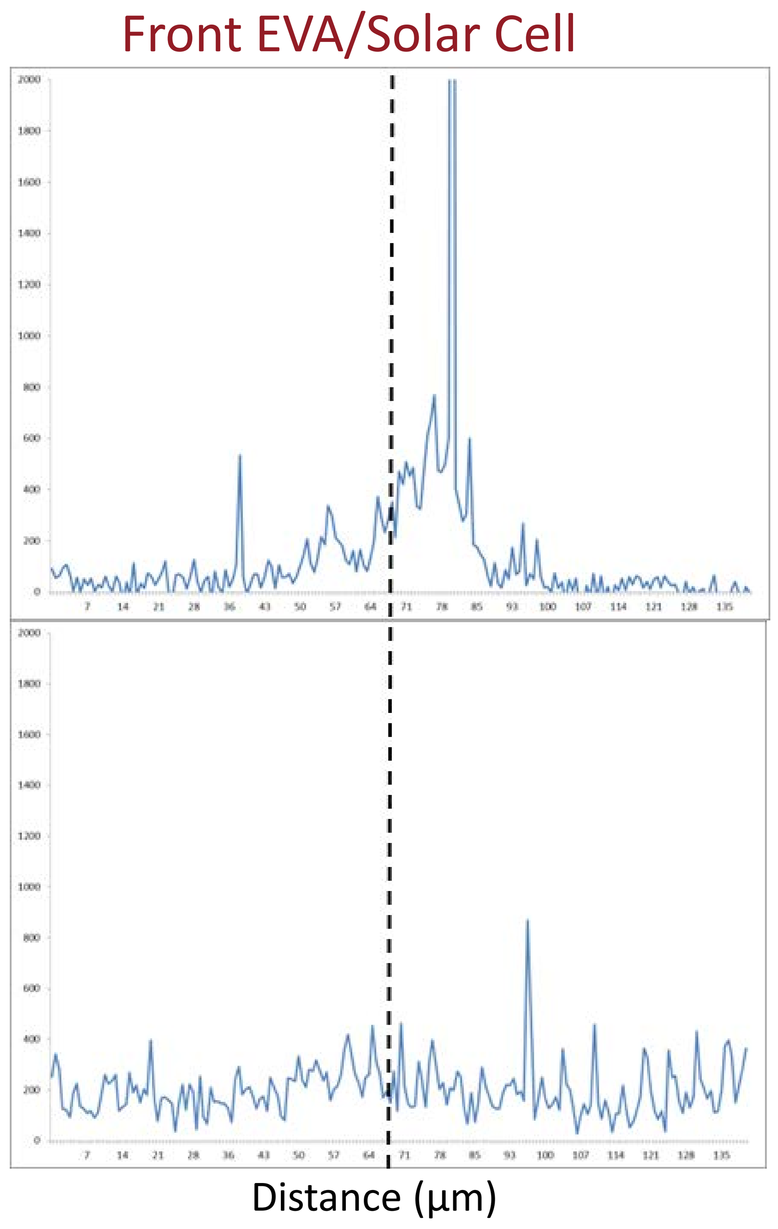
Glass/Front Encapsulant



PID 96h test
G/Std EVA/cell
Sodium migration is much faster through the Standard EVA

PID 96h test
G/Ionomer/StdEVA/cell
Sodium migration is much slower through the 50µm ionomer

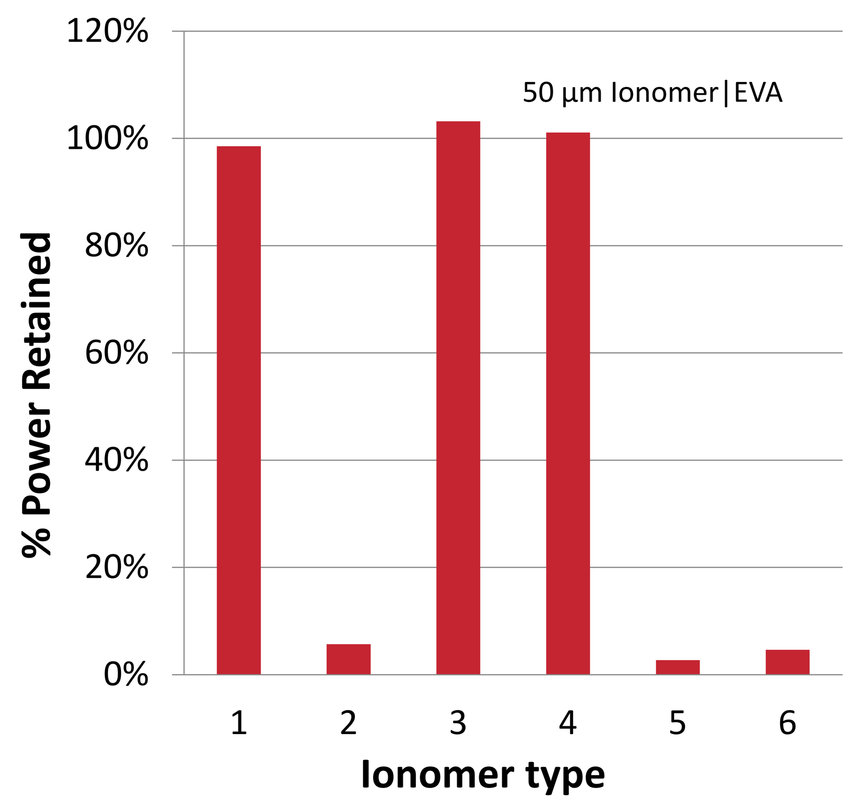
Front EVA/Solar Cell

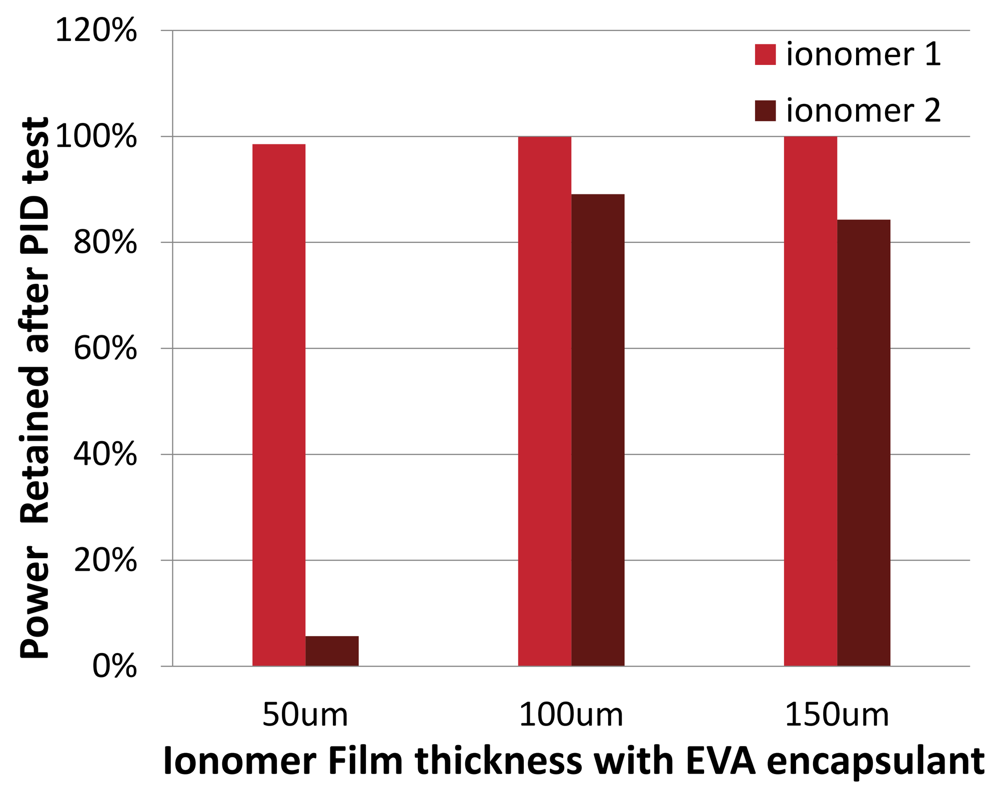


Elemental mapping of the encapsulant following a simulated PID exposure was determined using Laser Ablation – Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). In this experiment, a laser beam is focused and scanned across the sample surface, generating fine solid particles from the top 5-20 µm of the sample surface. The particles are continuously introduced into a high temperature Argon plasma, which serves as a hard ionization source. The resulting singly charged elemental ions are analyzed by a mass spectrometer

4. Experimental Results

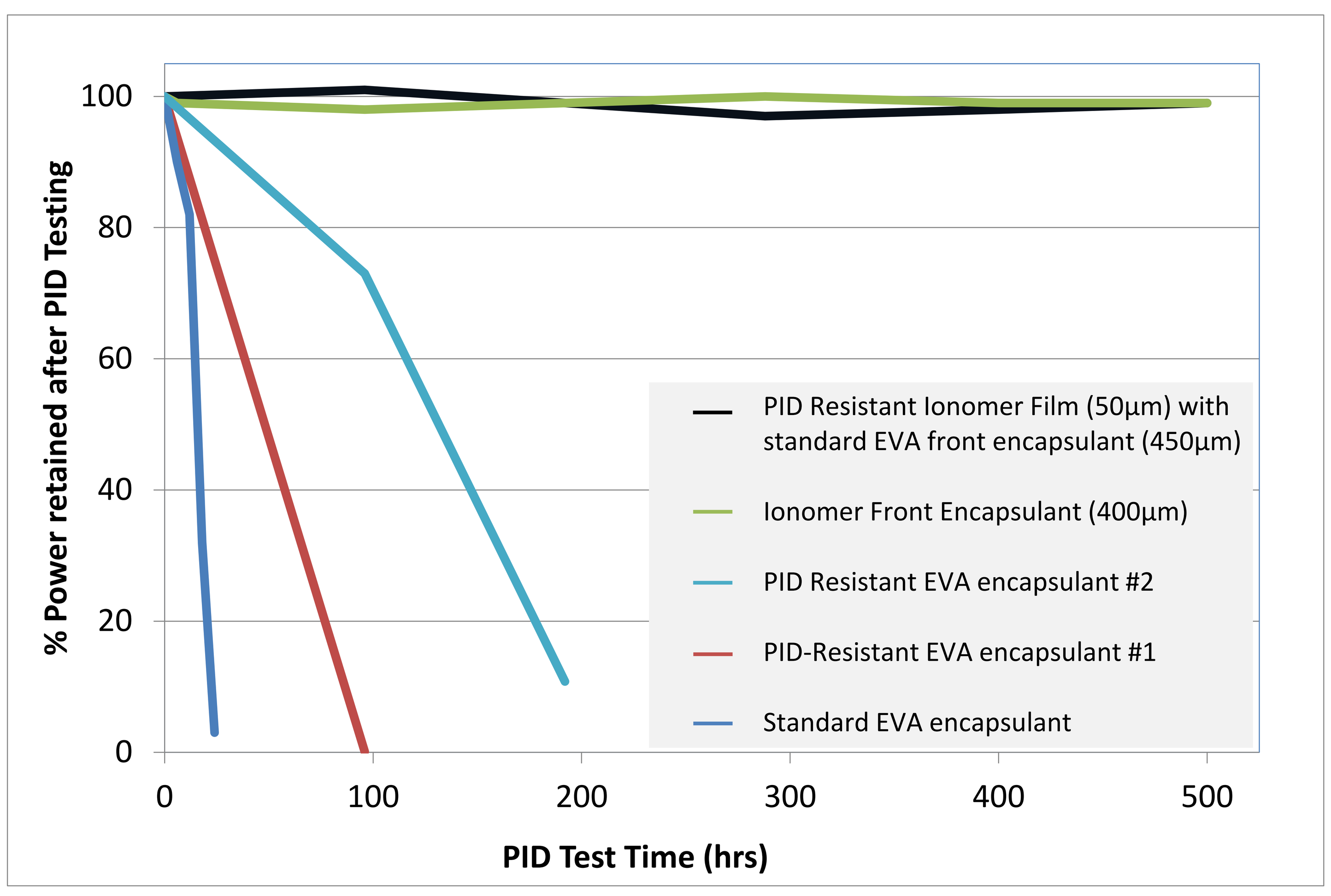
Ionomer selection and **film thickness** have a significant impact on PID and power retention. Optimization of these parameters is needed to provide a low cost solution.





5. Conclusions

50 µm Ionomer|450 µm EVA is **as effective as** single 400 µm Ionomer Encapsulant over 500h of testing.



Acknowledgements: Special thanks to John Jensen, John Kalinowski, Kurt Raughley, and Gail Raty for their contribution to this work.