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Mitigating risk in solar projects: The power of a reliable bill of materials



Mark Hutchins

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Welcome!

Do you have any questions?  

Send them in via the Q&A tab.  We aim to answer as many as we can today!

You can also let us know of any tech problems there.

We are recording this webinar today. 

We'll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience.  



Mitigating Risk in Solar Projects: The Power of a Reliable Bill of Materials

Guy Beaucarne, PhD
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PV Application Technical Leader
Dow, Packaging & Specialty Plastics Business

PV Magazine webinar, 30 September 2025

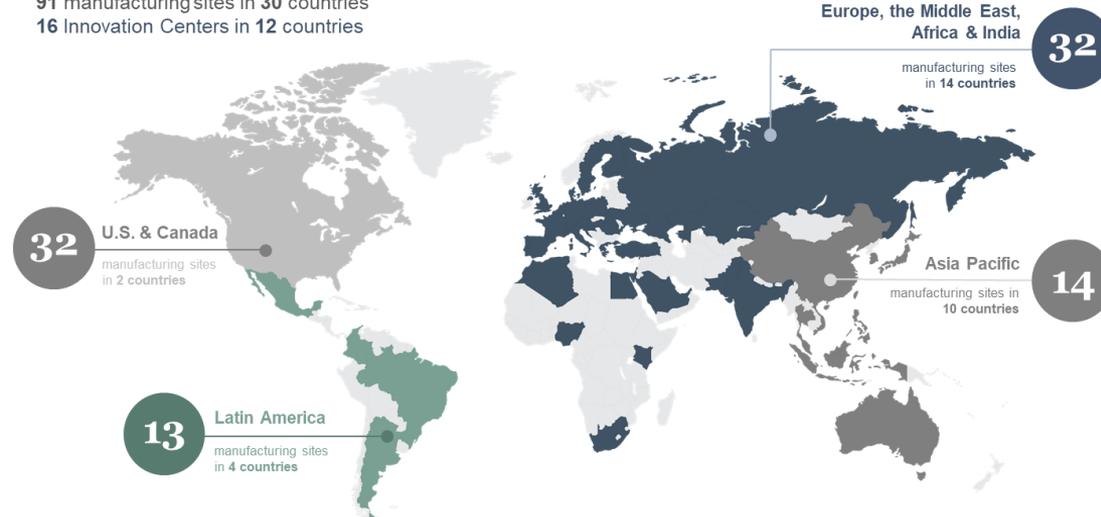
DOW AT A GLANCE

Every answer starts with asking the right question.

At Dow, these questions and the pursuit of solutions for the world's toughest challenges inspire us to collaborate and use our materials science experience to create innovative solutions that transform our world and offer a sustainable future.



91 manufacturing sites in 30 countries
16 Innovation Centers in 12 countries



 \$43B net sales in 2024 ¹	 ~36,000 employees	 91 manufacturing sites	 30 countries in which Dow manufactures products
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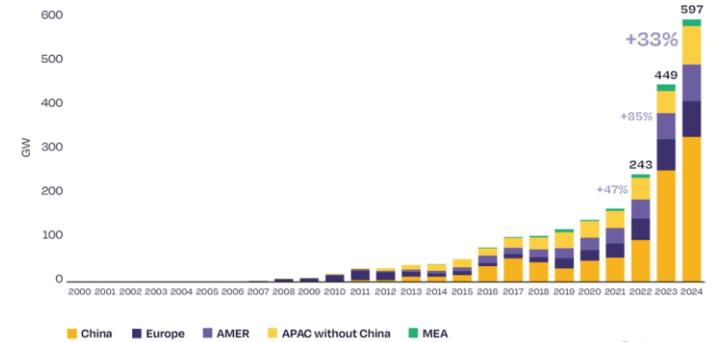
CONTENTS

- Introduction
- Solar cell encapsulants
- Frame sealants
- Rail bonding adhesives
- Potting agents
- Conclusion

INTRODUCTION

- Fast PV growth
- Economics of a PV system based on assumption of 25 years lifetime with high performance
- Premature failure or excessive degradation: problem for everyone involved
- Some risks can be controlled

Annual solar PV installed capacity 2000-2024



World annual solar PV market scenarios 2025-2029





Solar Cell Encapsulants

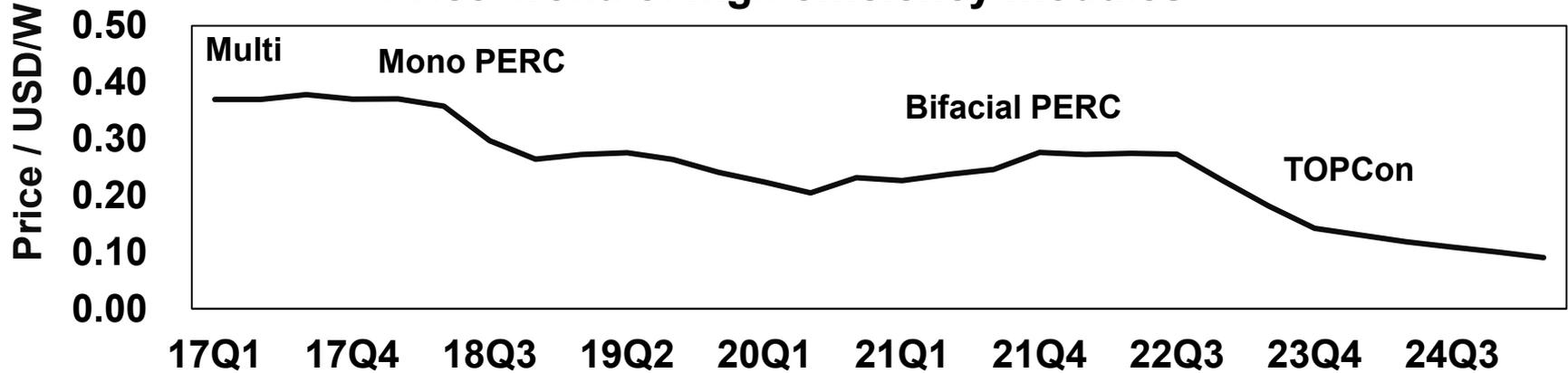
Yuyan Li, PhD

PV Application Technical Leader

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QUALITY CRISIS

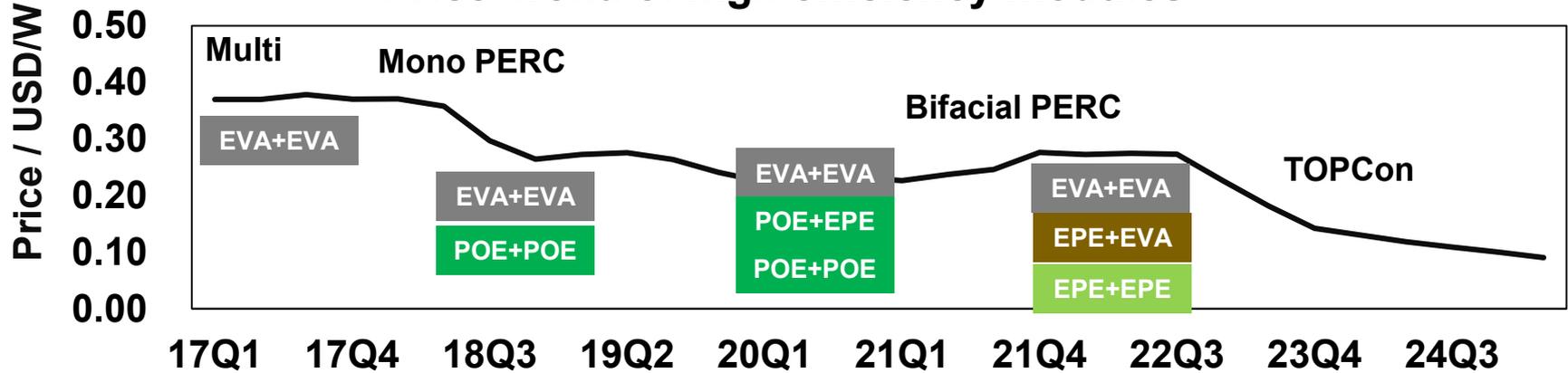
Price Trend of high efficiency modules



QUALITY CRISIS

Sacrifice quality for lower cost

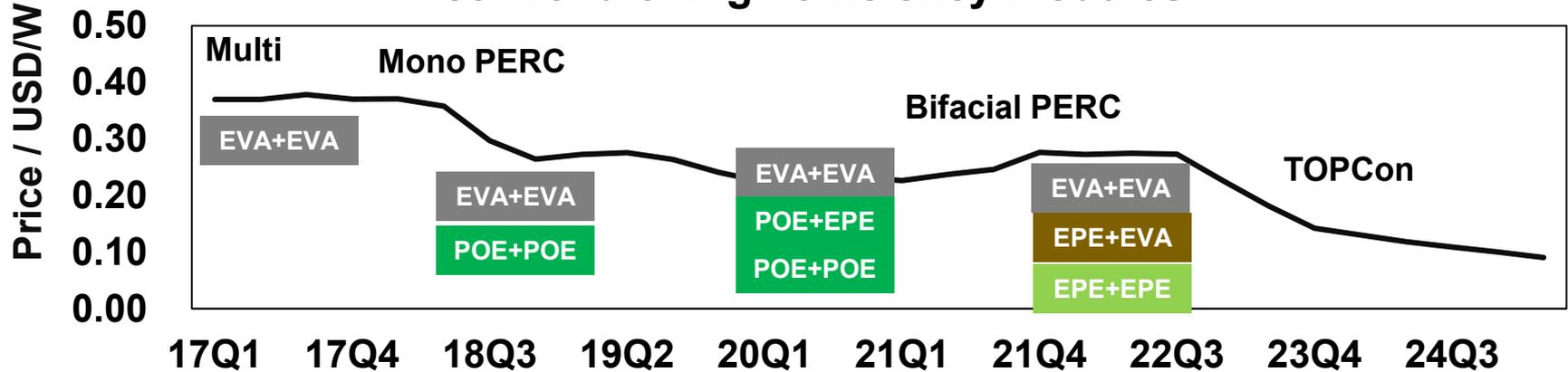
Price Trend of high efficiency modules



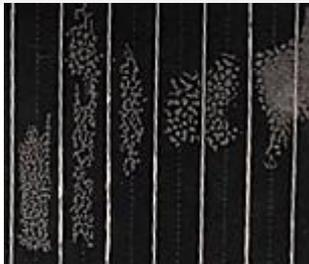
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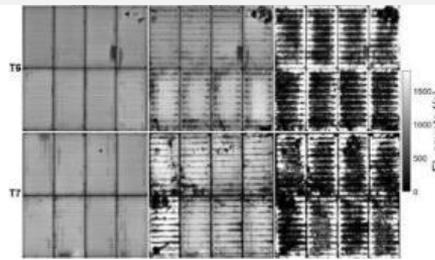
Price Trend of high efficiency modules



Typical module failures: Higher risk with pursuing extreme lower cost.



Delamination



UVID

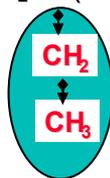
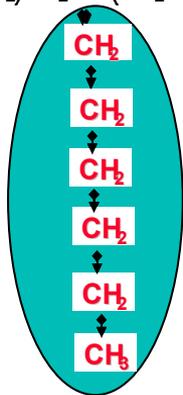
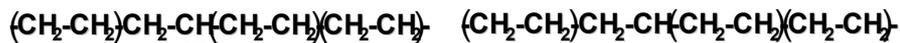
PID



Glass broken



DOW --- LARGEST POLYOLEFIN ELASTOMER (POE) SUPPLIER



Dow INSITE™ technology



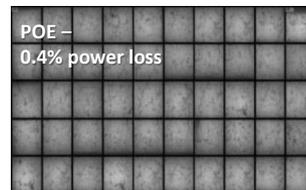
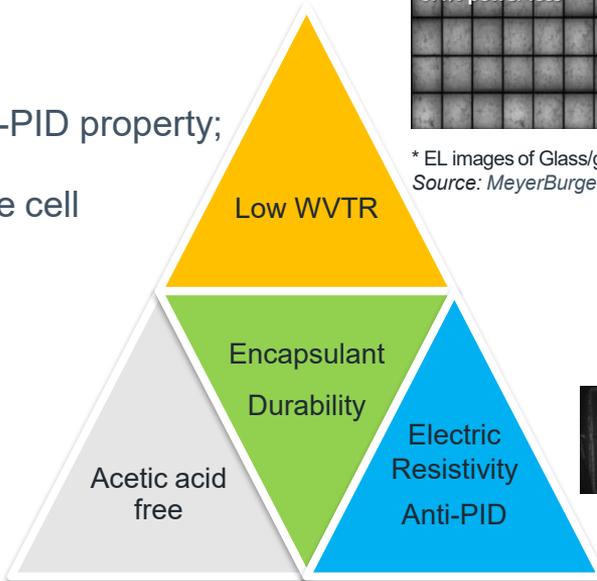
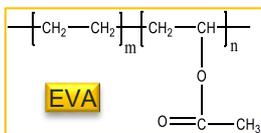
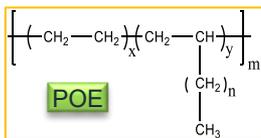
Fast curing PV



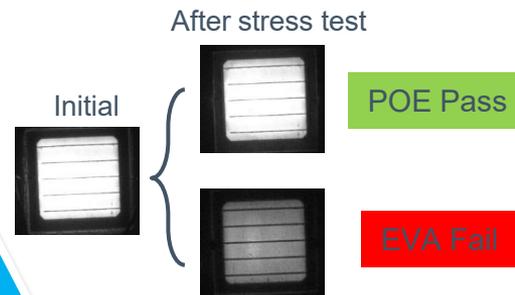
ENCAPSULANT DURABILITY: KEY PROPERTIES

ENGAGE™ PV POE from Dow has strong value over EVA in helping to achieve bifacial module reliability:

- High moisture barrier, low WVTR;
- Good electrical insulation and anti-PID property;
- No acetic acid in POE, address the cell corrosion problem.



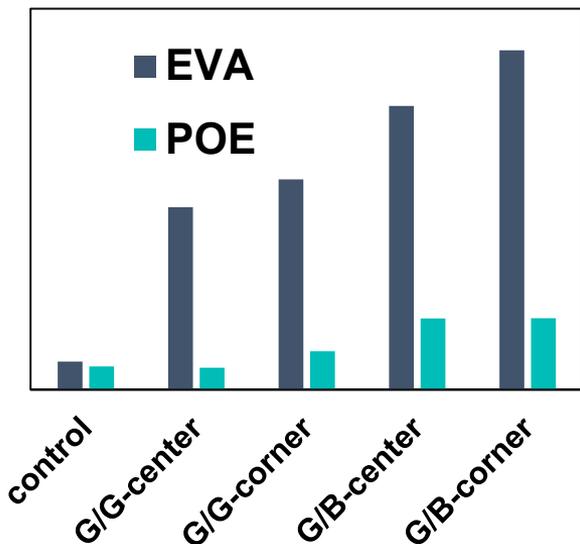
* EL images of Glass/glass module after aging at DH for 7000 hours
Source: MeyerBurger



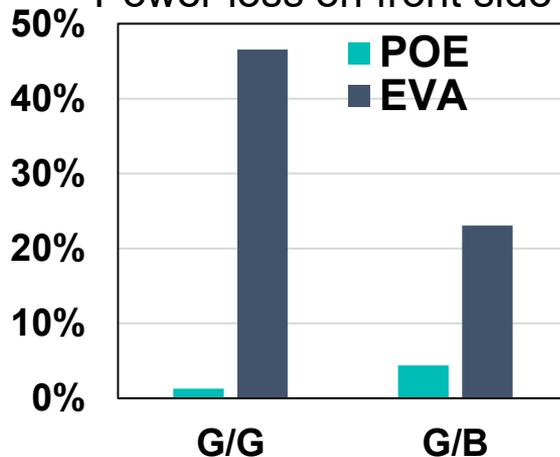
EL image
bright if cells are good,
dark if cells are damaged.

THE BENEFIT OF POE LOW WVTR FOR TOPCON MODULES

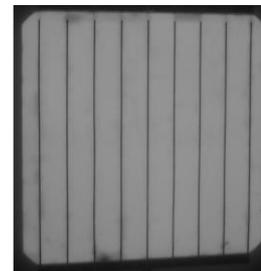
Water ingress for modules after 8 weeks DH aging



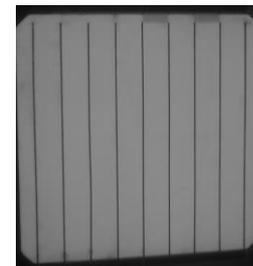
Power loss on front side



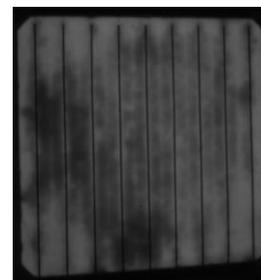
EL images after 8 weeks DH aging



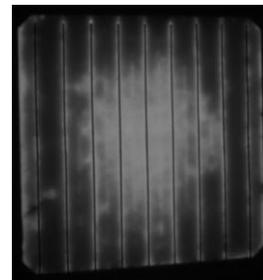
G/B-POE



G/G-POE



G/B-EVA



G/G-EVA

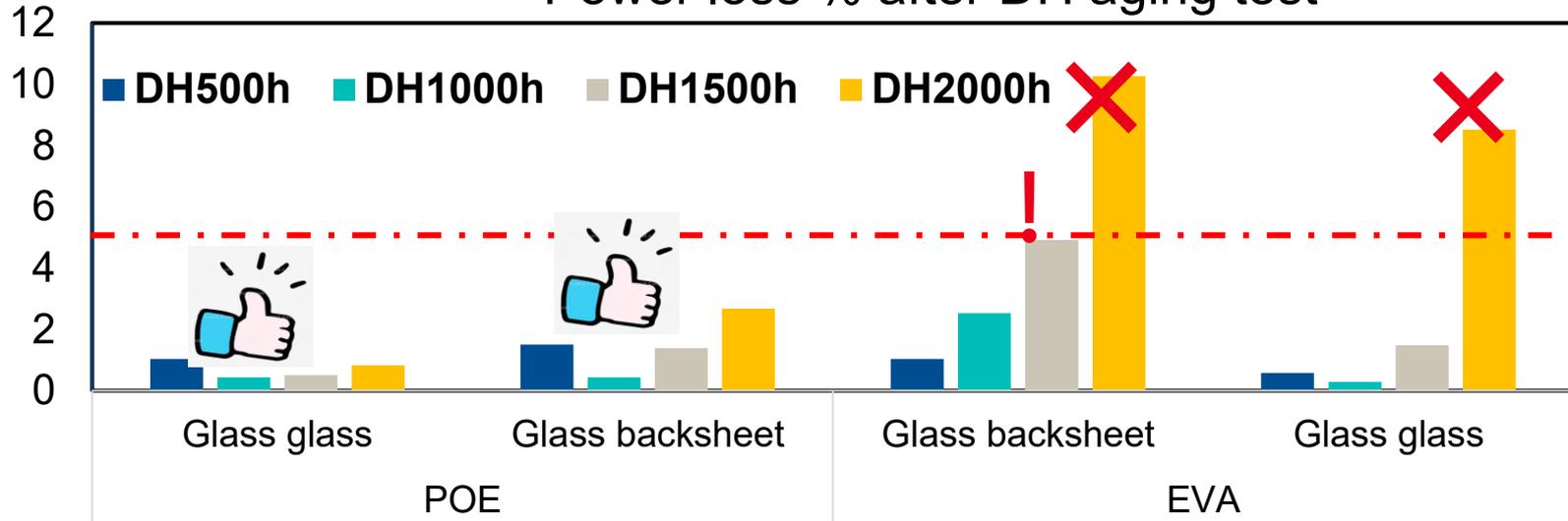
- Higher content of moisture could be detected in EVA encapsulated modules;
- Good power output maintenance in POE encapsulated modules;
- Extreme power loss in EVA encapsulated modules;
- G/G modules could trap the corrosive products, leads to worse corrosion behavior comparing with G/B.



Typical values, not to be construed as specifications. Users should confirm results by their own tests.

EVA CANNOT MEET DH 2000H AGING EVEN FOR THE BEST TOPCON-LECO CELL

Power loss % after DH aging test

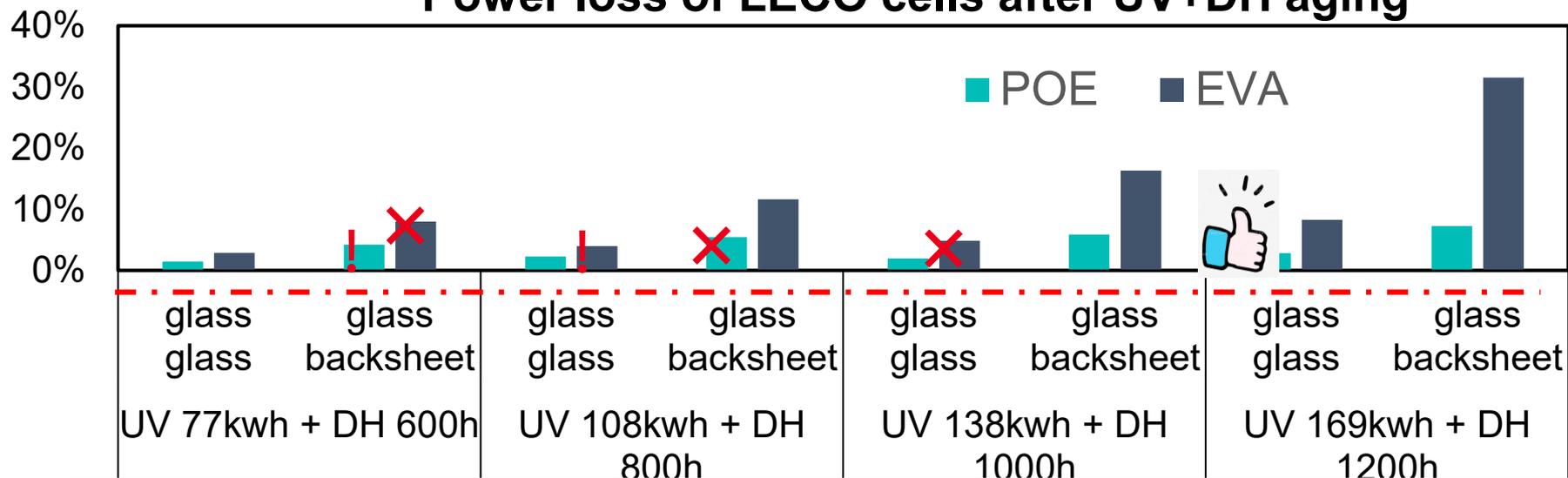


Even for the best LECO cell, modules using EVA film fail the DH 2000h aging:

- For both glass glass and glass backsheet modules using EVA film have significant loss after DH 2000h;
- The glass glass module using EVA film, a sharp power loss from DH 1500h to DH 2000h, might be because of the moisture ingress results in corrosion and cell failure.

CORROSION REMAINS CRITICAL FOR TOPCON-LECO CELLS

Power loss of LECO cells after UV+DH aging



UV+DH aging on LECO cells:

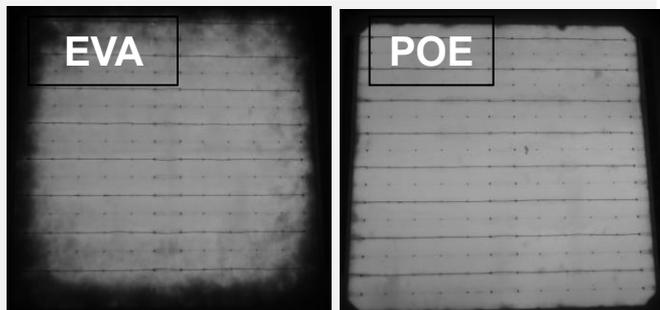
- UV+DH as comprehensive environmental aging test is more in line with actual outdoor use;
- **For both glass/glass and glass/glass backsheet modules, POE+POE performs more reliably than EVA+EVA;**



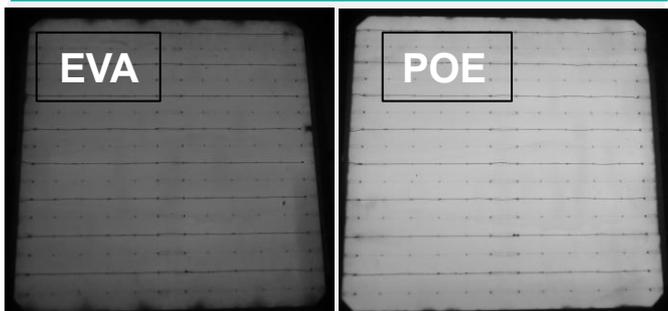
Typical values, not to be construed as specifications. Users should confirm results by their own tests.

EL IMAGE AFTER UV 169 KWH + DH 1200 H

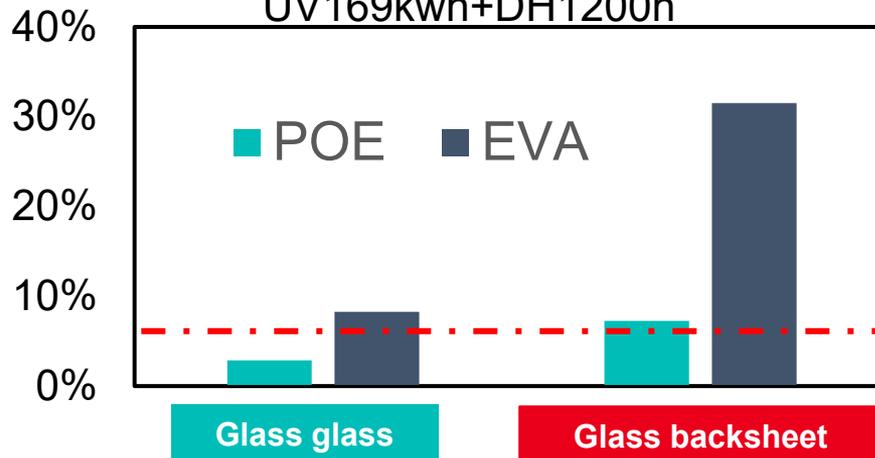
Glass backsheet



Glass glass

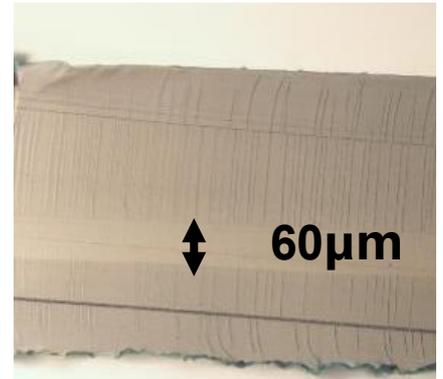
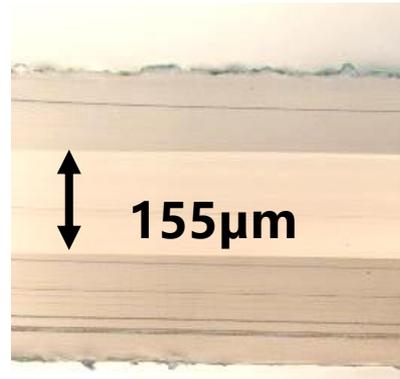
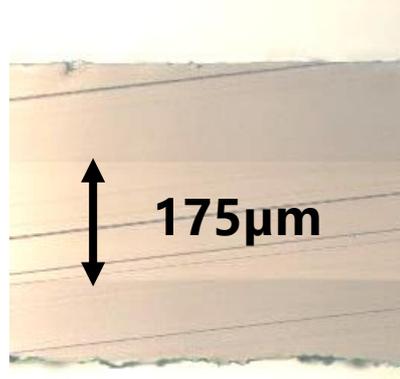
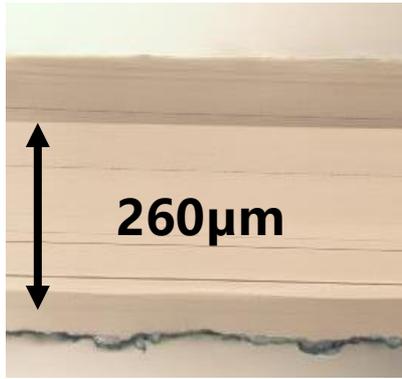


Power loss of LECO cells after UV169kwh+DH1200h



- UV+DH as comprehensive environmental aging test is more in line with actual outdoor use;
- **For both glass glass and glass backsheet modules, POE+POE performs robust over EVA+EVA;**

EPE FILM --- CORE POE LAYER THICKNESS MATTERS FOR RELIABILITY

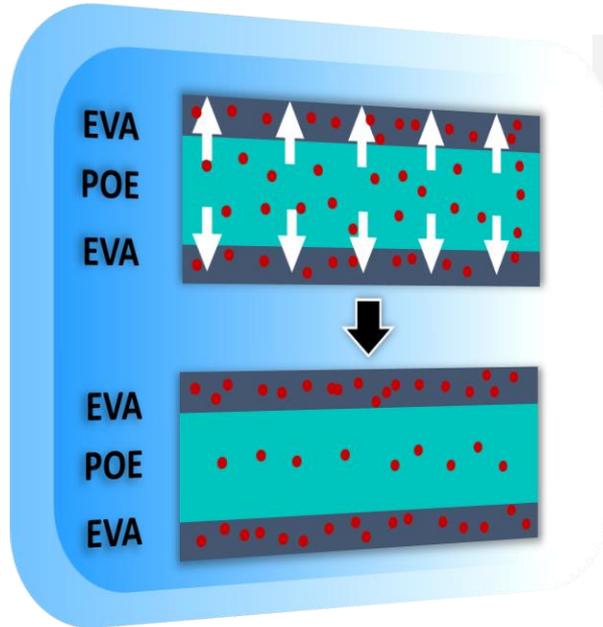


Core POE layer thickness is key to the film property:

- Moisture barrier property determined by POE layer thickness, higher the better;
- Anti-PID performance highly impacted by POE layer thickness;
- Gel content retention become even worse with thinner core POE layer.

THINNER POE CORE INTENSIFIED RELIABILITY ISSUE

Thicker core POE layer

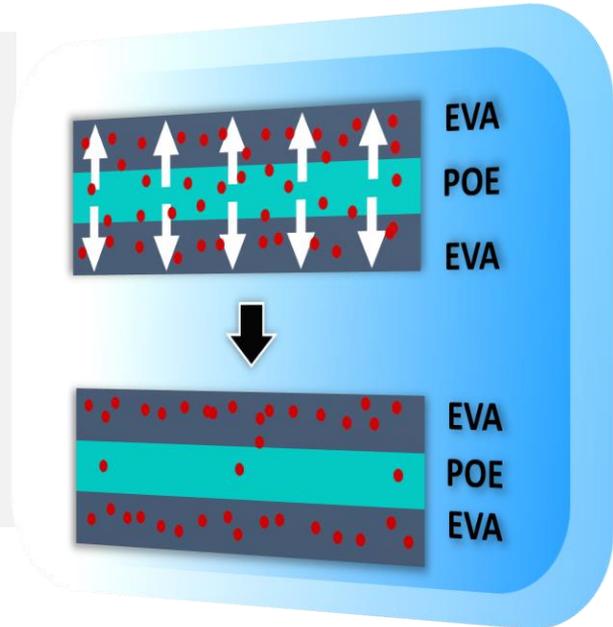


Additive migration

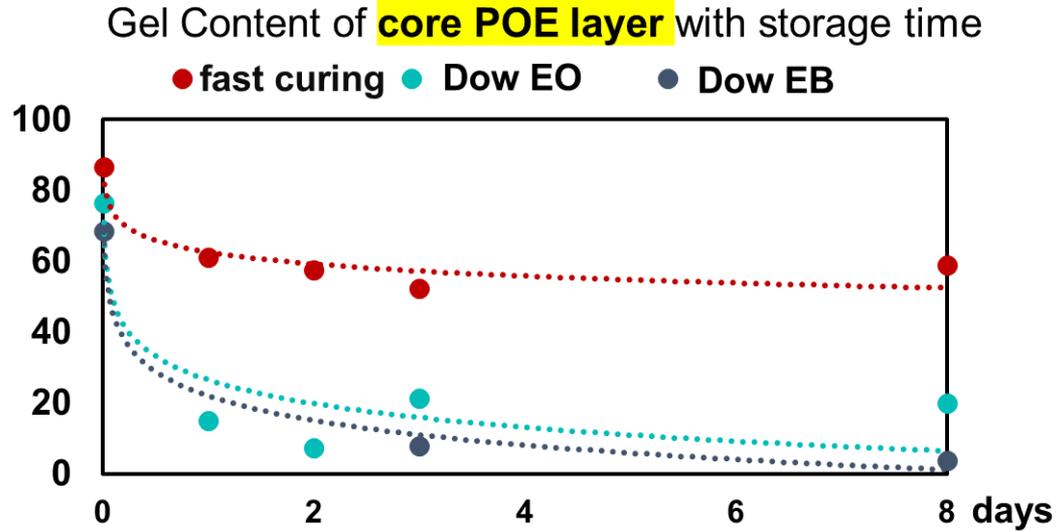
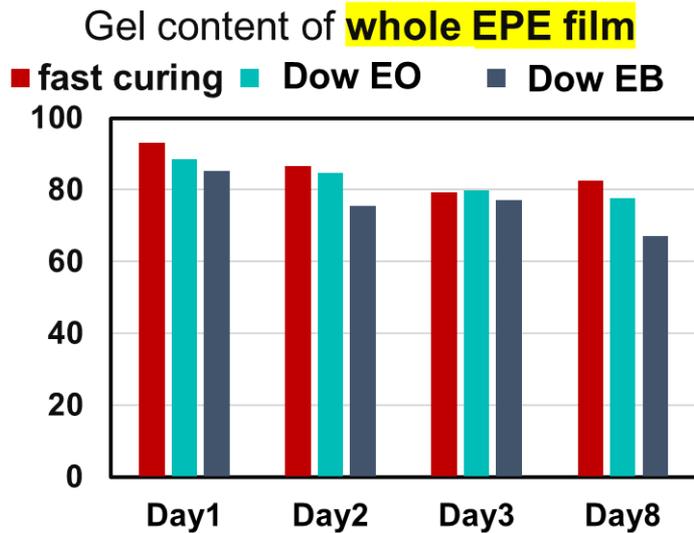
Core POE layer has lower gel as designed .

Thinner core POE has even lower gel after additive migration.

Thinner core POE layer



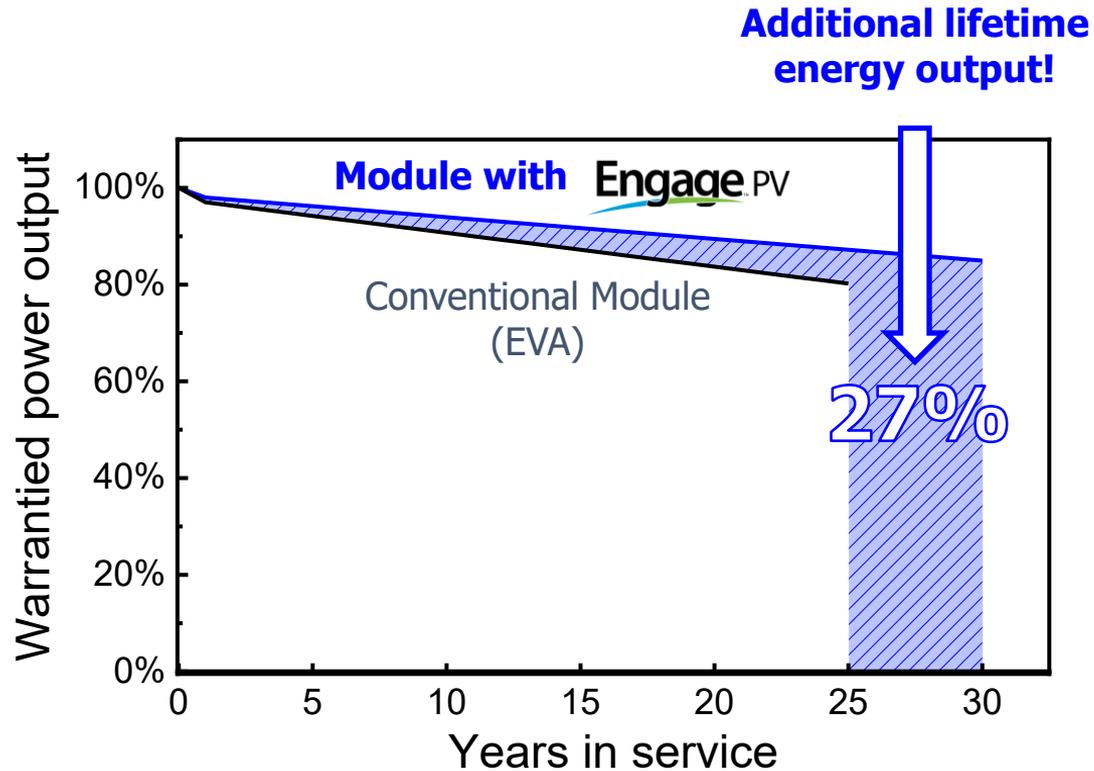
DOW NEW PV GRADE --- MORE RELIABLE WITH BETTER GEL RETENTION



Core POE layer gel content decreased with storage time due to additive migration:

- New fast curing PV grade perform excellent to maintain the gel used for core POE layer in EPE film;
- Perform much better than current EO and EB PV grades.

POE ENCAPSULANTS MAXIMIZE DURABILITY AND VALUE OF PV



Typical values, not to be construed as specifications. Users should confirm results by their own tests.

ENGAGE™ PV POE: BETTER CHOICE TO ENHANCE RELIABILITY



ENGAGE™ PV POE show **low WVTR** and **high VR** comparing with other POE and EVA material.



Especially for TOPCon-LECO cells, **POE is needed to help ensure the enhanced cell efficiency to be practical** in modules and power generation in the field.



Better curing property brings more reliable and **higher gel retention** for the core POE layer in EPE film.



ENGAGE™ PV POE helps **improve PID resistance**, helps enable **lower LCOE** and **better project economics** for solar developers.



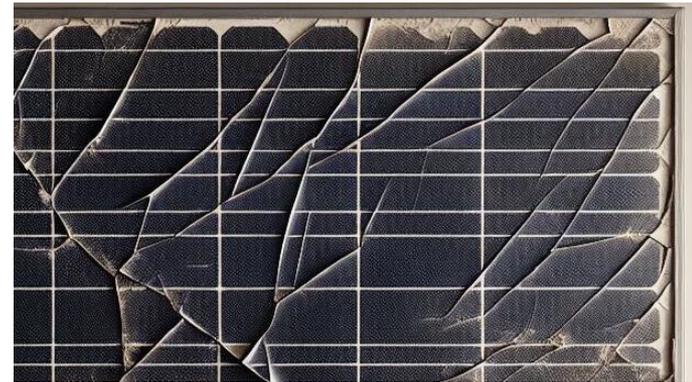
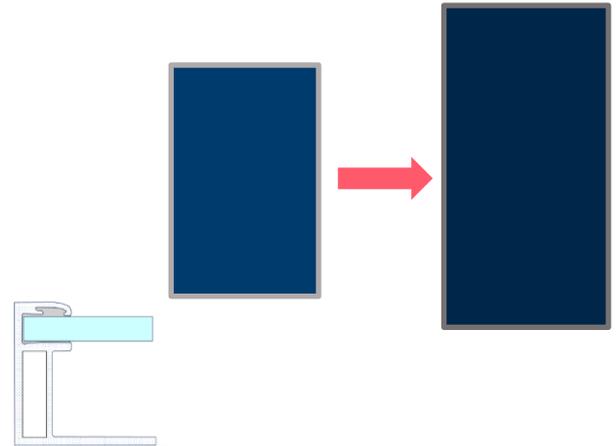
Engage PV
polyolefin elastomers



Frame sealants

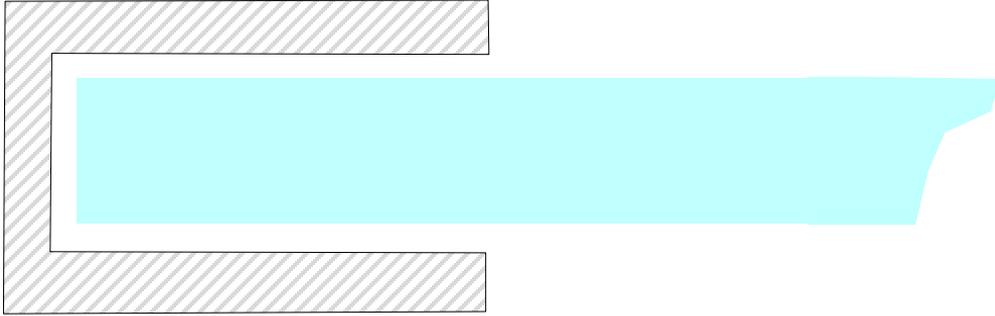
FRAMED EDGE OF MODERN MODULES

- Recent major changes in module designs
 - Glass-backsheet → glass-glass
 - 3.2 mm glass → 2 mm glass
 - Fully tempered glass → heat-strengthened glass
 - Small modules (size $\leq 2 \text{ m}^2$) → large modules (size $> 2 \text{ m}^2$)
- Yet no significant change to edge design, same frame sealants
- Glass breakage in glass-glass module has become frequent problem
 - Often: 'spontaneous' glass breakage
 - Low energy crack pattern
 - Cracks often originate from edge
- Can frame sealant properties have an impact on glass breakage?



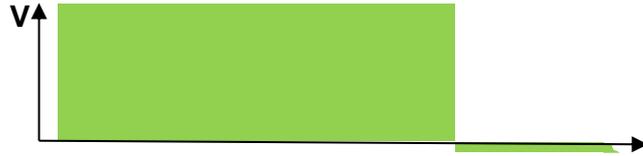
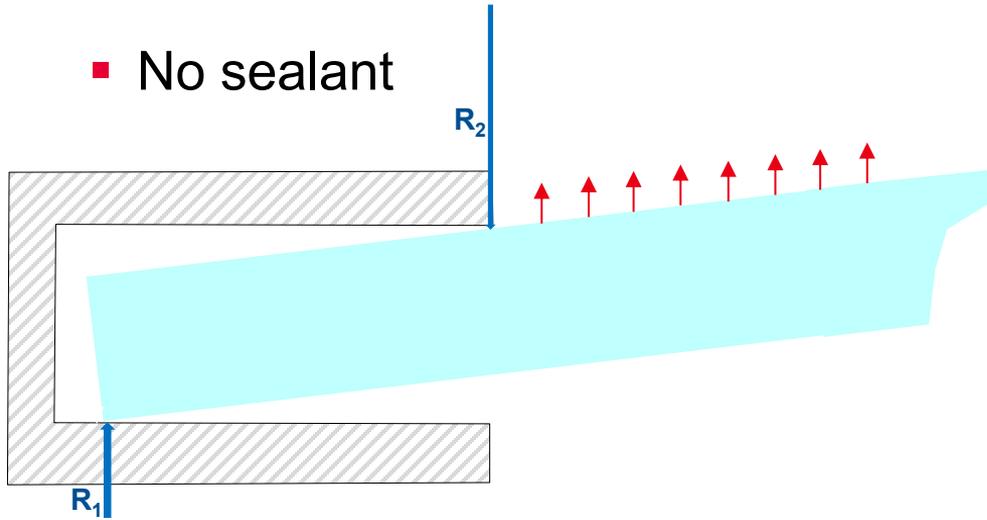
FRAME SEALANTS IMPACT STRESS AT GLASS EDGE

- No sealant



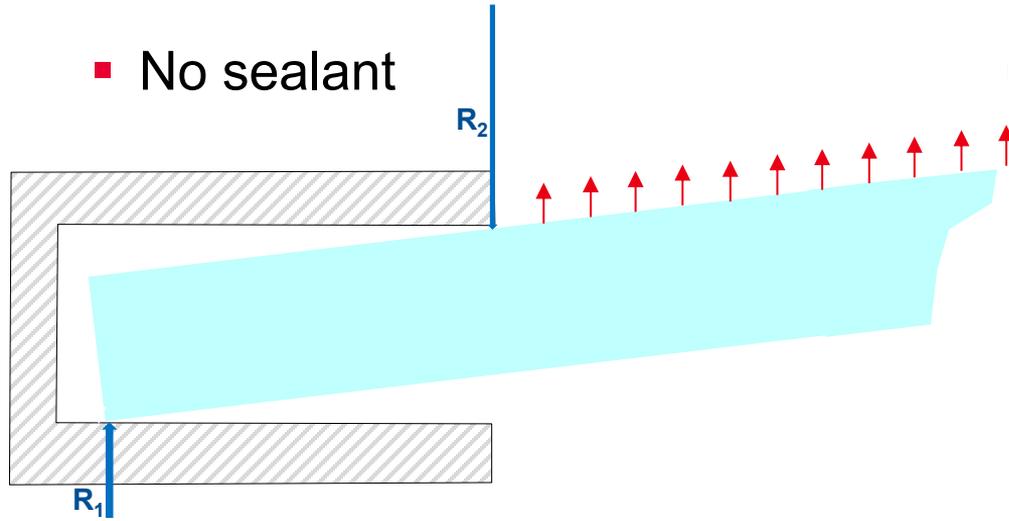
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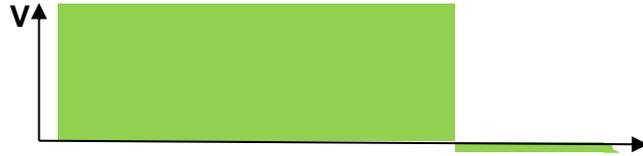
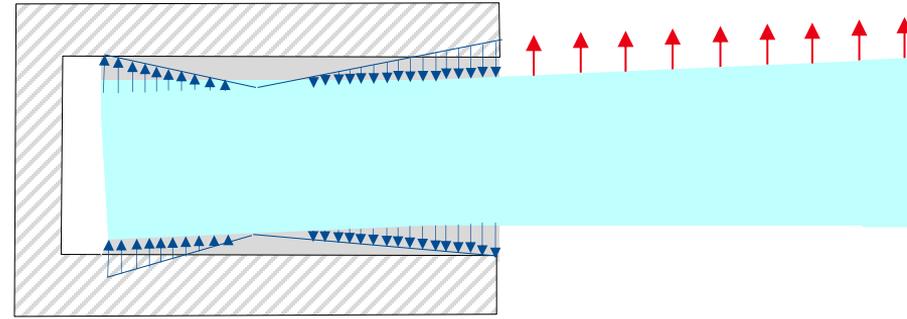


FRAME SEALANTS IMPACT STRESS AT GLASS EDGE

■ No sealant



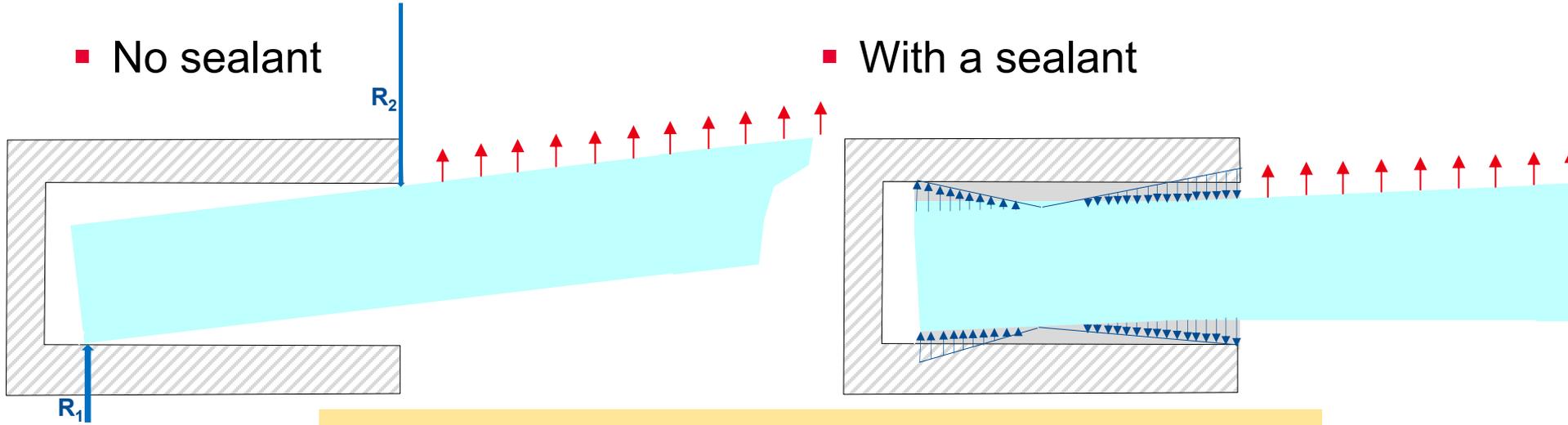
■ With a sealant



FRAME SEALANTS IMPACT STRESS AT GLASS EDGE

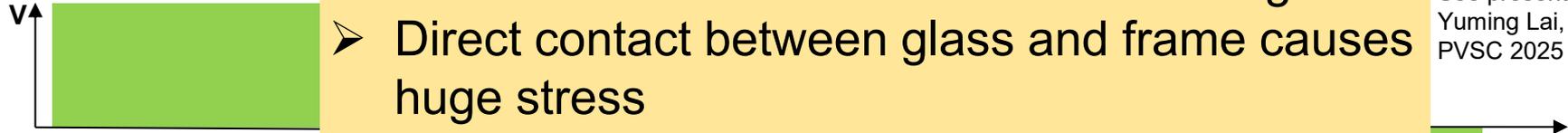
■ No sealant

■ With a sealant



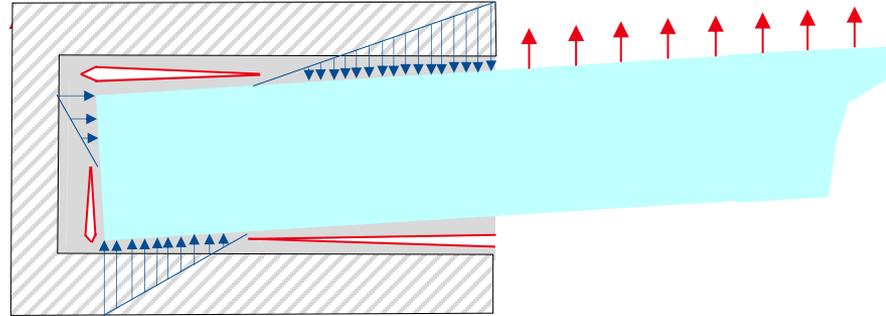
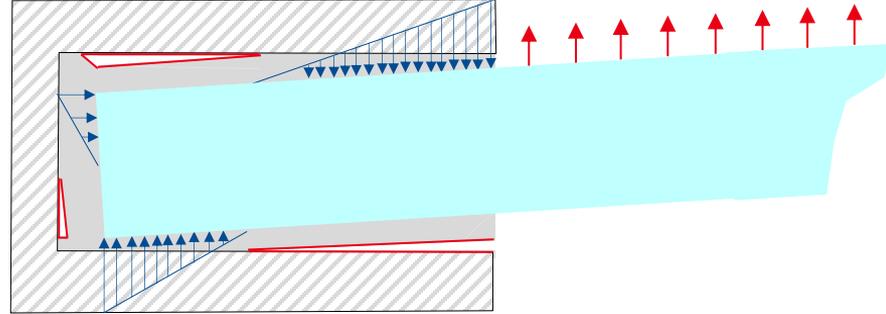
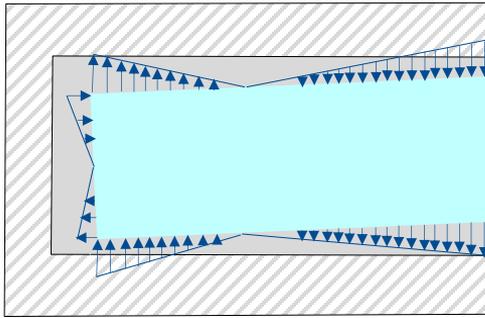
- Frame sealant is critical to limit stress in glass
- Direct contact between glass and frame causes huge stress

See presentation by
Yuming Lai, IEEE
PVSC 2025



WHAT IF THE SEALANT FAILS?

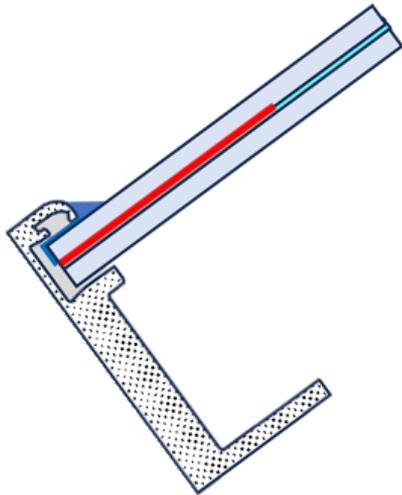
- Frame sealants can fail adhesively or cohesively



- In both cases:
 - Slightly higher deflection
 - Forces on glass are more concentrated → higher local stress

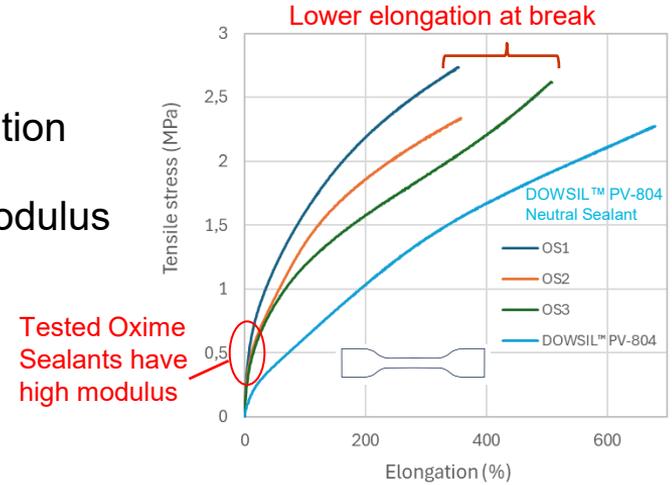
SEALANT FAILURE CAN ALSO CAUSE DELAMINATION

- Water often remain at lower edge of module for significant time
- Loss of sealant adhesion → water penetrates down to encapsulant → reacts with chemical bonds between glass and encapsulant → delamination → corrosion and loss of insulation



NOT ALL FRAME SEALANTS ARE BORN THE SAME

- Commonly used PV sealants are based on oxime chemistry
- Formulated to be stiff (high modulus) material. Lower elongation
- Reference sealant has alkoxy chemistry and has medium modulus



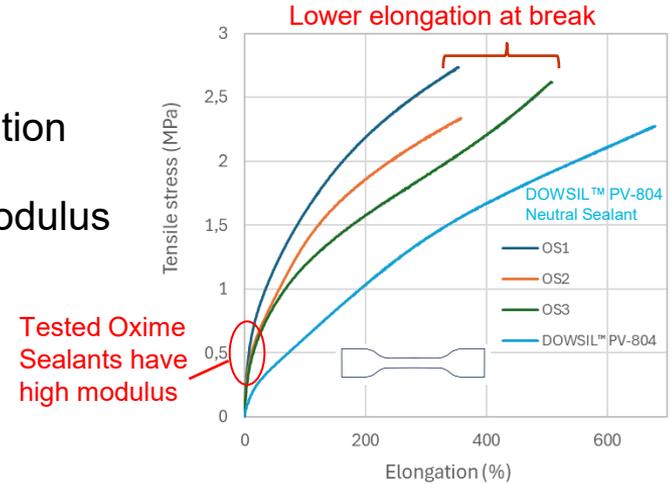
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- Adhesion quality of some sealants appears variable

Lap shear tests



	As cured		1 week water immersion	
	Shear strength (MPa)	% cohesive failure	Shear strength (MPa)	% cohesive failure
OS2 batch A	0.65	83%	0.61	0%
OS2 batch B	1.56	100%	1.42	100%
OS3 batch A	1.44	100%	1.16	40%
OS3 batch B	1.43	100%	1.42	88%



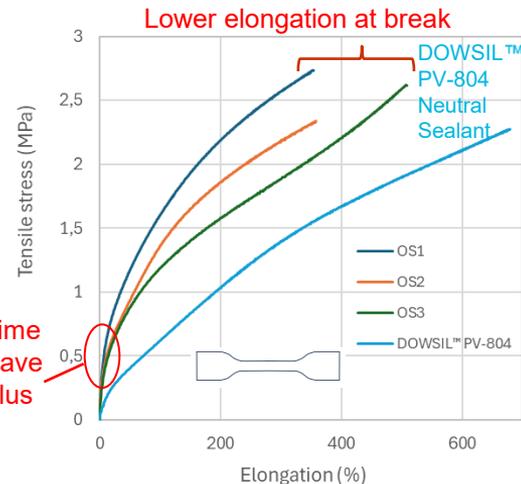
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Tested Oxime Sealants have high modulus

Two batches of the same material can have very different properties: aging during transport and storage, manufacturing problems?

NOT ALL FRAME SEALANTS ARE BORN THE SAME

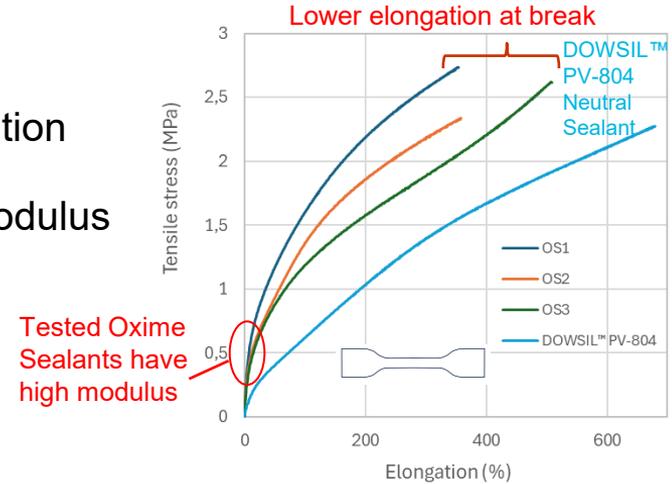
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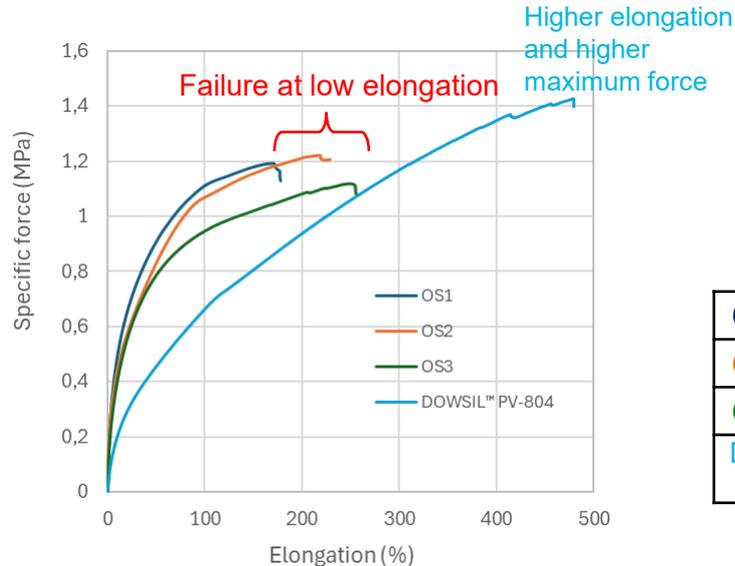
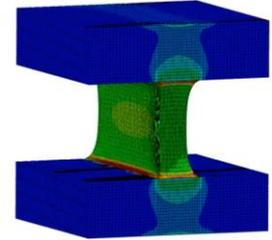
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Issues get revealed during water immersion, typically not detected during incoming inspection



SEALANT PERFORMANCE UNDER COMPLEX STRESS SITUATIONS

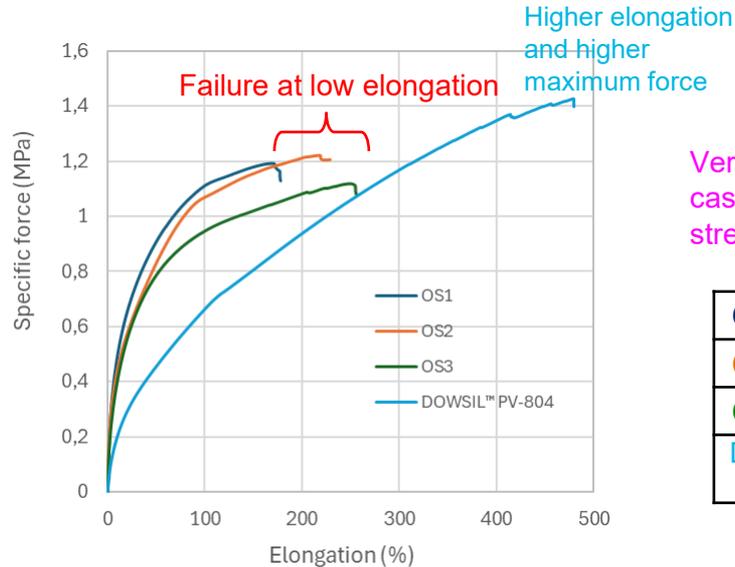
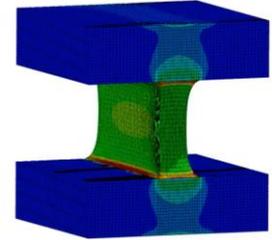
- Real joints undergo complex stress situations in framing application
- Tensile tests on H-bar samples produce complex stress patterns combining shear and tensile stresses



	First campaign, glass-Al		2nd campaign, Al-Al	
	F _{max} (MPa)	Elongation at F _{max} (%)	F _{max} (MPa)	Elongation at F _{max} (%)
Oxime Sealant 1	1.20	72	1.20	157
Oxime Sealant 2	0.59	126	1.22	203
Oxime Sealant 3	1.18	101	1.14	243
DOWSIL™ PV-804 Neutral Sealant	1.3	489	1.45	478

SEALANT PERFORMANCE UNDER COMPLEX STRESS SITUATIONS

- Real joints undergo complex stress situations in framing application
- Tensile tests on H-bar samples produce complex stress patterns combining shear and tensile stresses

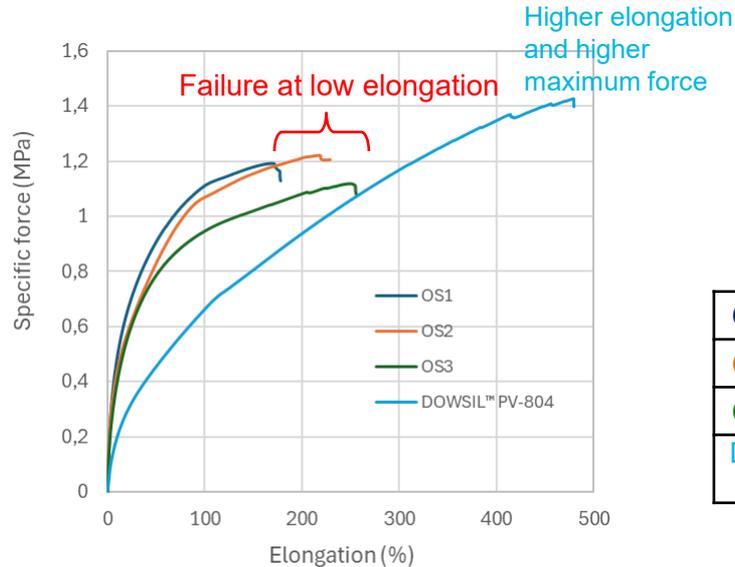
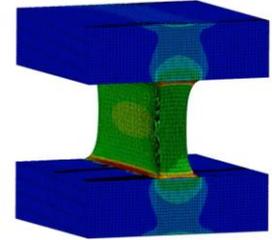


Very low elongation in case of complex stress situation

	First campaign, glass-Al		2nd campaign, Al-Al	
	F _{max} (MPa)	Elongation at F _{max} (%)	F _{max} (MPa)	Elongation at F _{max} (%)
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Two batches of the same material have very different properties



Typical values, not to be construed as specifications. Users should confirm results by their own tests.

FRAME SEALANTS: CONCLUSIONS

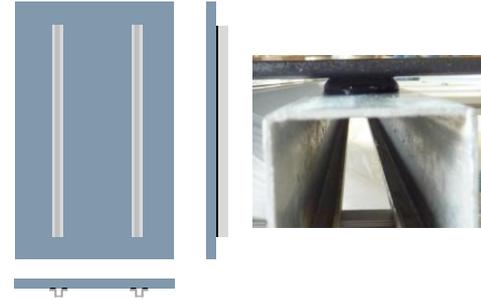
- Frame sealants play a critical role in limiting stress in glass at edges
- Recent PV module trends pose larger demands on sealants
- Failure of sealant can lead to glass breakage and water infiltration ultimately resulting in corrosion and loss of insulation
- Common oxime PV sealants are stiff materials with poor elongation in complex stress situations
- There is some evidence of materials properties variability for some producers



Rail bonding adhesives

RAIL BONDING

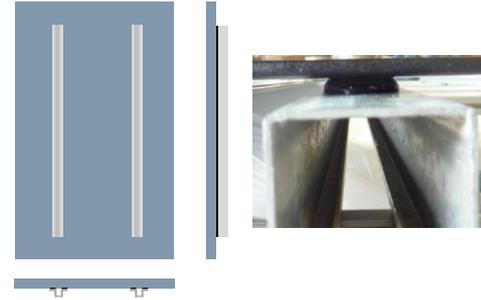
- In some PV technologies, bonding glass-glass laminates to rails with structural adhesive preferred to frame with U-profile
- Common on thin-film PV modules and some BIPV components
- Emergence of crystalline Si PV modules with glass-glass structure and edge seal → also applicable for future standard modules?
- Advantages:
 - Frameless, less metal → potential cost savings
 - Higher, well-controlled adhesive thickness
 - Allows more movement than anchoring in frame
 - Structurally well-understood problem



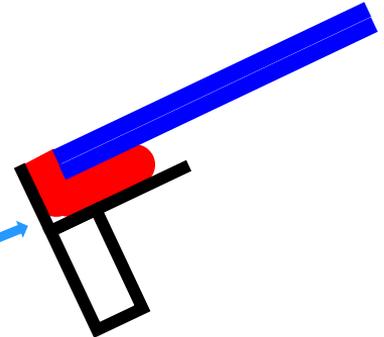
} Lower risk of glass breakage

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 - Frameless, less metal → potential cost savings
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 - Structurally well-understood problem
- Frame bonding possible also possible with this technology



} Lower risk of glass breakage

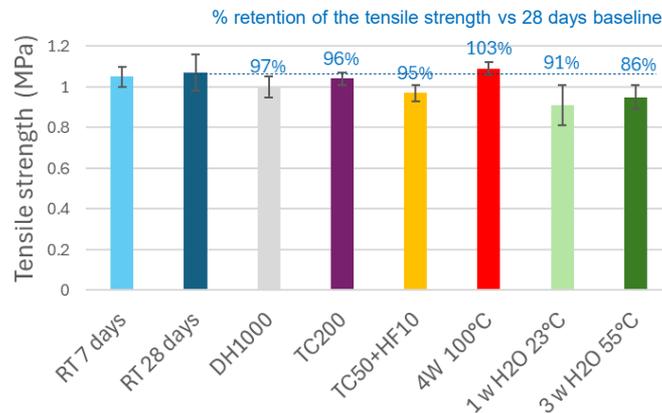


STRUCTURAL BONDING OF GLASS IS A SUCCESSFUL TECHNOLOGY

- Similar technology used for more than 50 years in structural glazing
- Structural glass adhesives are high performance materials with strict quality assurance
- Structural joint design requires dedicated technical knowledge
- PV structural adhesives launched 15 years ago, strong track record
- Excellent durability in construction accelerated tests, PV accelerated tests and in the field



H-bars:
glass/
DOWSIL™ PV-8301 Fast Cure Sealant/
Anodized Al



Typical values, not to be construed as specifications. Users should confirm results by their own tests.



Junction box potting agents

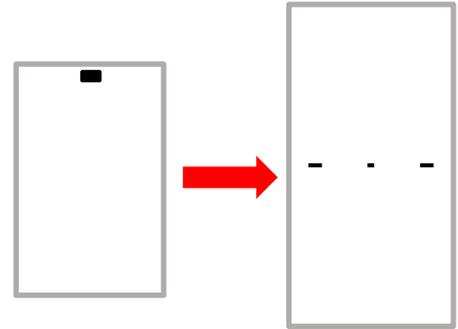
POTTING AGENTS

- Material used to fill junction boxes
- Almost always a silicone material
- Function:
 - Protects electrical components against corrosion and moisture
 - Offers electrical insulation and arcing protection
 - Helps enable dissipation of heat
 - Key component for fire prevention
- Requirements
 - Low viscosity
 - Fast cure
 - Good and durable adhesion to junction box material
 - Good thermal conductivity

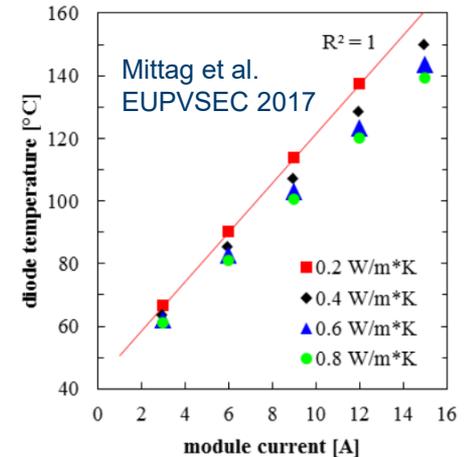


RELIABILITY OF J BOX RELIES ON GOOD THERMAL MANAGEMENT

- Module size ↑, J box size ↓, currents: 9 A → 14 A → 18 A
- Heat has to dissipate away from bypass diode, through potting agent, to junction box walls
- High temperature of bypass diode can lead to long term and sometimes catastrophic degradation (e.g. thermal runaway)
- High thermal conductivity → lower diode temperature → lower risk of diode-related problems
- Diode tests in IEC standards do not cover all situations that do occur in the field
- Not all potting agents are born the same:



	Thermal conductivity (W/m K)	UL94 flame class (3 mm)
Potting agent 1	0.3×10^{-6}	HB
Potting agent 2	0.3×10^{-6}	V-0
Potting agent 3	0.4×10^{-6}	V-1
Dowsil™ PV-7326	0.54×10^{-6}	V-0



Typical values, not to be construed as specifications. Users should confirm results by their own tests.

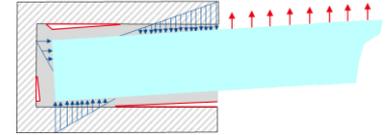
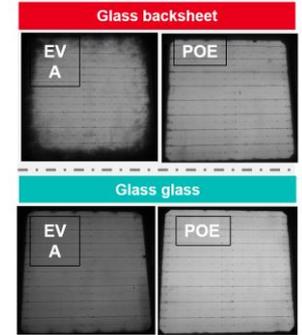




Conclusions

CONCLUSIONS

- Polymeric module materials have a large impact on the reliability, durability and safety of PV modules
- Materials need to be selected carefully for long-term high performance
- Small immediate savings on materials can lead to major problems in the field and to financial losses
- It is important to look beyond IEC certification
- Dow can provide advice, insights and testing for your material selection



	Thermal conductivity (W/m K)	UL94 flame class (3 mm)
Potting agent 1	0.3×10^{-4}	HB
Potting agent 2	0.3×10^{-4}	V-0
Potting agent 3	0.4×10^{-4}	V-1
Dowell™ PV-7326	0.54×10^{-4}	V-0



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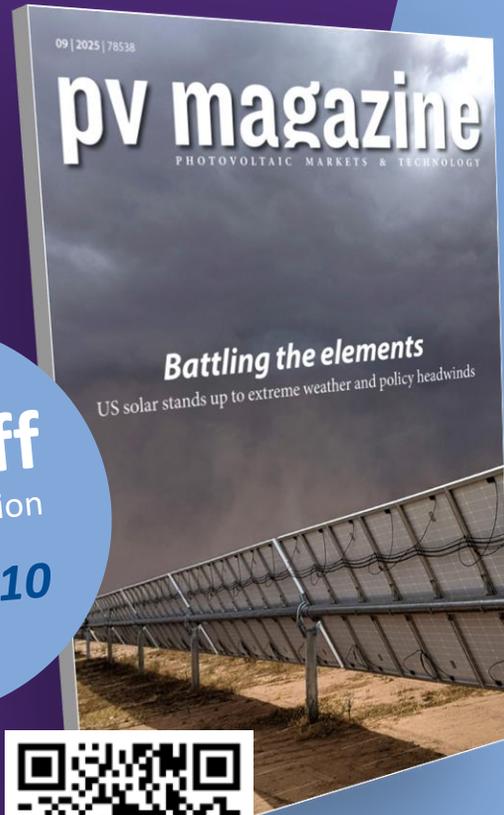
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