Development of a Low Cost Ultra Specular Advanced Polymer Film Solar Reflector

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Outline

- Project Description
- Objectives
- Innovative Approach
- Key Technical Results
- Significance of Results
- Future Work Planned

Project Description

- Low-cost reflectors critical to achieve SunShot cost goals
- Benefits of advanced thin-film reflectors
  - Light weight
  - Low-cost
  - High design flexibility
  - Unbreakable
  - Ease of transportation and field installation
- Solution: development of an ultra-specular advanced (USA) polymer-based front surface reflector (FSR)

Objectives

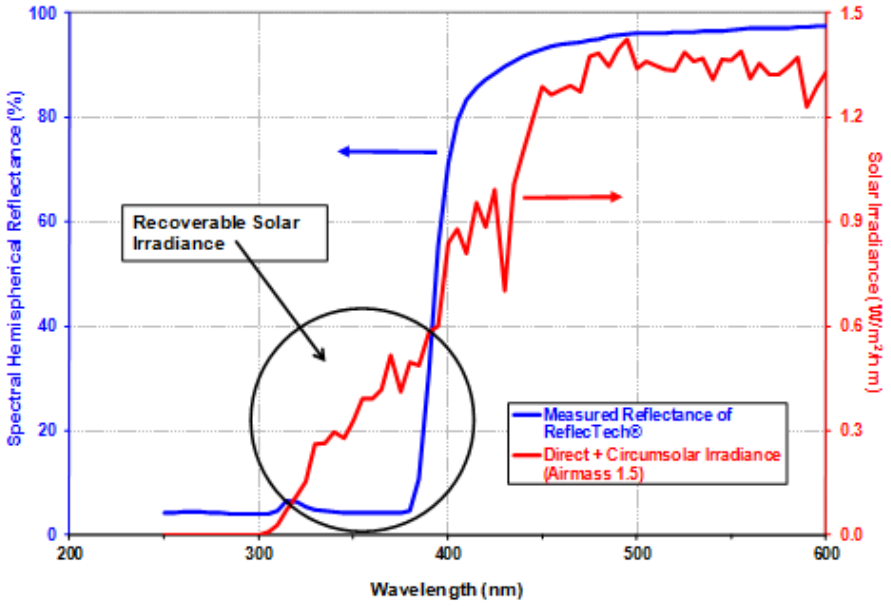
- Increase reflectance (~1% greater)
- Improve specularity ($\leq$1 mrad)
- Maintain service lifetime (30+ y)
- Reduce cost

Innovative Approach

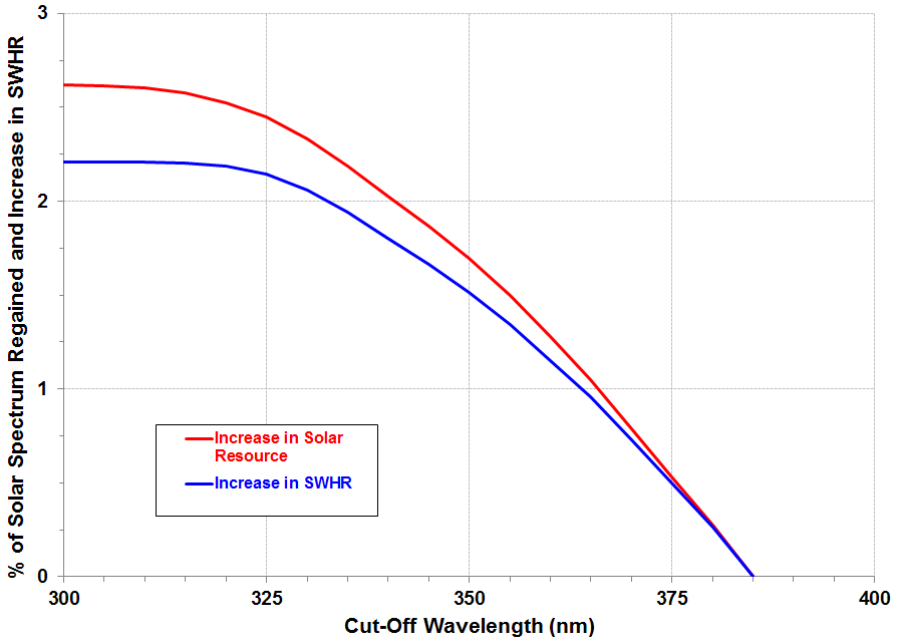
- Front surface construction results in fewer layers to absorb or scatter sunlight
  - Increased reflectance
  - Improved specularity
- UV-curable ARC applied above silver
  - Formulated to further reduce spectral absorption & increase reflectance
  - Provide weatherability
- Reduced material content and film layers
  - Significant cost savings
  - Improved specularity

Re-Formulation of ARC for Increased Reflectance

Can increase SWHR by 1-1.5%:



Spectral Reflectance of ReflecTech® Mirror Film and Terrestrial Solar Irradiance



% of Solar Spectrum Regainable as function of λ_{CutOff}, and Increase in SWHR

Key Technical Results

- Performed screening tests of candidate ARC formulations that potentially adhere directly to silver
- Deposited self-assembled monolayers (SAMs) on silver to promote adhesion
- Samples of ARC formulations with optimized UV screening properties have been prepared and subjected to accelerated exposure conditions
- A project-related patent application has been filed

Adhesion Promotion Methods

- Modify ARC for direct adhesion to silver
- Incorporate adhesion-promoting additives
- Use of organic primer layer
- Transparent metal oxides
- Multi-Layer ARC
- Self-Assembled Monolayers (SAMs)

Direct ARC/Ag Adhesion

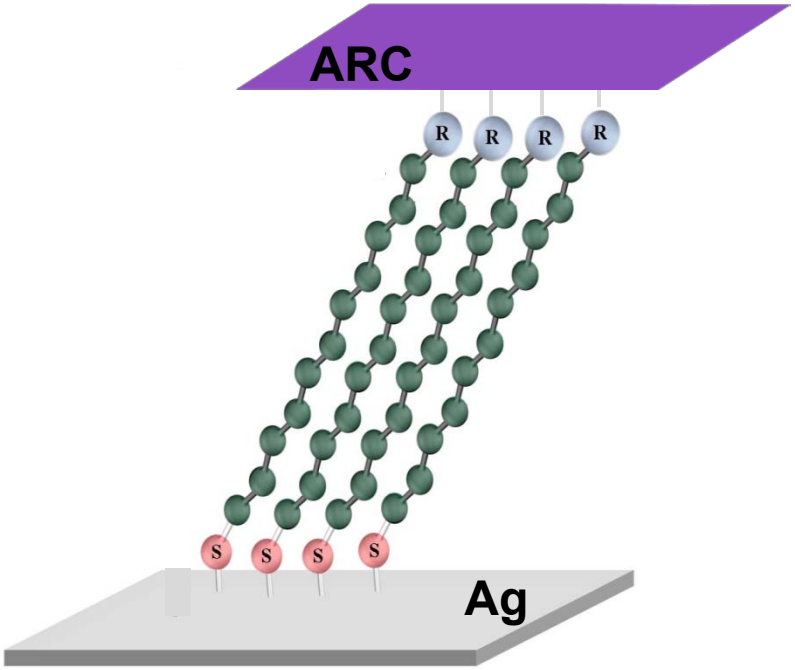
- 7 base abrasion resistant coating (ARC) formulations screened for direct adhesion to Ag
  - If adhered did not provide abrasion resistance
  - If abrasion resistant then did not adhere
  - One had adhesion and abrasion resistance but not outdoor weatherable
- Continued efforts to improve adhesion
  - Incorporate acidic adhesion promoters
  - Addition of lower functional monomers / oligomers

Adhesion of Dual-Layer ARC

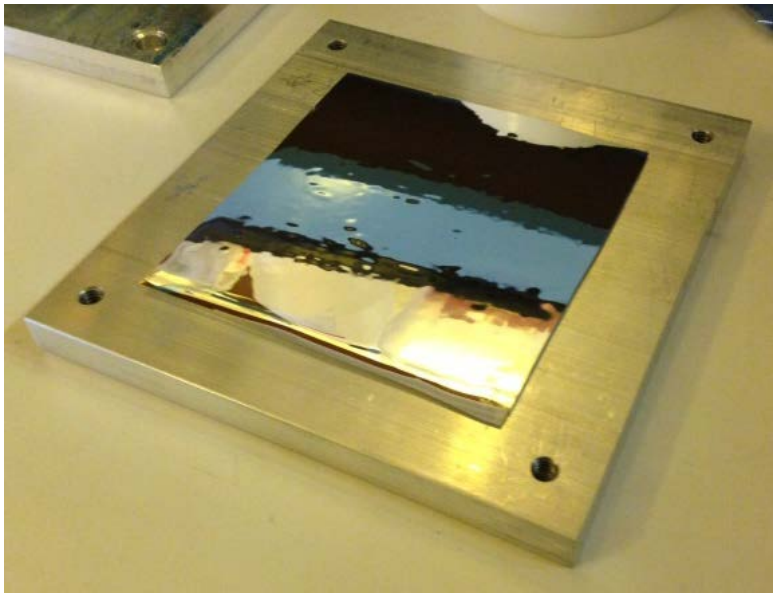
- Initial success with dual-layer ARC system
  - First layer adheres to silver but no abrasion resistance
  - Top layer provides abrasion resistance, adheres to underlayer, and is weatherable
- Increased reflectance demonstrated

Self-Assembled Monolayer Bonding Agents

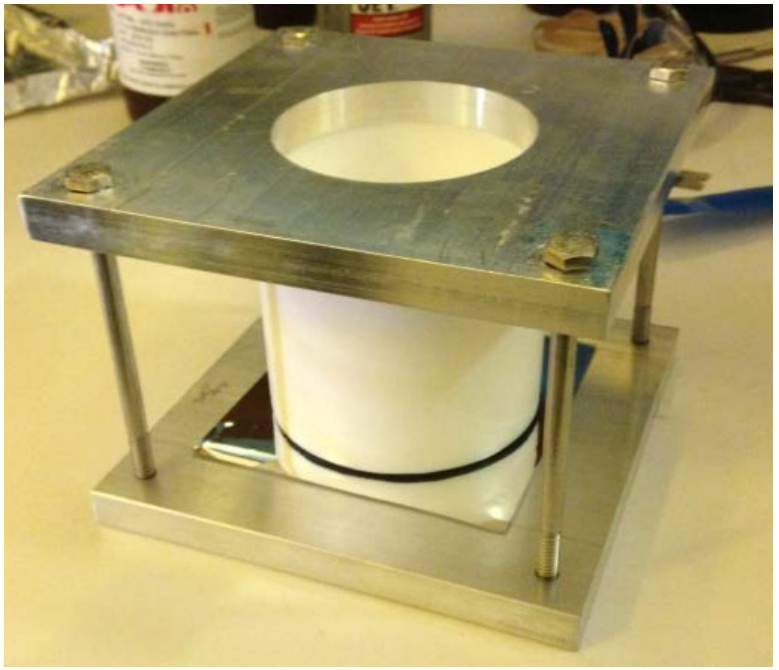
- SAMs can chemically functionalize the silver surface to control and customize adhesion properties
- Allows design of the silver surface to promote adhesion with the ARC
- Highly passivates the silver surface to prevent corrosion
- Reactive terminal end tailored for adhesion to ARC



Solution Deposition of SAMs on Ag-PET Substrates



Sample silver-surface substrate



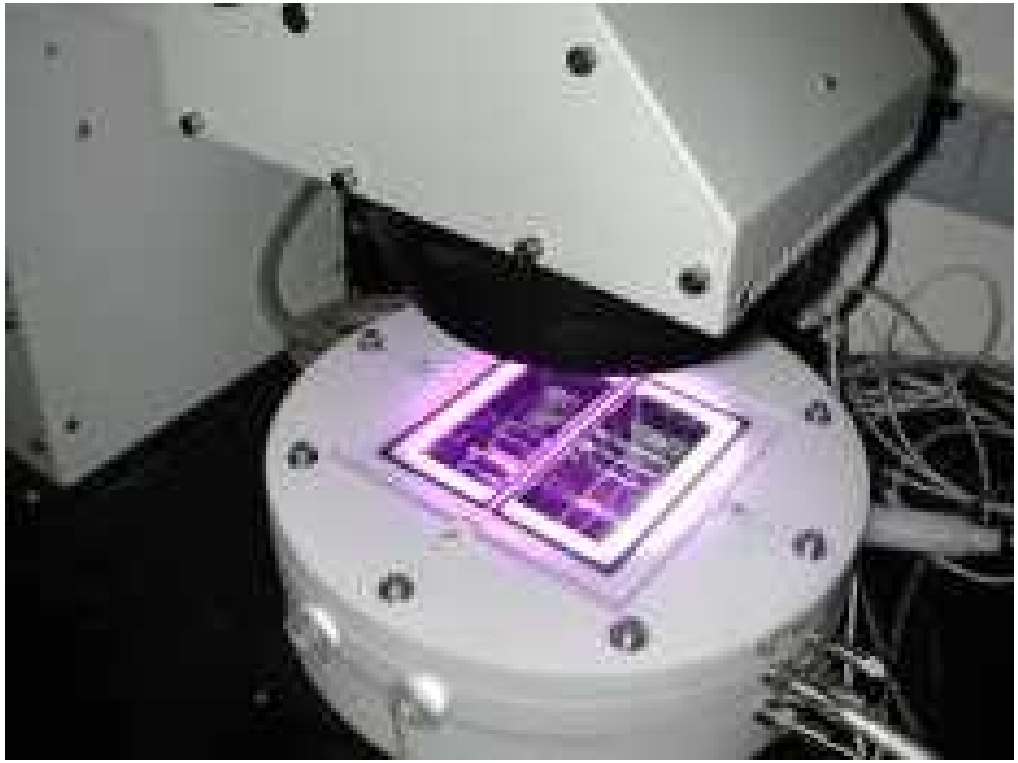
Attachment of reactor fixture for application of SAM to substrate

Solution Deposition of SAMs on Ag-PET Substrates

- Standard solution deposition techniques used to form SAMs on Ag-PET substrates
  - 4 SAM chemistries with unique adhesion properties deposited onto Ag-PET
  - Sufficient quality achieved
- Improved ARC wetting and coating uniformity on substrates observed
- Improved terminal chemical functionalities for ARC adhesion assessed
- Preliminary testing of ARC coating and adhesion to the SAM-modified Ag-PET substrates is under way

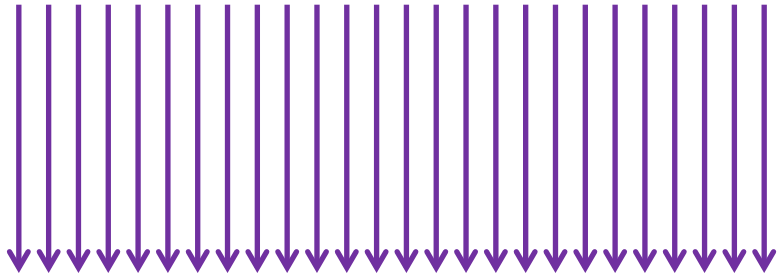
Accelerated Testing of ARCs

- NREL solar simulator chamber
  - 2X terrestrial UV intensity
  - 25°C
  - <5% relative humidity
- 4 ARC formulations coated onto quartz substrates
- $\tau(\lambda)$ measured as a function of UV exposure to determine sample weatherability

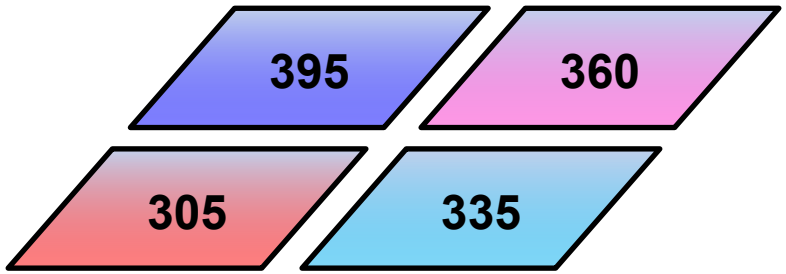


Activation Spectra Screening Tests

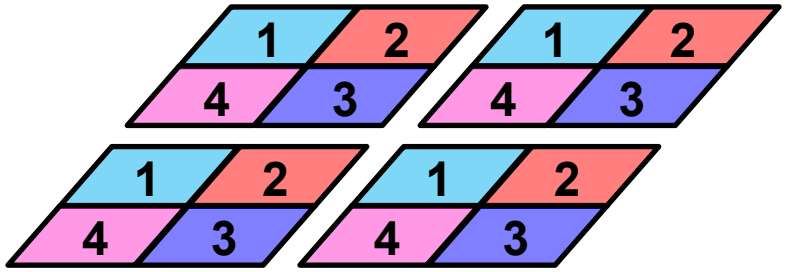
Incident UV Light



4 UV Cut-Off Filters



4 sets of 4 ARC Formulations (1 set per Filter)



- ARC formulations must survive light exposure & protect underlayers
- Samples shielded by a series of sharp cut-off filters
- Determine spectral absorption bands important for outdoor durability

Future Work Planned

- Modification of photo initiator concentration and selection to fortify ARC formulation for exterior durability will be investigated
- ARC formulations that maintain adhesion during accelerated humidity exposure will be prepared for the next level of silver-adhesion and weathering experiments
- Optimal ARC formulations will be selected based on activation spectra experiments and adhesion screening experiments
- Accelerated exposure testing of ARC-SAM-Ag-PET samples will be performed