



# **Durability and Accelerated Aging Test of the Polymeric Mirror-Film Prototype**

## **Cooperative Research and Development Final Report**

**CRADA Number: CRD-21-17856**

**NREL Technical Contacts: Guangdong Zhu and Tucker Farrell**

**NREL is a national laboratory of the U.S. Department of Energy  
Office of Energy Efficiency & Renewable Energy  
Operated under Contract No. DE-AC36-08GO28308**

**Technical Report  
NREL/TP-5700-93249  
July 2025**

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## Cooperative Research and Development Final Report

**Report Date:** February 7, 2025

In accordance with requirements set forth in the terms of the CRADA agreement, this document is the CRADA final report, including a list of subject inventions, to be forwarded to the DOE Office of Scientific and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

**Parties to the Agreement:** Hawai'i Innovation Laboratory (HIL)

**CRADA Number:** CRD-21-17856

**CRADA Title:** Durability and Accelerated Aging Test of the Polymeric Mirror-Film Prototype

**Responsible Technical Contact at NREL:**

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**Sponsoring DOE Program Office(s):**

Office of Energy Efficiency and Renewable Energy (EERE), Solar Energy Technologies Office

**Joint Work Statement Funding Table showing DOE commitment:**

Estimated Costs	NREL Shared Resources a/k/a Government In-Kind
Year 1	\$35,000.00
Year 2, Modification #1	\$0.00
TOTALS	\$35,000.00

**Executive Summary of CRADA Work:**

The participant is developing a low-cost liquid metal coating for concentrated solar power (CSP) polymeric mirrors. Current CSP technology uses bulky and costly glass mirrors. As a lighter alternative, polymeric mirror film is cheaper than glass mirrors, yet expensive to manufacture. The participant is working to develop a room temperature liquid-metal thin-film deposition technique and CSP polymeric mirror film that will reduce expenditures by 80% and film cost by 50%.

## **CRADA benefit to DOE, Participant, and U.S. Taxpayer:**

- Assists laboratory in achieving programmatic scope, and/or
- Uses the laboratory's core competencies.

## **Summary of Research Results:**

### **TASK DESCRIPTIONS:**

#### **Purpose**

NREL will provide durability and accelerated aging test of the polymeric mirror film prototype.

#### **Statement of Work and Task Descriptions**

**The participant will complete the following tasks:**

#### **Task 1:**

The participant will participate in a monthly check-in with the NREL Principal Investigator. If a check-in meeting is missed two months in a row, the agreement may be cancelled by the American- Made Challenges Solar Prize team.

#### **Task 1 Results:**

The participant met with the NREL Principal Investigator (PI) virtually and via email for check-ins and discussions on experiment details and results. The participant integrated the feedback to improve the prototype, followed by re-prototyping and re-testing the new mirror film prototype.

Also, during these discussions, the participant requested to rescope the tasks for specular reflection measurement of the mirror film prototype for multiple iterations of the prototype. The feedback received was integrated to improve the prototype, followed by re-prototyping and re-testing of the new mirror film prototype.

#### **Task 2:**

Prototype and characterize Liquid Metal (LM) mirror films at Sandia National Laboratories user facilities in the Center for Integrated Nanotechnologies (CINT).

#### **Task 2 Results:**

This task was completed by the participant in collaboration with the Sandia Solar Thermal Group at CINT. The mirror film prototyped at CINT was used for tasks 3 and 4.

### Task 3:

Send the prototype film along with the technical data to NREL for durability and accelerated aging tests.

### Task 3 Results:

The participant, HIL, has prototyped the LM mirror film and sent us various mirror films from 3M, Reflectech, and their own prototype for specular, diffuse, and hemispherical reflectance measurements. The NREL team conducted the reflectance measurements and provided a written report with recommendations. HIL iterated on their LM film based on the feedback received and resubmitted the improved prototypes for further testing that has been completed by NREL.

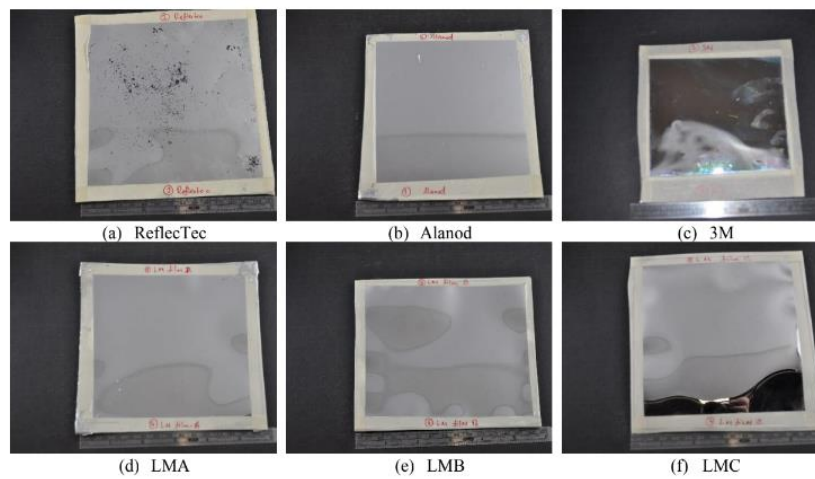


Figure 1 Sample photos as received. This is prior to any washing or additional handling.

Table 2. Standard initial characterization measurements

Instrument	Measurements	Method
<b>Reflectometer SOC Solar 410</b>	16 readings	Locations laid out in evenly spaced grid across sample surface
<b>Reflectometer D&amp;S 15-RGB</b>	5 readings at each of 34 apertures – 46, 25, 15 and 7 milliradians	5 locations – central, and at each corner. Use each aperture at each location.
<b>Spectrophotometer L1050</b>	Not used	Not used
<b>Cary 7000</b>	2 readings each, hemispherical and diffuse	1 spot each, multiple readings only to capture measurement discrepancy

Table 3. Measurement results of thin-film samples. All measurements in % Reflectance

Measurement	ReflecTec	Alanod	3M	LMA	LMB	LMC
<b>Solar-Weighted Reflectance – Specular (Cary 7000)</b>	77.8	87.1	87.8	68.6	72.3	72.3
<b>Solar-Weighted Reflectance – Diffuse (Cary 7000)</b>	15.1	2.7	3.2	9.4	5.9	5.7
<b>Solar-Weighted Reflectance – Hemispherical (Cary 7000)</b>	92.9	89.8	91.1	78.0	78.2	77.9

#### Task 4:

Revise the material choice and fabrication protocol based on the test results, incorporate the test result in the new prototype, and send it to NREL for testing.

#### Task 4 Results:

HIL revised their prototype protocol and sent a second batch of samples for reflectance measurement, which has been completed by NREL.

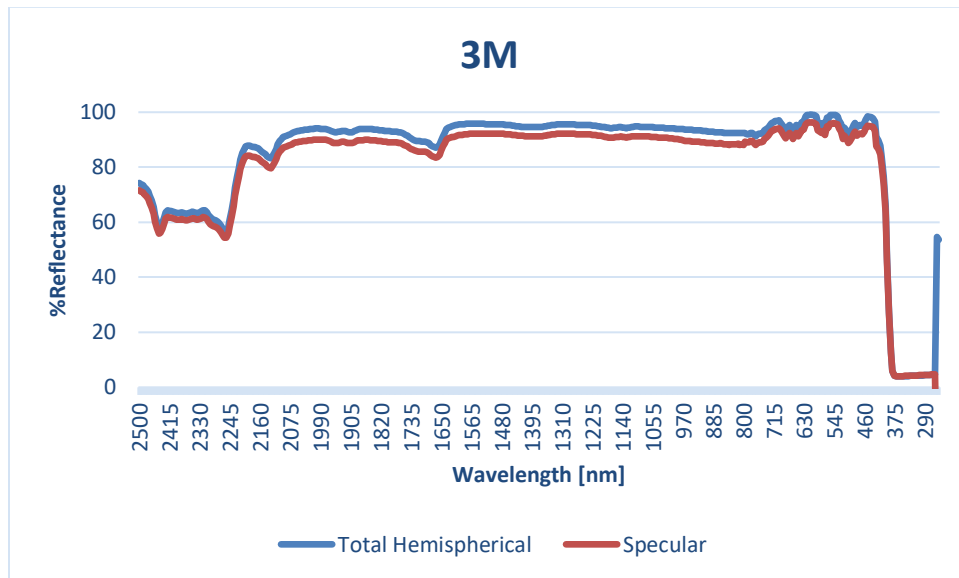
#### NREL will complete the following tasks:

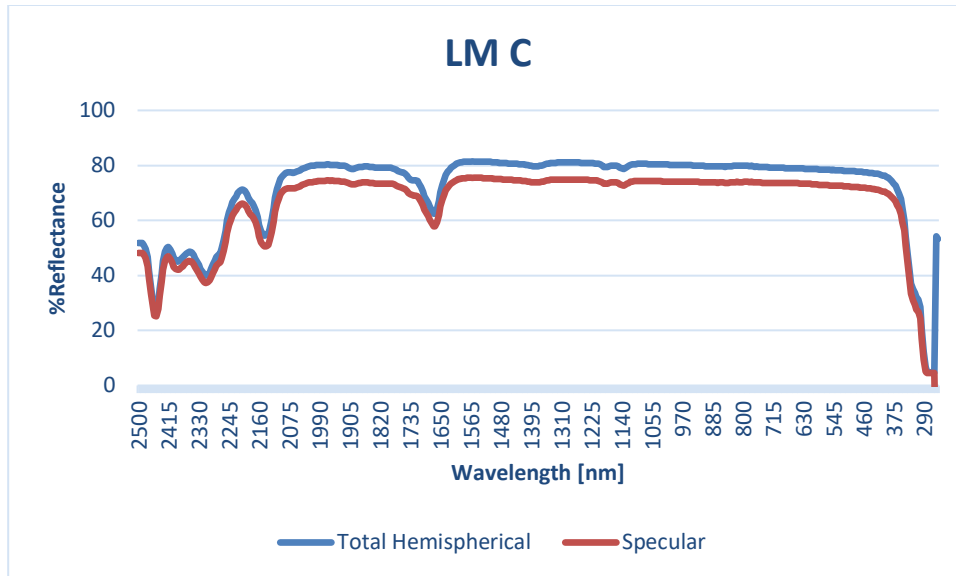
#### Task 5:

Measure full reflectance characterization (hemispherical and specular reflectance over solar spectrum) of the version-1 prototype films (with three samples, 10 cm x 10 cm).

#### Task 5 Results:

NREL measured the hemispherical and specular reflectance of 5 provided samples using an Agilent Technologies Cary spectrophotometer. The specular reflectance was derived from using the specular exclusion port on the instrument. Example results are shown below for an industry-standard 3M thin film and the experimental “LM” film.





See results for tasks 6, 7, and 8 below.

**Task 6:**

Test the key durability tests, including resistance to UV degradation (3 samples, 2-months tests, initial and final reflectance measurements), sand-like abrasion resistance (3 samples, initial and final measurements), and interlayer delamination (3 samples, score at center, AFM characterization).

**Task 7:**

Report the key durability concerns to the participant and advise for improvement.

**Task 8:**

After the key durability concerns are addressed by the participant, NREL will test the version-2 samples for accelerated aging, such as corrosion/yellowing (BlueM), radiative degradation/moisture resistance/thermal degradation (Ci5000, 3 months – 2 test conditions, 2 initial/final full reflectance characterization, 6 intermediate SOC reflectance measurements).

**Task 6-8 Results:**

The participant, HIL, prioritized improving the reflectivity of the mirror film over weatherability and durability testing. Consequently, they did not develop or send the mirror film for weatherability testing.

**Task 9:**

NREL agrees to provide the following to the DOE Office of Scientific and Technical Information (OSTI): (1) an initial abstract suitable for public release at the time the CRADA is executed; (2) a final report, within thirty (30) days upon completion or termination of this CRADA, to include a list of Subject Inventions; and (3) other scientific and technical information in any format or medium that is produced as a result of this CRADA.

**Task 9 Results:**

This report serves to meet the requirement for the CRADA Final Report with preparation and submission in accordance with the agreement's Article X.

**Subject Inventions Listing:** None.

**ROI #:** None.