Low-Cost, Advanced Metallization to Mitigate Cell-Crack-Induced Degradation

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DuraMAT Capabilities

1. Data Management & Analytics, DuraMAT Data Hub
2. Predictive Simulation
3. Advanced Characterization & Forensics
4. Module Testing
5. Field Deployment
6. Techno-Economic Analysis

Industry Goals

- Produce screen-printable silver ink with crack-tolerance to substrate fractures.
- Incorporate low-cost, multi-walled carbon nanotubes for electromechanical reinforcement.
- Develop capability to electrically bridge cracks forming in PV cells for increased lifetime.
- Reduce LCOE by lowering cell degradation rate.

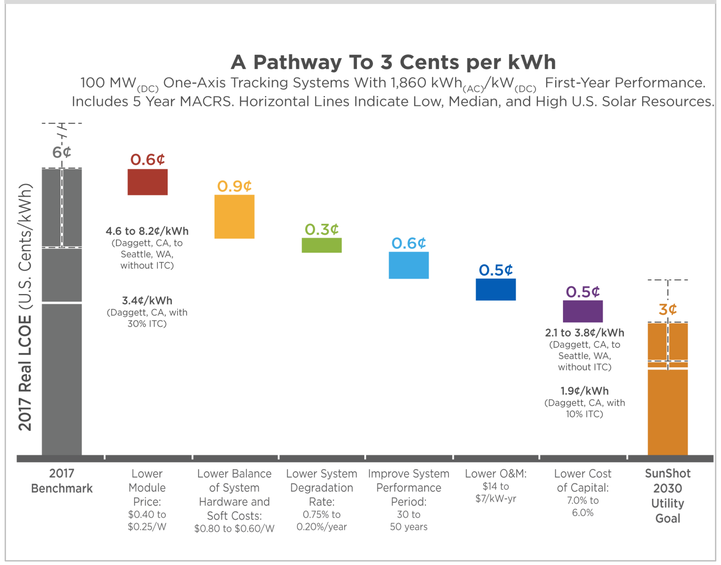
Accomplishments

- Successfully formulated CNT-enhanced silver paste using commercial DuPont paste, matching both the viscosity and fineness of grind.
- Demonstrated CNT-enhanced metallization can bridge > 70 µm gaps with ability to "self-heal" 20 µm gaps.
- Control over fracture toughness of metal lines through CNT incorporation.
- Printed and fired specialty MetZilla™ paste on *PERC* cells, with an efficiency of 20.58%.

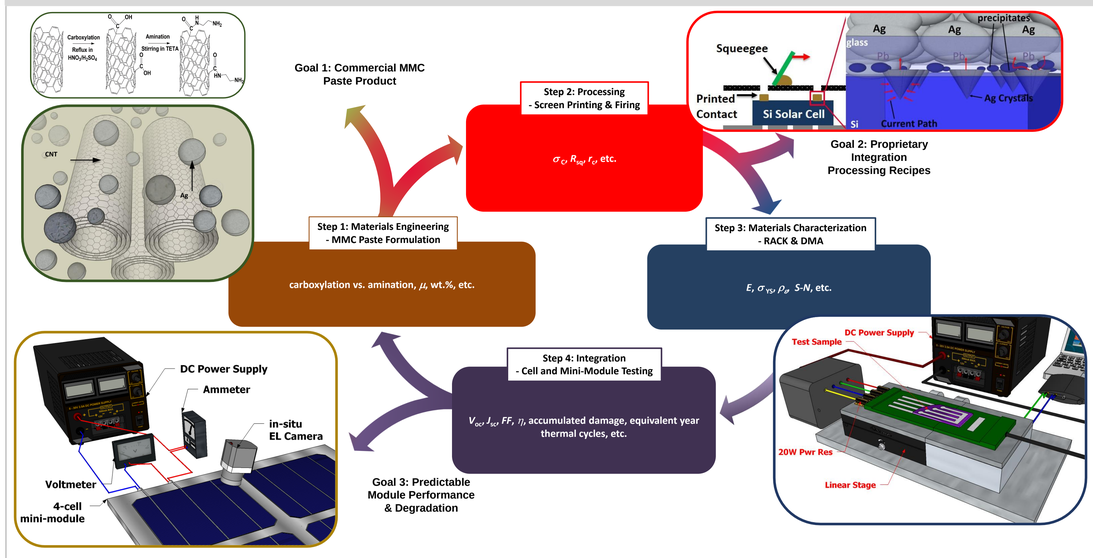
Outcomes and Impact

- Demonstrate increased module reliability against stress-induced cell fractures.
- Make specialized paste products available for integration on commercial Si PV modules.
- Target future partnerships with cell production companies.
- Provide new materials and integration solutions for terrestrial PV.

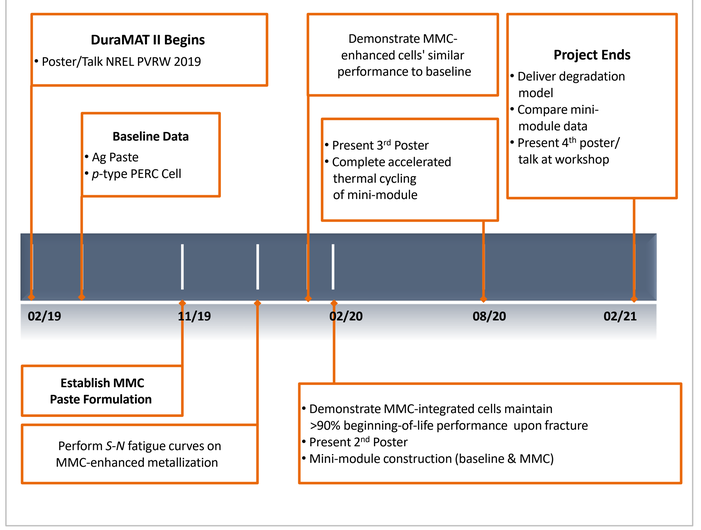
Cost Drivers



Capability Development

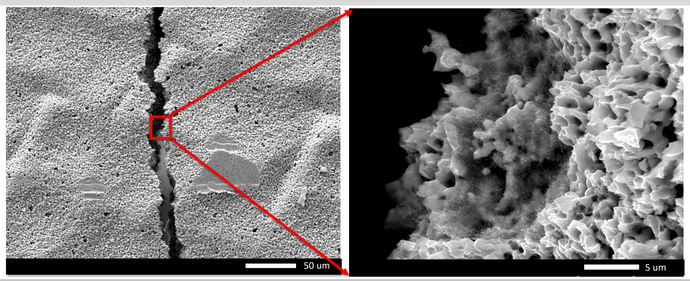


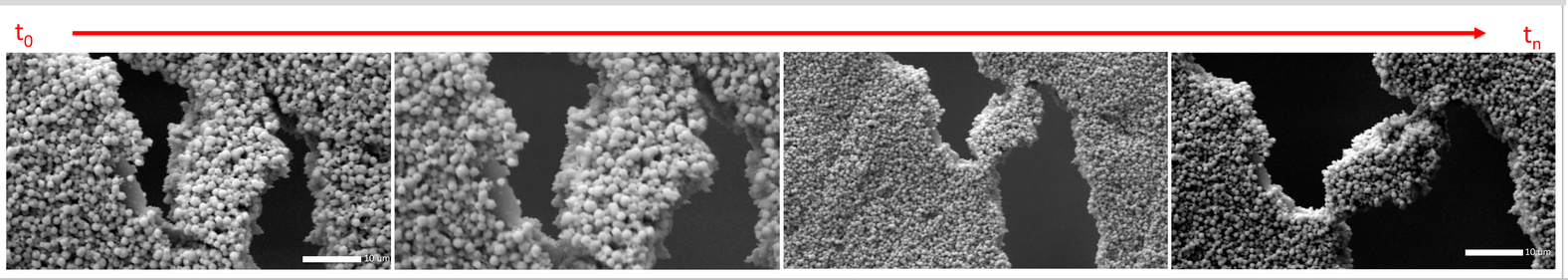
Project Timeline



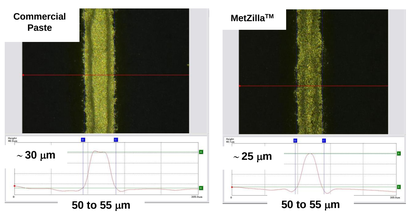
Materials Characterization

In Situ Scanning Electron Microscopy During Strain Test

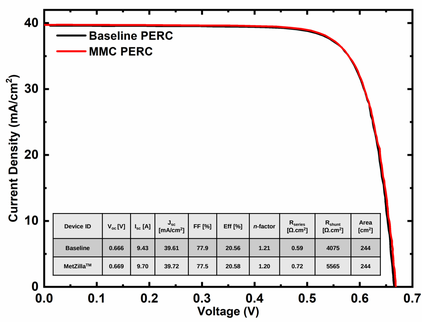




Screen Printing & Light *IV*

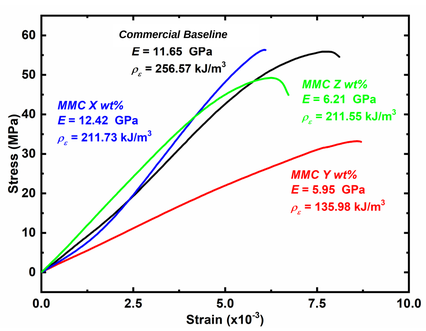


	R_s (Ω.cm²)	$R_{face\text{-}to\text{-}face}$ (Ω.cm²)	Laydown Weight Wet (g)	Laydown Weight Dry (g)
Commercial Paste	7.800	0.041	0.161	0.130
MetZilla™ Paste	8.700	0.056	0.151	0.115 – 0.125



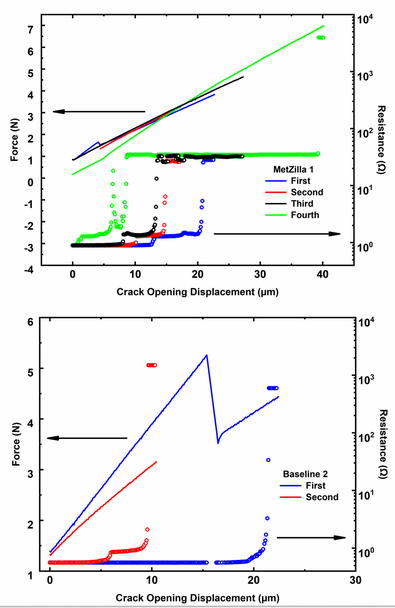
Device ID	V_{oc} [V]	I_{sc} [A]	J_{sc} [mA/cm²]	FF [%]	Eff [%]	n-factor	R_{series} [Ω.cm²]	R_{shunt} [Ω.cm²]	Area [cm²]
Baseline	0.666	9.43	39.61	77.9	20.56	1.21	0.59	4075	244
MetZilla™	0.669	9.70	39.72	77.5	20.58	1.20	0.72	5565	244

Dynamic Mechanical Analysis (DMA)

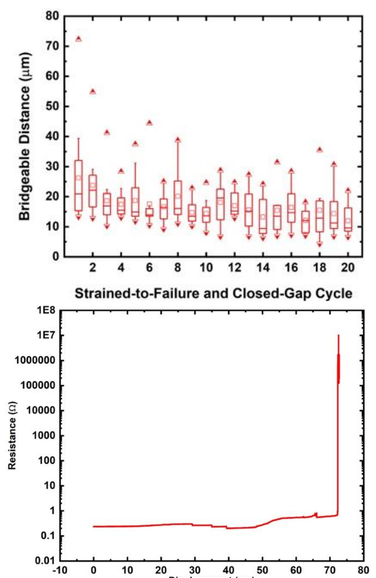


- ✓ Control over mechanical performance with various CNT concentrations.
- ✓ Strain energy density can be maximized with optimal CNT incorporation.
- ✓ Cell performance of MetZilla™ paste is identical to the commercial product.
- ✓ The maximum bridgeable gap exceeds 70 µm.
- ✓ "Self-healing" settles at ~ 20 µm.
- ✓ Bridging phenomena independently verified by NREL and CINT at Sandia National Laboratories.

Three-Point Bending Test



Resistance Across Cleaves and cracKs (RACK)



Summary

Durability by Deliberate Design;
Perfecting a Process that is Engineered to Last

Osazda Energy, LLC. provides materials engineering solutions to improve solar cell and solar module reliability. Our specialized metal matrix composites have been proven to electrically bridge stress-induced cracks that appear in solar cells; the composites also self-heal to regain electrical continuity. As the solar market is rapidly shifting towards thinner platforms for lower costs and making its way into wearable power systems and unmanned aerial vehicle market, our materials engineering solutions promise substantially improved reliability for solar power systems.