SAND2019-9898C

Discover, Develop, and De-Risk module materials, architectures, accelerated testing protocols,data analytics, and financial models to reduce the LCOE of solar energy

Field Module Study and Non-Destructive Field Testing

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SAND2019-____ C
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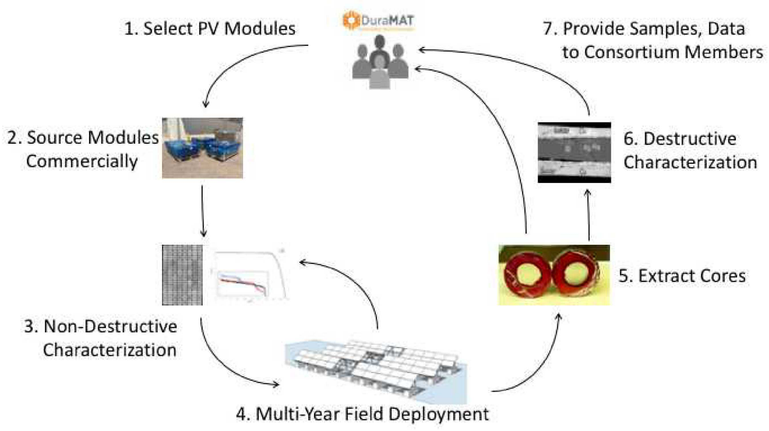
Field-Aged Module Library

Characterize material degradation from natural aging in commercially relevant PV modules.

- Acquire commercially available PV modules from independent vendors
- Deploy alongside existing operational systems for extended timeframe (upwards of 10 years)
- Remove single modules of each type at a fixed interval for destructive characterization to track changes in packaging materials



Group	Manufacturer	Model	Cell Type	Flash, W
1	Jinko	JKM270PP-60	Multi-Si	273 ± 1.0
	Canadian Solar	CS6K-300MS Quintech	Mono-Si	300 ± 1.7
	Hanwa Q-Cells	Q.Peak-G4.1 300	Mono-Si	302 ± 1.2
	LG	LG320N1K-A5	Mono (N)	319 ± 0.6
	Panasonic	VBHN330SA17 HIT	HIT N-type	330 ± 0.4
2	Mission Solar	MSE300SQ5T	Mono PERC	292 + 1.1
	Itek	350 SE	Mono P-type	355 ± 0.8

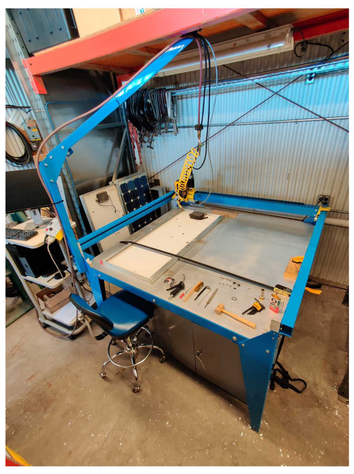
Status

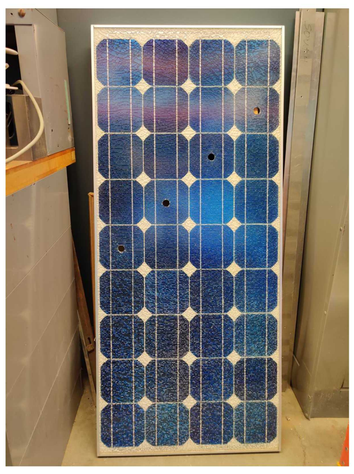
- Group 1 systems commissioned January 2019
- Mission Solar commissioned May 2019
- Itek planned commissioning September 2019
- Subsequent installations on hold pending Years 2 and 3 funding decision

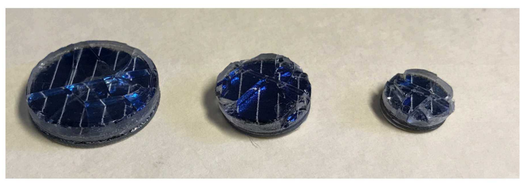
Automated Coring Process

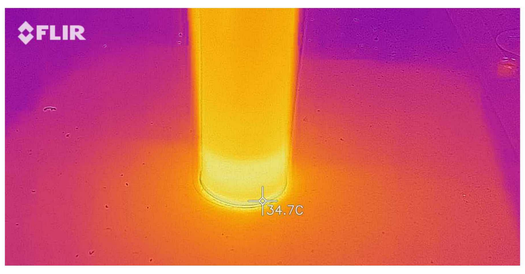
Develop capability to extract samples from modules for destructive characterization

- High throughput to handle large number of modules being processed
- Minimize damage to polymeric packaging materials during extraction







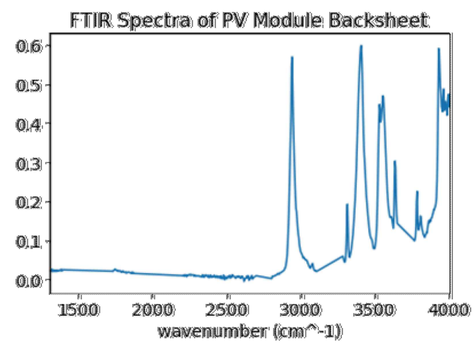


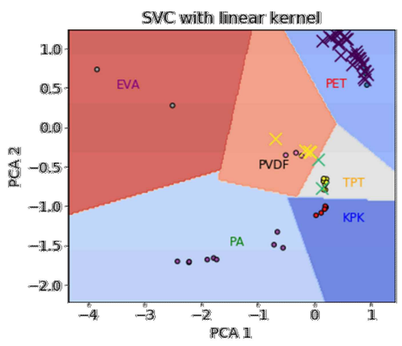
- Modified CNC plasma cutter
- Precise, repeatable sampling location
- Tight process control to avoid overheating, sample damage
- ½" – 1" samples
- ~ 2 samples/hour
- Minimizes operator involvement

Non-Destructive Field Characterization - FTIR

Identify backsheet of fielded modules, track changes with time

- Agilent 4300 Handheld FTIR
- Custom Python analysis methods to classify and identify backsheet





Approach

- Measure FTIR spectra on known backsheet materials
- Measure FTIR spectra on unknown backsheet materials
- Combine data, transform using standard normal variant method and run Principal Component Analysis (PCA).
- Train a Support Vector Machine (SVM) on the PCA results from the known materials.
- Apply the SVM to classify the unknown materials
- Validate the classification graphically
- Add validated classifications to the training set and repeat.

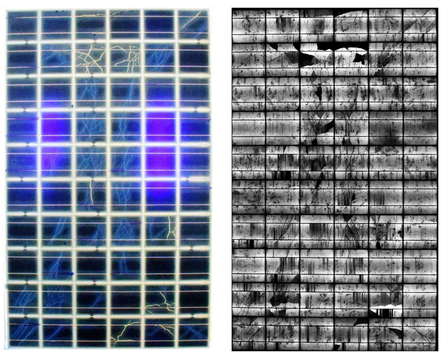
Classification accuracy is expected to improve as more data is added

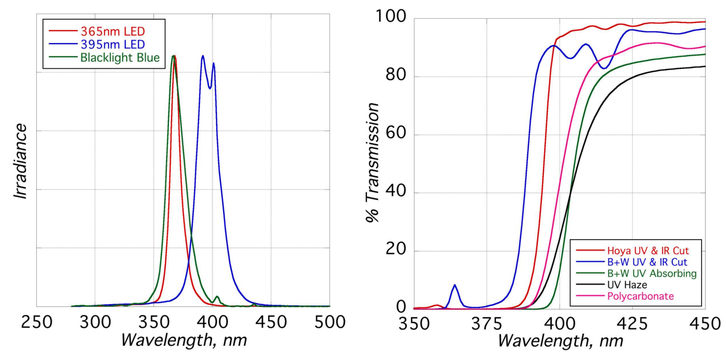
Manufacturer	Model	PVID	Project	Backsheet
Jinko	JKM270PP-60	4174	DuraMAT	TPT
Canadian Solar	CS6K-270P	3247	PVL	PVDF
Canadian Solar	CS6k-275M	3806	PVL	PVDF
Canadian Solar	CS6k300MS	4151	DuraMAT	PVDF
QCells	Q.Peak BLK G4.1 290	3736	PVL	PET
QCells	Q.Plus BFR-G4.1 280	3808	PVL	PET
QCells	Q.Peak-G4.1 300	4137	DuraMAT	PET
LG	LG320N1K-A5	4164	DuraMAT	PET
Panasonic	VBHN330SA17 HIT	4190	DuraMAT	PET
Mission Solar	MSE300SQ5T	4239	PVL/DuraMAT	PET
Trina Solar	TSM-PD05.08 260W	3185	RTC	PET

Non-Destructive Field Characterization – UV Fluorescence

Non-contact method to detect cell cracks and qualitatively assess oxygen diffusion in EVA

- Fluorophore formation during UV exposure leads to visible fluorescence under UV light
- Oxygen diffusion through cracks or around cells quenches fluorescence





- 365nm LED has tightest distribution, may work without additional filter
- Polycarbonate and "Haze" filter provide better filtration than multilayer interference filters
- LED can be powered by battery, facilitating field use

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