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Development of a Spray Deposition Method for a Polysilsesquioxane Coating for PV Modules

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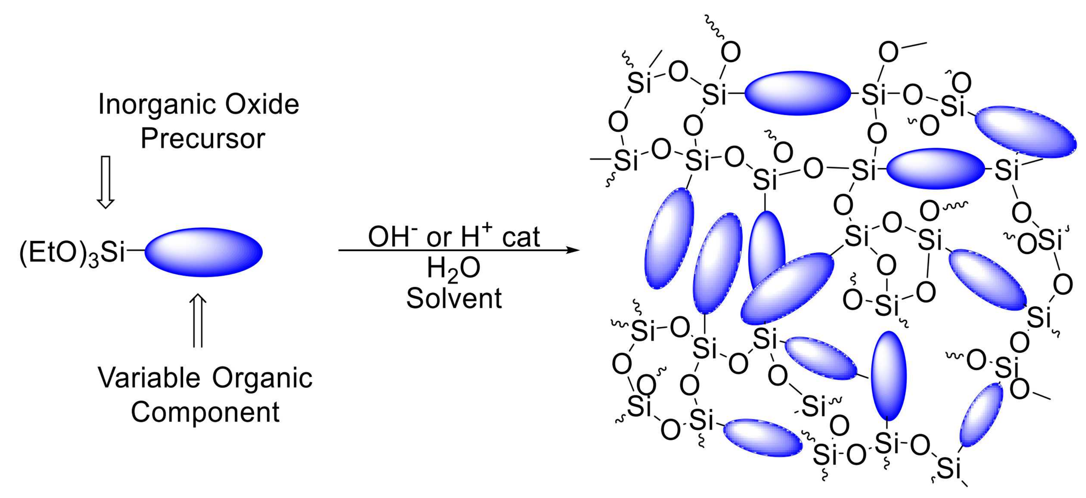
Goals

The goal of this SPARK project is to develop a methodology to spray deposit thin films of commercially available polysilsesquioxanes (PSSQs) precursors onto thin film photovoltaic substrates. The PSSQ coatings would serve as a replacement of the back cover glass. The spray deposition process is highly amenable to manufacturing and replacement of the glass back sheet would reduce module weight, thereby decreasing shipping and installation costs.

Background

Polysilsesquioxanes (PSSQs), a class of organosilicon polymers with the empirical formula $[RSiO_{3/2}]_n$ where R is a hydrogen or carbon moiety, are attractive for use as potential replacement for the back cover glass. PSSQs offer the opportunity to combine the favorable properties of an inorganic oxide (thermal stability, hardness, etc.) with those of an organic (functionality, processability, etc.) to create materials tailored for barrier film applications. A range of hydrocarbon "R" groups enables a range of carrier solvents which, may in turn, offer control of the wetting characteristics of the PSSQ coating across the range of different metal, glass and organic polymer materials that comprise the 'back metal contact' of a thin film PV module. In addition polymerization and deposition conditions may be also altered to influence the film morphology (e.g. low porosity/permeation).



Spray deposition, as opposed to spin or dip coating, is highly amenable to manufacturing processes associated with the production of thin film photovoltaic modules with relatively large surface areas. However the production of a pinhole free, environmentally robust, PSSQ coating via this deposition method is challenging because a number of variables can impact the final quality of the coating.

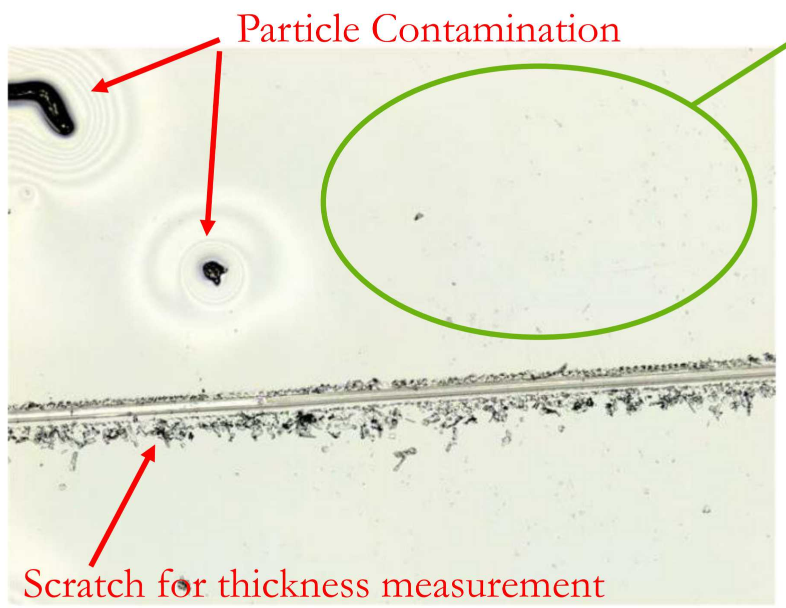
Project Scope

- 9 month timeline, $50k budget
- Application commercially available, partially polymerized, PSSQ solutions initially to glass and metalized (Al and Cr) coupons to evaluate impact of spray deposition variables on film quality and thickness. Variables include nozzle size, pressure, flow rate, surface preparation, solution concentration, number of coatings and thermal cure.
- Evaluate performance of an optimized PSSQ coating deposited onto a First Solar mini-module.

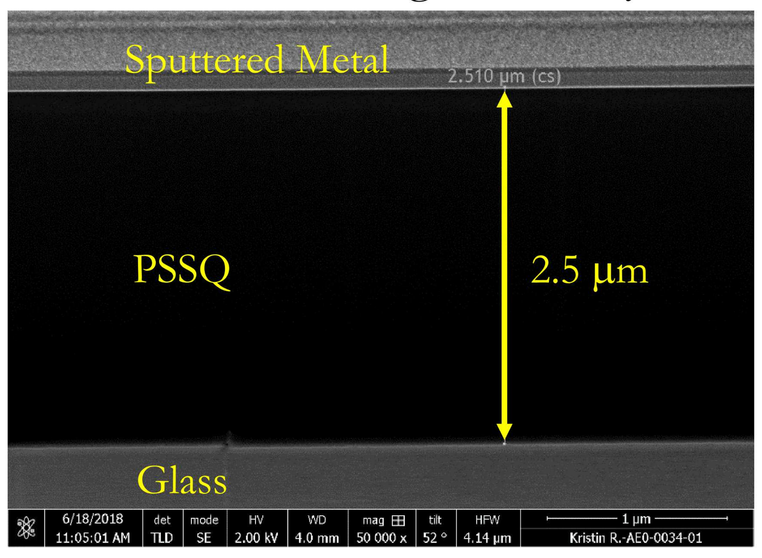
Materials & Methods

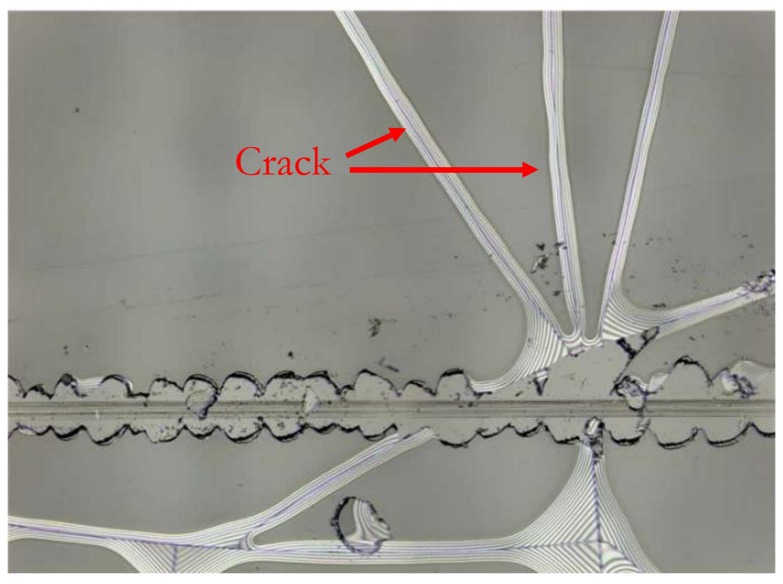
- 10 x 10 cm float glass (uncoated, Al coated or Cr coated)
- 3M Accuspray Spray Gun
- Gelest Hardsil® AP solution (Curable PSSQ T-resin diluted with 2-methoxy-1-propanol)
- PSSQ coatings prepared by spraying solutions onto a horizontally oriented float glass coupon by sweeping the spray gun across the coupon.
- PSSQ coatings thermally cured for 1 h at 25 ^oC, then 1 h at 220 ^oC.
- Characterization using optical microscopy, profilometry and SEM.

Results

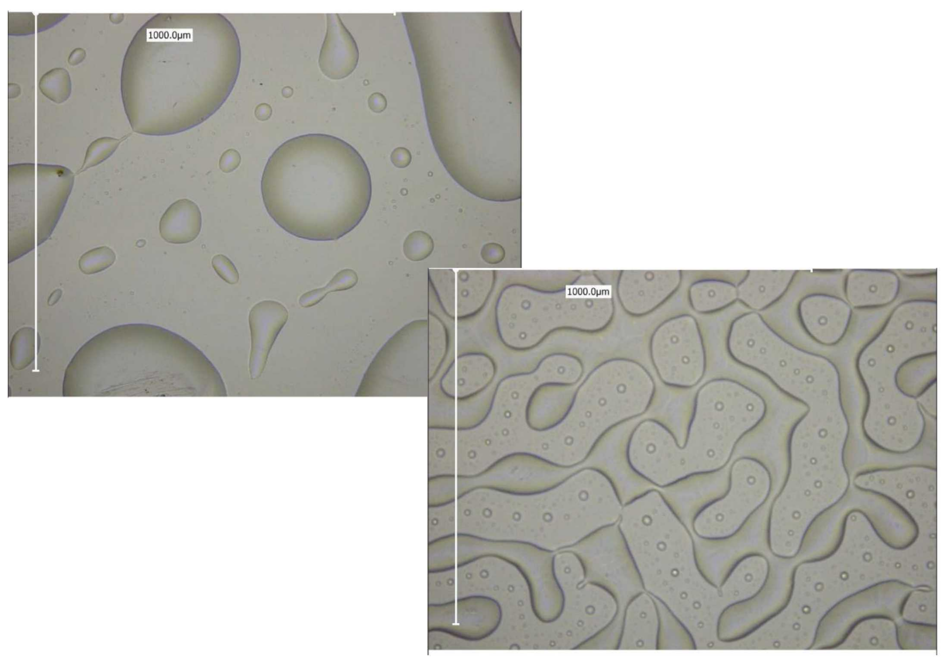


Coating quality is good in absence of particle contamination. Coatings dense by SEM.





Thicker coatings (> 5 μm) prone to stress cracking and delamination after thermal cure.



"High" volumes of solution per unit area required to overcome wetting issues. Surface pre-treatments ($HNO_{3(aq)}$, $NaOH_{(aq)}$ or Ar plasma) did not improve wettability with delivery of lower solution volumes per unit area.

Conclusions & Path Forward

- A number of spray coat conditions have been explored. Major variables that affect film quality include solution concentration, spray gun pressure, rate of solution delivery, and skill of the operator.
- Dense coatings with a uniform thickness have been prepared on the float glass coupons. However, defects can arise across the coupon due to particle contamination from the laboratory environment. Wetting around edges of coupon is can also be an issue.
- Hardsil® AR will be evaluated in an attempt to improve wettability issues.
- Performance of PSSQ coating on First Solar mini-module.

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