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Macro- and Microscale Particle Size Effects of Soil on Photovoltaic Surfaces

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Key Points

The texture or patterning of soil on PV surfaces may influence light capture at various angles of incidence.

Accumulated soil can be considered a micro-shading element, which changes with respect to AOI.

Methods

Cleaned microscope slides were spray coated with a suspension of test soil in acetonitrile using either an aerosol sprayer [Burton & King, PVSC 39] or single drop deposition via microliter pipette.

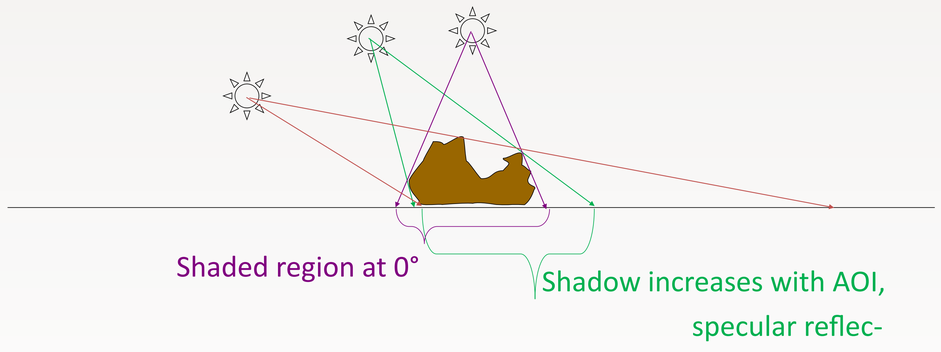
Samples coated using the aerosol spray technique were best quantified by mass loading (g/m^2), whereas the mass of the single droplet samples could not be determined accurately. Soil coverage is reported in terms of area alone for these samples.

Transmittance was measured for each coupon placed within an integrating sphere at 10° intervals. (see image series to the right).

Results

Irregular soiling (Fig. 1) can cause micro-shadowing at high angles of incidence (AOI), leading to unexpected transmission behavior (Fig. 2). Micro-shadowing does not follow the typical cosine dependence. Controlled soil patterns on a large (coupon-wide) scale were difficult to produce (Fig. 3), requiring a smaller scale test system.

A variation in the deposition technique was developed to use a consistent quantity of soil (1 g/100 mL or 1 g/50 mL) in a series of mixed solvents deposited by microliter pipette. The soil particles assembled in disparate patterns as the solvents dried (Figs. 4, 5). Highly dispersed (un-patterned) soils are the least detrimental to light transmission. (Figs. 6,7)



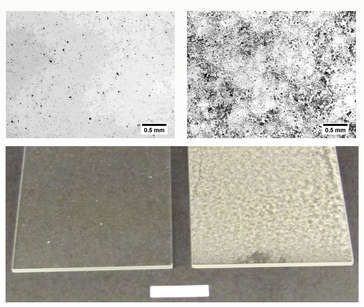


Figure 1: Light and heavily soiled coupons coated using 100% EtOH. The scale bar is 1 cm.

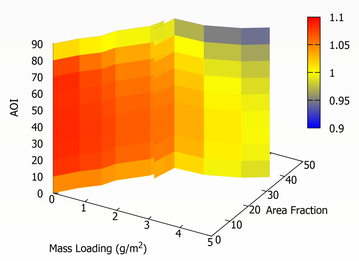


Figure 2: Reflectance intensity (color) with respect to AOI, soiling and area fraction.

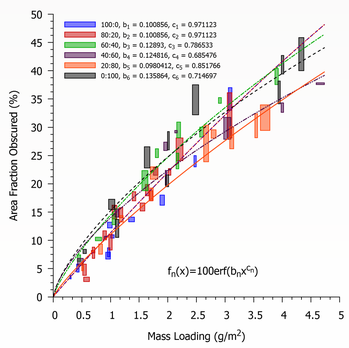


Figure 3: Patterning by aerosol spray gun was not sufficiently controllable.

Figure 4: Spot-patterned coupon cast from a 10 µl pipette in 100% ACN.

Figure 6: Transmittance through spot soiled coupons is pattern dependent at low AOI; invariant at high AOI.

Results

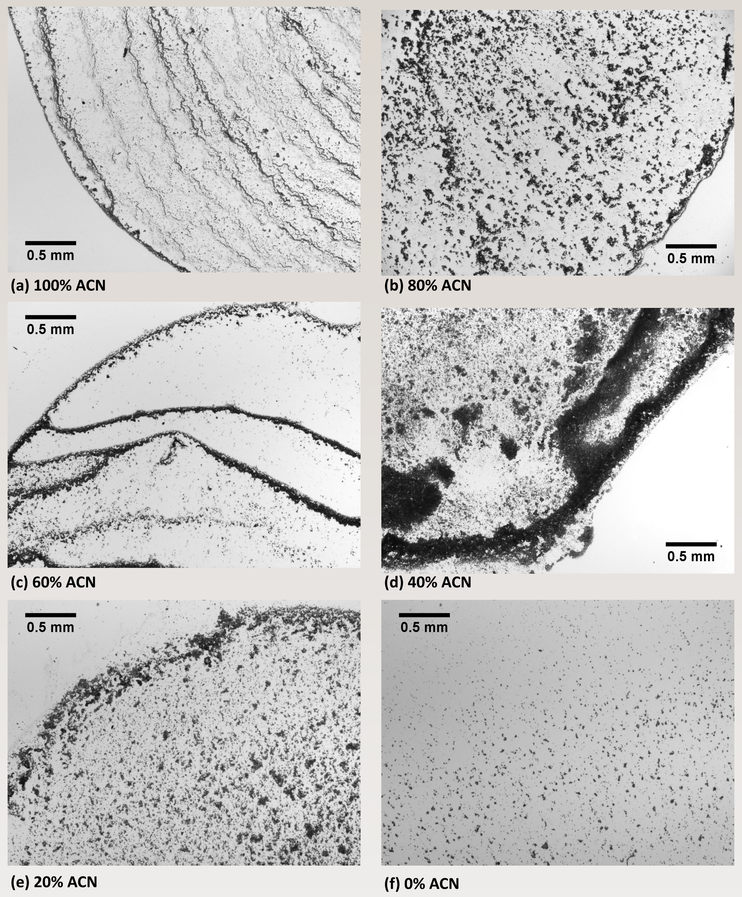


Figure 5: Images of spot-patterned samples at 2.52x.

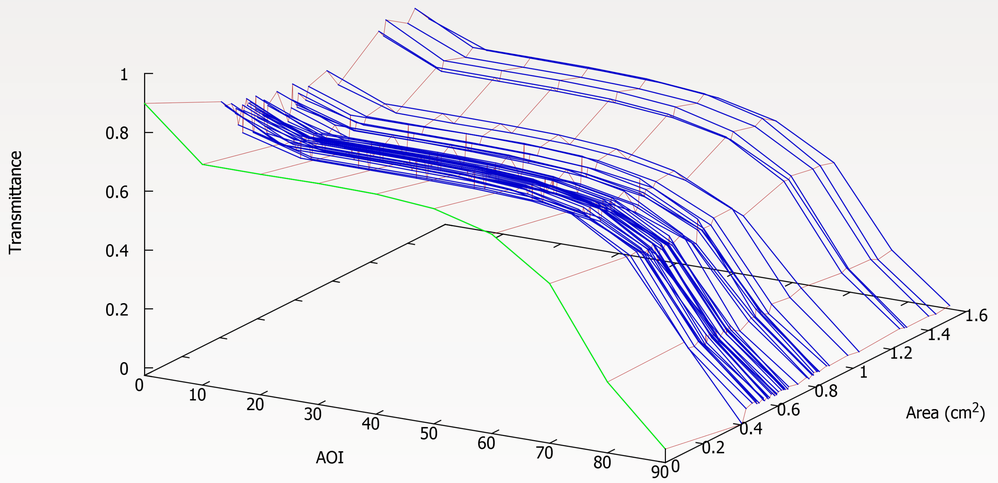
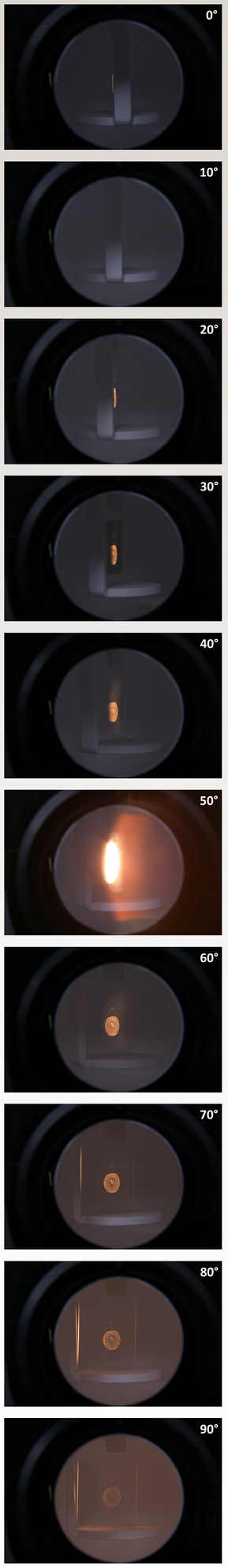


Figure 7: Transmittance as a function of AOI and area for spot-patterned coupons. Samples prepared with 0% ACN are very diffuse, allowing a greater light transmission than other coupons with the same soil loading.



Conclusions

The amount of accumulated soil and the dispersion over the surface are critical aspects to soiling losses.

Spot soiled coupons do not exhibit a change in response to high AOI.

Dispersion for a given soil loading is significant. Sparse, uniform soiling is less detrimental to light transmission. Dense soiling can reduce transmission at high AOI.

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