Improving Electrodynamic Dust Shield Efficiency for Solar Energy Applications

Charles Pett[2], Guangnan Wu[2], Wyndham Hudson[3], Chih-Hsiang Chien[1], Chang-Yu Wu[1], Bing Guo[4], Jennifer Chesnutt[1], Jonathan Scheffe[2]

[1]Department of Environmental Engineering Sciences, University of Florida, [2]Department of Mechanical & Aerospace Engineering, University of Florida, [3]Department of Electrical Engineering, University of Florida, [4]Mechanical Engineering Program, Texas A&M University at Qatar

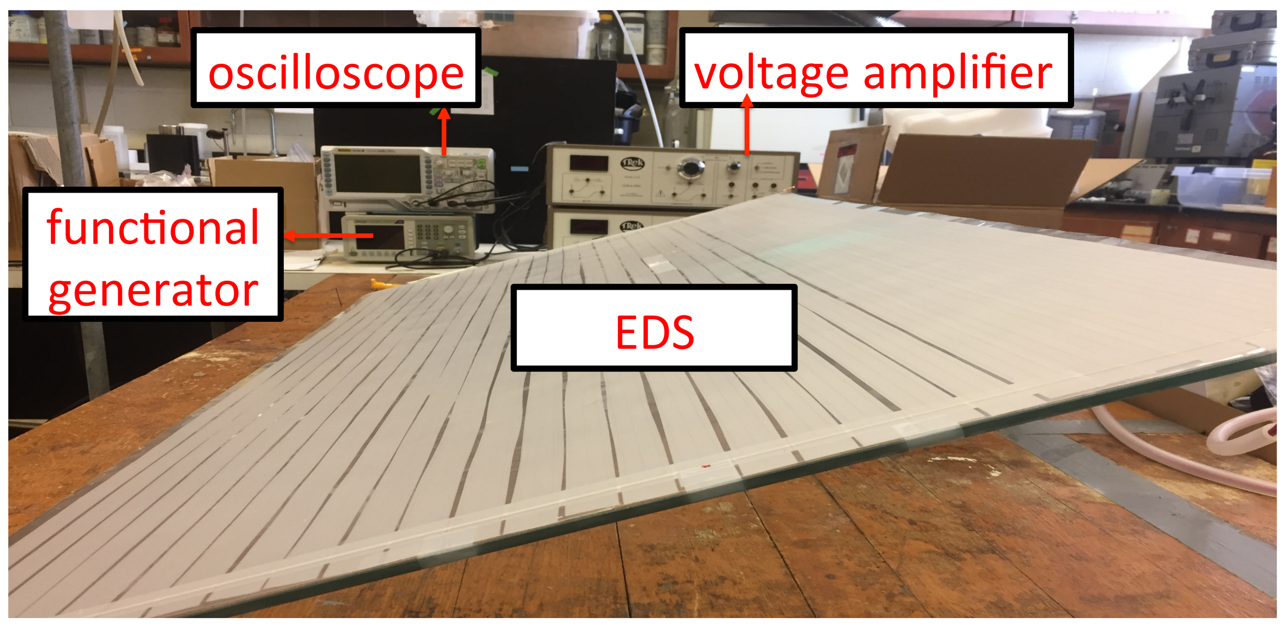
Introduction

- An Electrodynamic Dust Shield is a device to remove dust via electric field force. It has been applied on solar panels to mitigate soiling in desert areas without the need of water. [1]
- The effect of different types of glass on removal efficiency is not clear.
- The removal efficiency can be quantified by mass difference. However, light transmission efficiency is more relevant to solar energy utilization.

Fig. 1. Soiled solar panels and a clean panel (*lower right*). Source: Qatar Foundation Solar Test Facility.

__Objectives__: **Investigate removal efficiency using different types of glass with various pulse waves. Compare different methods to quantify removal efficiency.**

Experimental Methods



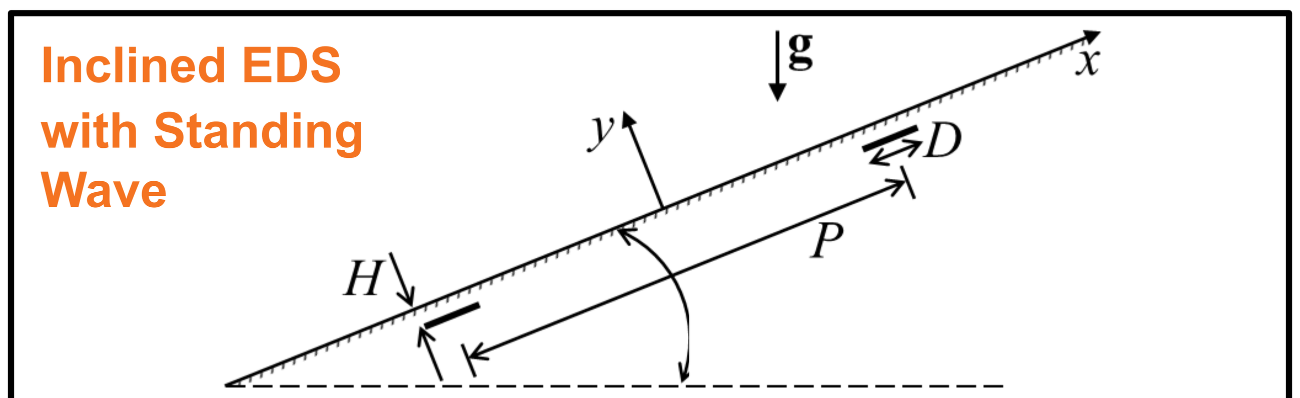


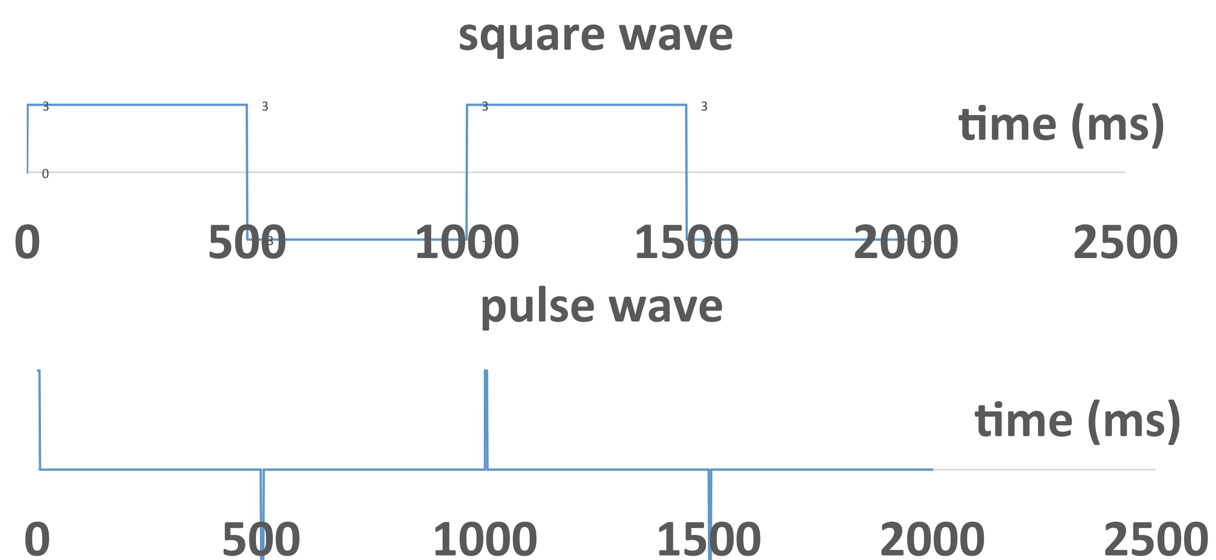
Fig. 2. Inclined EDS, standing wave, voltage V = 6 kV$_{p-p}$, frequency f = 1 Hz, D = 0.3 mm, P = 7 mm, H = 105 μm, PET cover with 100 μm thickness.

Material comparison

- Efficiency was compared between willow glass and tempered glass.

Waveform comparison

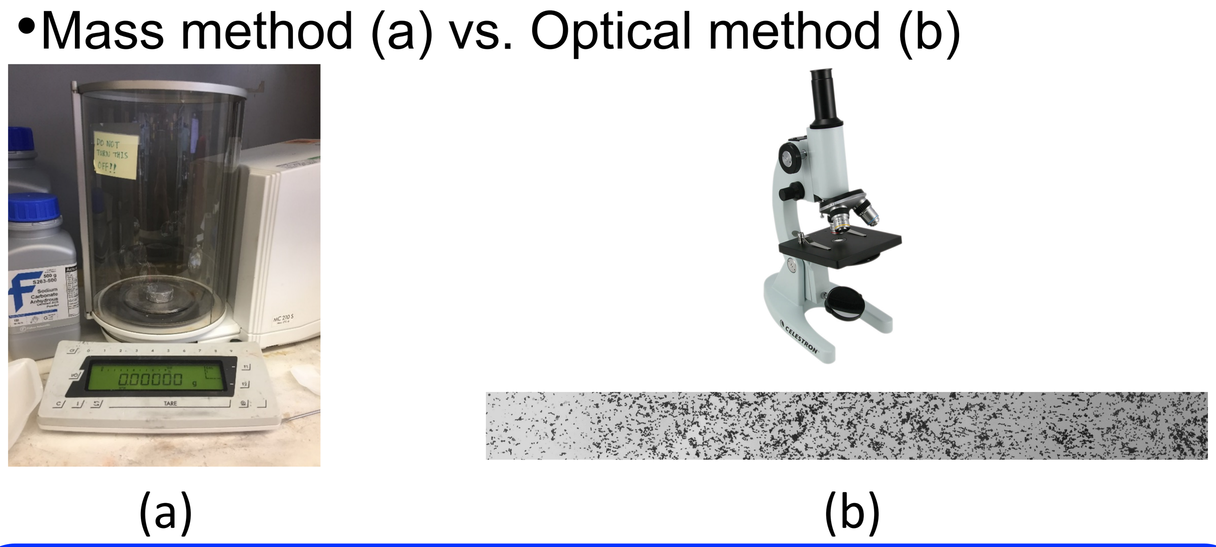
- Reference wave: A standing wave with the shape of a square wave applied. Particles were accumulated in the same location because repelled particles' trajectories followed electric field lines. [2]
- Test wave: pulse wave with 5 ms and 10 ms.
- Particles were expected to spend around 5 ms to leave the surface and then deposit back on the surface after EDS was activated.



Experimental Methods

Methodology comparison

- Mass method (a) vs. Optical method (b)



Result and Discussion

The effect of different glass on dust removal efficiency

- Between two types of glass, there was no significant difference in dust removal efficiency. However, willow glass is too fragile for practical use.
- The dust removal efficiency was not only affected by glass thickness, but also the surface of the glass material.

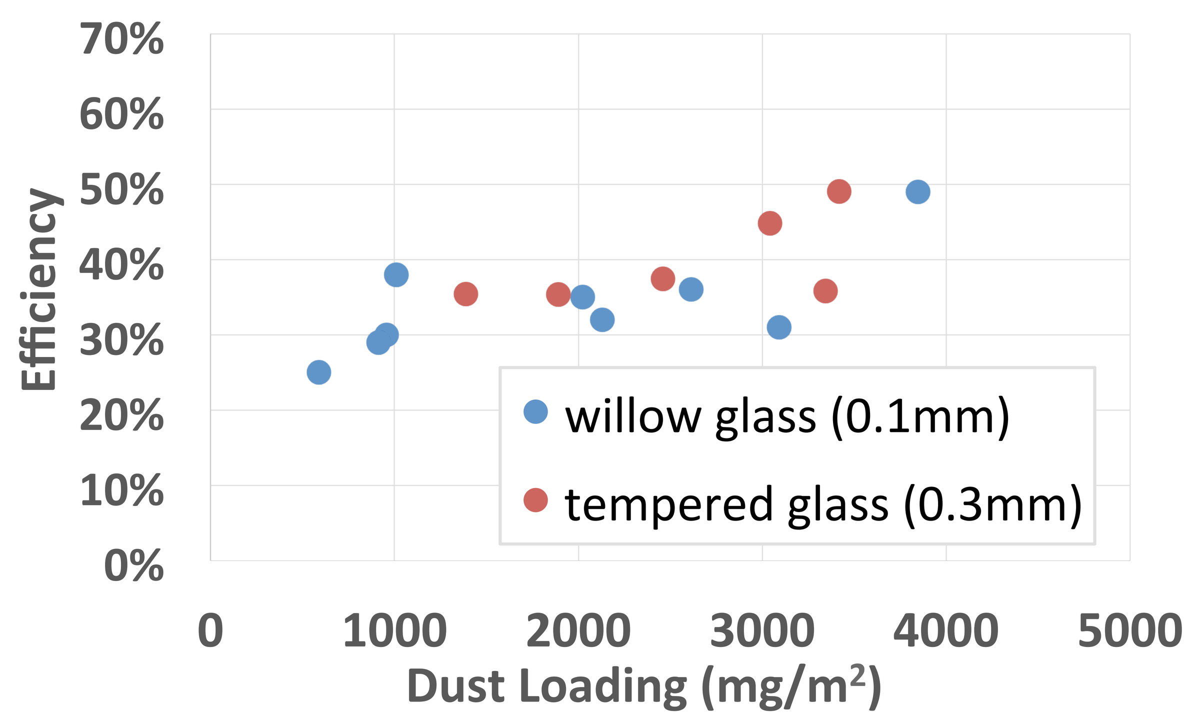


Fig. 3. Dust removal efficiency with 0.1 mm thick willow glass and 0.3 mm thick tempered glass.

The impact of pulse wave on dust removal efficiency

- Under different pulse waves, the square wave had the highest dust removal efficiency, 5 ms pulse wave had the lowest dust removal efficiency, and 10 ms pulse wave was in between.
- Low dust removal efficiency under 5 ms pulse wave could have resulted from insufficient time to charge EDS.

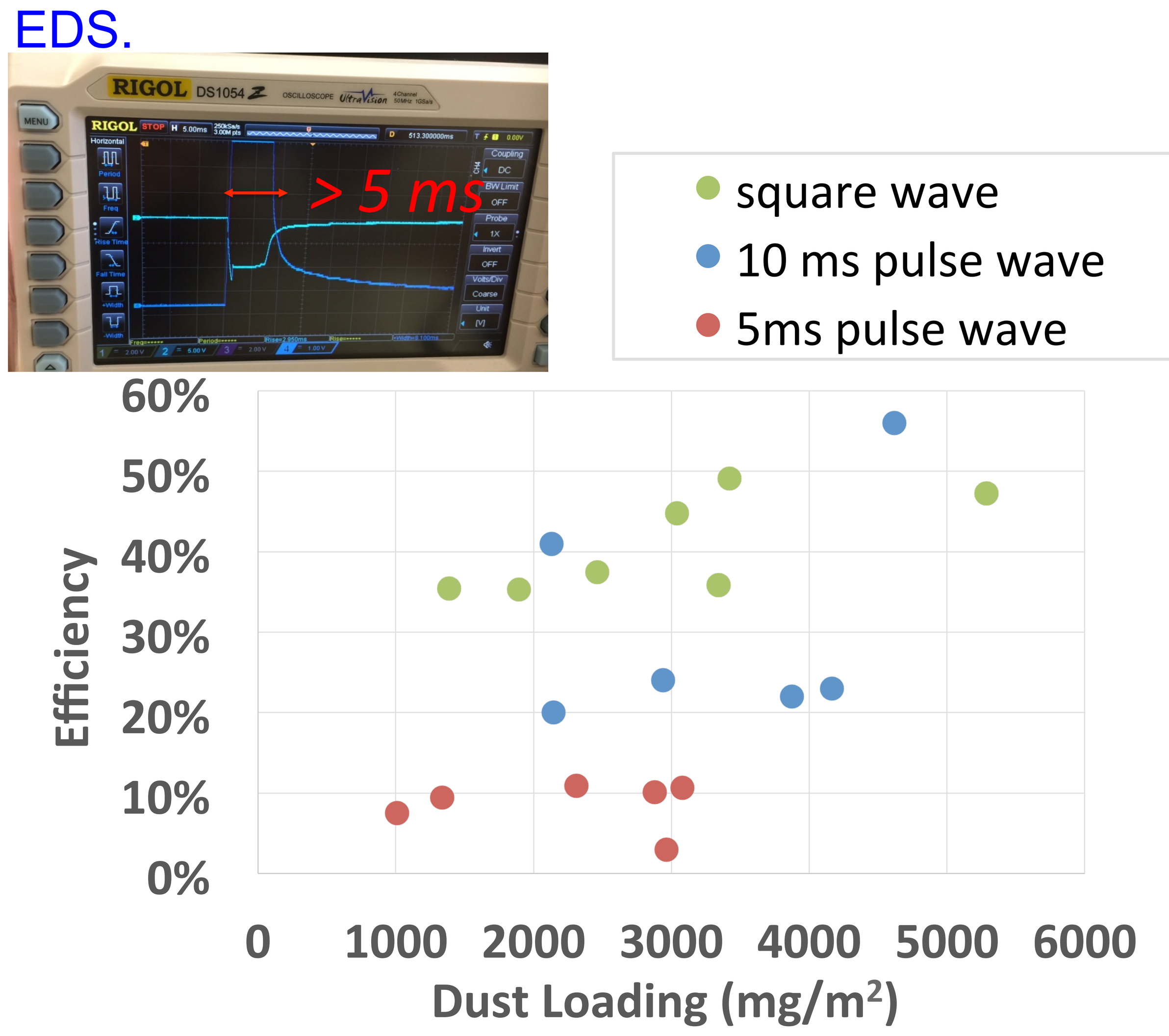


Fig. 4. Dust removal efficiency using different types of pulse waves.

Results and Discussion

Pollen Removal Efficiency

- Pollen removal efficiency was lower than that of dust
- An arbitrary correlation exists between pollen loading and efficiency

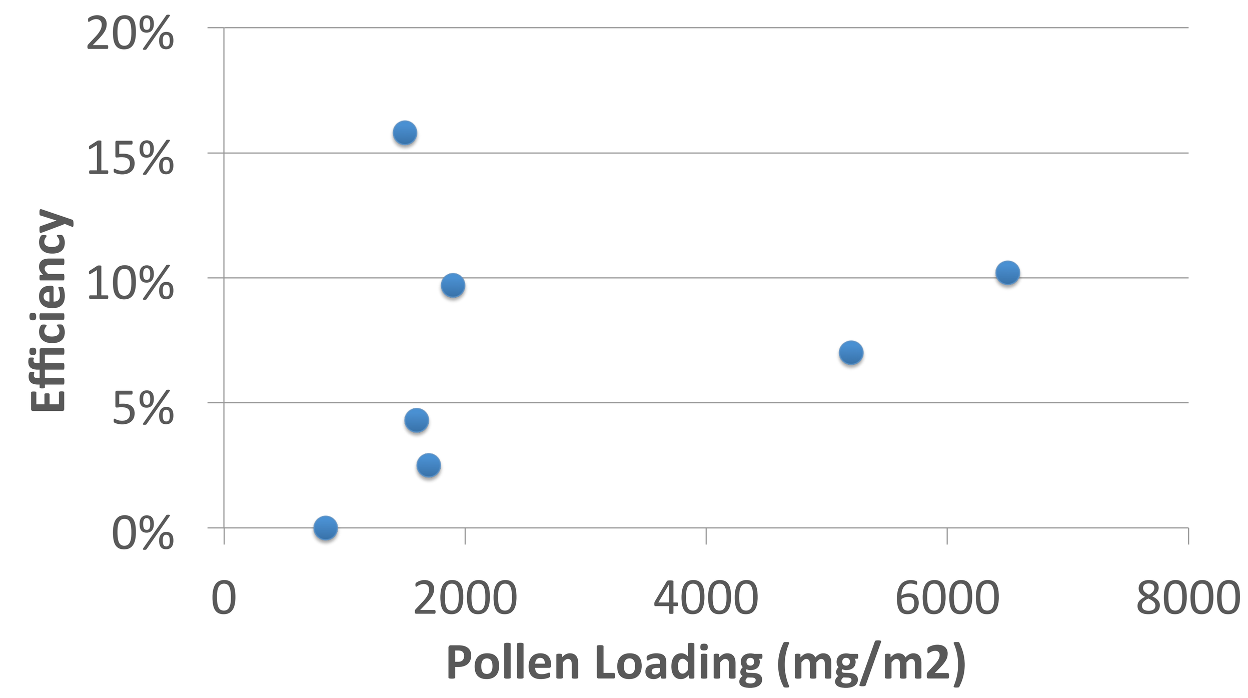


Fig. 5. Pollen removal efficiency

Optical method vs. Mass method

- The same trend existed between optical and mass method
- The dust caused light reduction from 6% to 14% when the dust loading was from 2000 to 5000 mg/m².
- Compared with mass method, the optical method had a lower removal efficiency

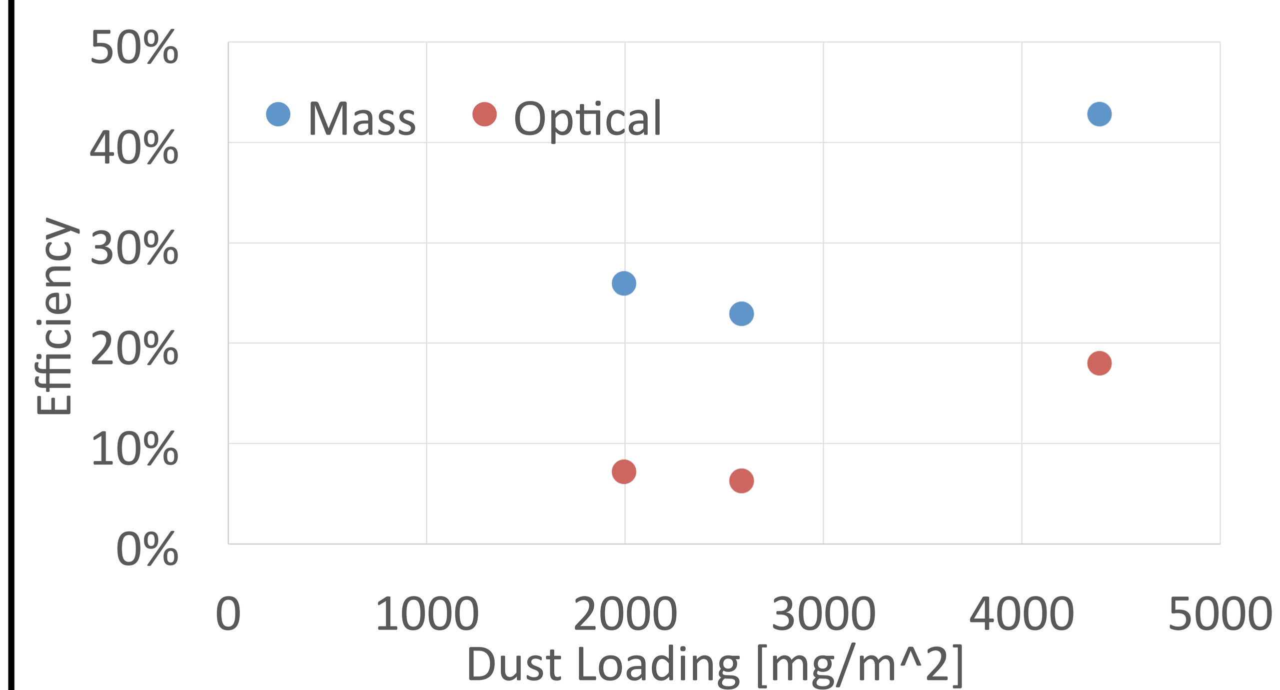


Fig. 6. The removal efficiency comparison between optical and mass methods.

Conclusions and Future Work

__Conclusions__:

- The square wave was the most efficient waveform with both optical and mass methods.
- The removal efficiency depended on material composition and thickness. Willow glass proved too fragile to use for future experiments. Thus, tempered will be used.
- EDS was not an effective device for removing pollen.

__Future Work__:

- Measure particle distribution around electrode regions via image analysis.

Acknowledgments & References

This project was supported by the 2015 Wells Fargo Clean Tech and Innovation Program.

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2. Chesnutt JKW, Ashkanani H, Guo B, Wu C-Y. (2017) Simulation of microscale particle interactions for optimization of an electrodynamic dust shield to clean desert dust from solar panels. Solar Energy; 155: 1197-207.