

Wind Energy Applications of Technologies for Contamination Prevention

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Wind Energy Technology Showcase
September 22, 2022



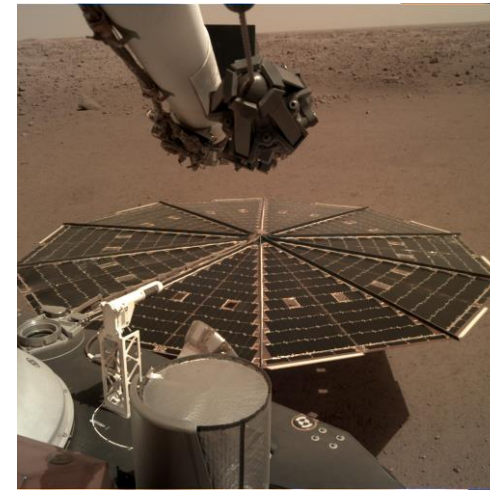
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Potential Wind Turbine Contaminants



Insect Residues



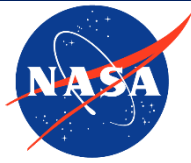
Dirt/Dust



Ice



Birds

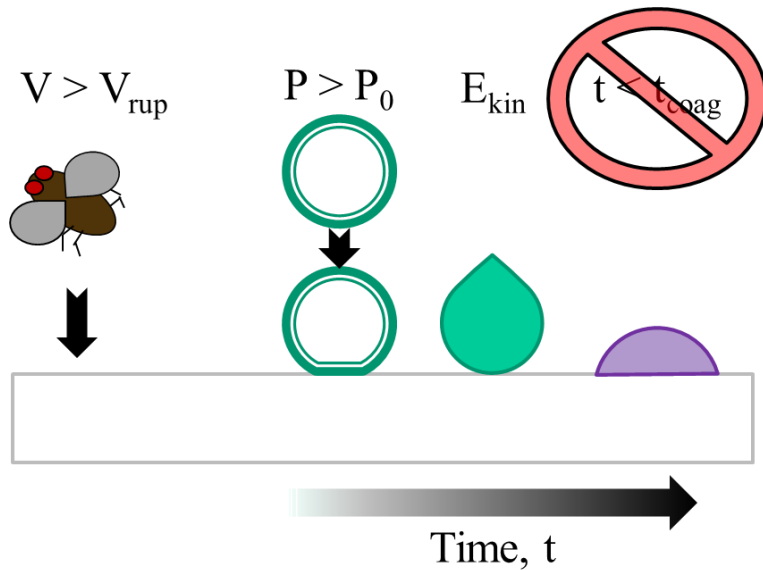


Applicable LaRC Technologies

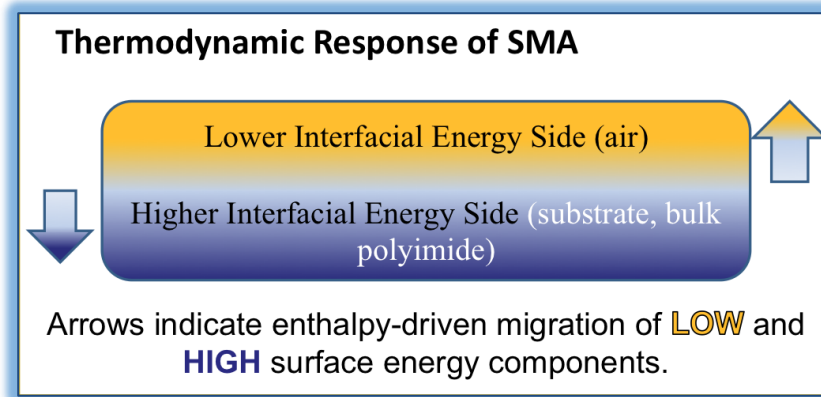
- ❖ LAR-17769 “Modifying surface energy via laser ablative surface patterning,” US Patent 8,987,632 & 10,259,077.
- ❖ LAR-18026 “Synthesis of novel copoly(imide oxetane)s with unique surface properties,” US Patent 9,822,088 & 11,130,742.
- ❖ LAR-18127 “Synergistic chemical and topographical modifications and articles of manufacture for dynamic insect adhesion mitigation,” US Patent 9,278,374.
- ❖ LAR-18352 “Fluorinated alkyl ether containing epoxies and articles of manufacture thereof,” US Patent 9,550,911.
- ❖ LAR-18655 “Synthesis and development of polyurethane coatings containing fluorine groups for adhesive applications,” US Patent 10,723,912.
- ❖ LAR-18540 “Synthesis of copolyimides containing fluorine and silicon surface modifying agents,” US Patent 10,808,079.
- ❖ LAR-18585 “Hydrogen bonding surface for ice mitigation,” US Patent 10,899,937.
- ❖ LAR-18755 “Coatings with molecular flexibility for ice adhesion mitigation,” US Patent 10,377,916 & 11,149,165.
- ❖ LAR-18780 “Influence on surface interactions by substructure topography,” US Patent Application 2015-638513.
- ❖ LAR-19483 “Durable contamination resistance coatings,” US Patent Application 2020-0079897.



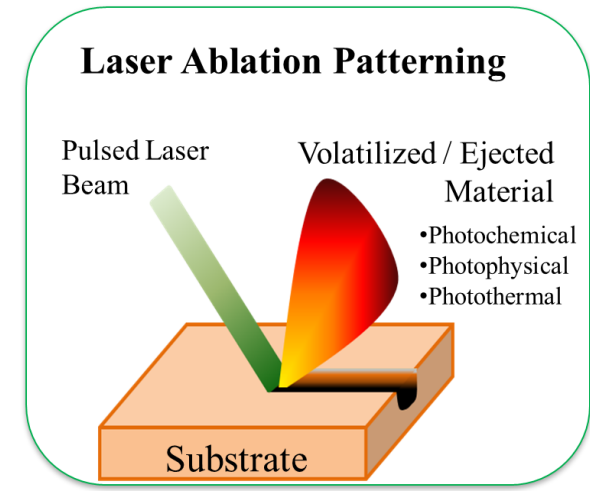
Contamination Mechanism and Approaches to Overcome it



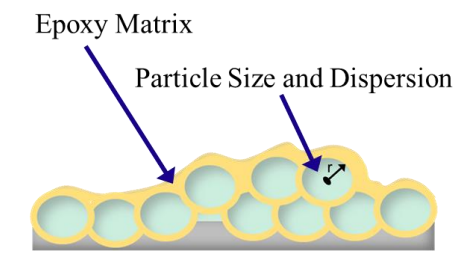
Surface Contamination is a Dynamic Process



Modification of Surface Materials Properties using Surface Modifying Agents (SMA)s



Patterned Topographical Modification

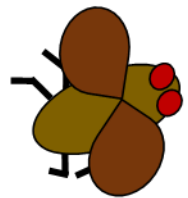
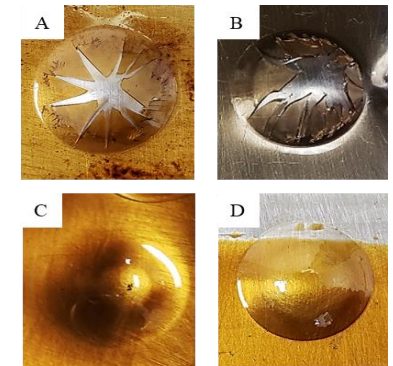
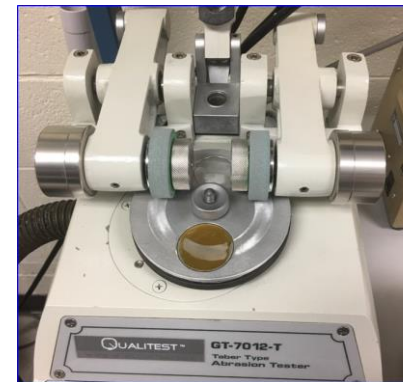
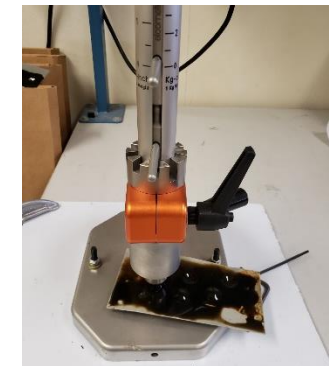
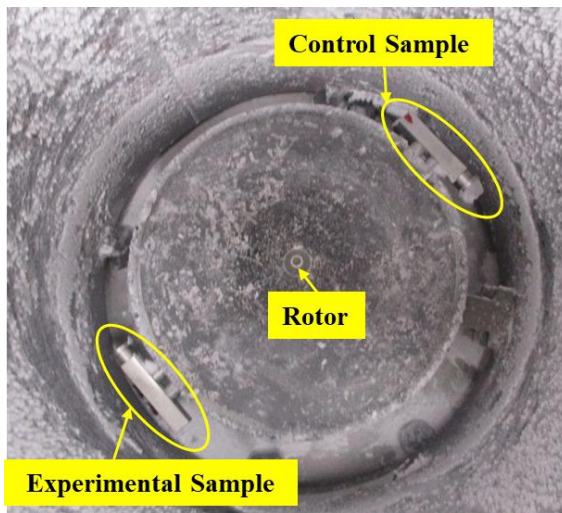


Random Topographical Modification

Evaluating Contamination Resistant Technologies

Primary Objective: Test Adhesion

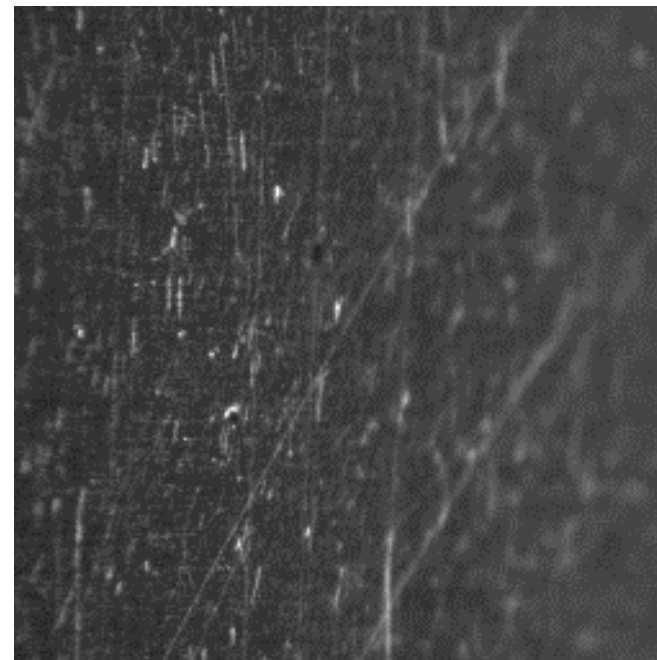
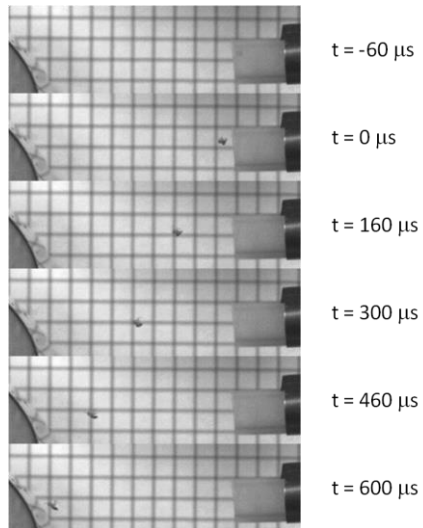
Secondary Objective: Operational Environment Assessment



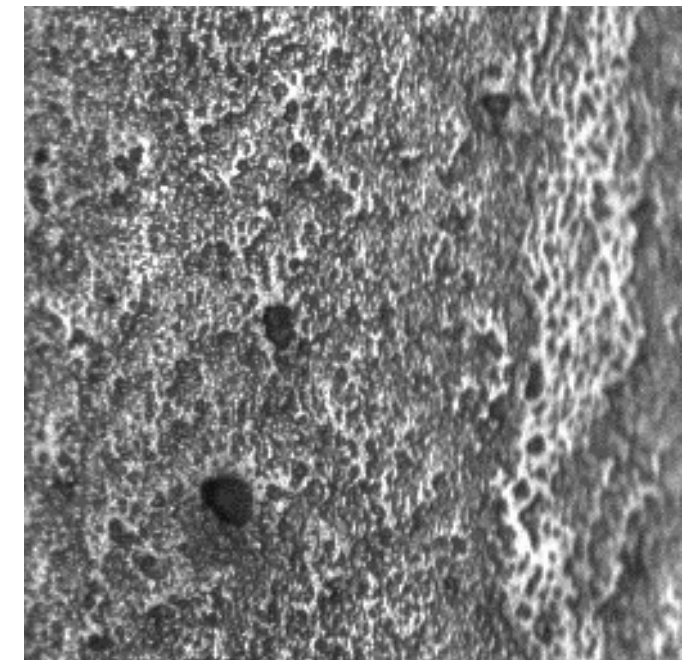
Insect Impact Testing

Insect residues can reduce energy production from 8% to 55%

Renewable and Sustainable Energy
Reviews, 2009, 13, 428-438.



**Uncoated Aluminum
Surface**



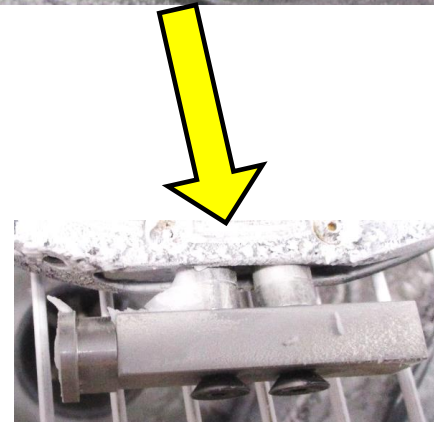
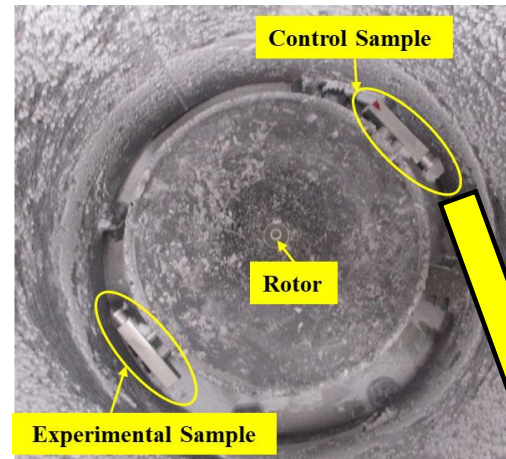
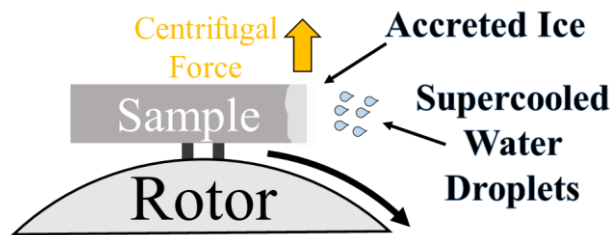
**Heirarchical Topography
Epoxy Composite Surface
(LAR-18352)**

- **Key point: several materials technologies address mitigation of insect residue adhesion focused on underlying physics of insect impact.**

Impact Icing Experiments

Ice accretion can cause full stop, disrupt aerodynamics, damage equipment, and be a risk to humans.

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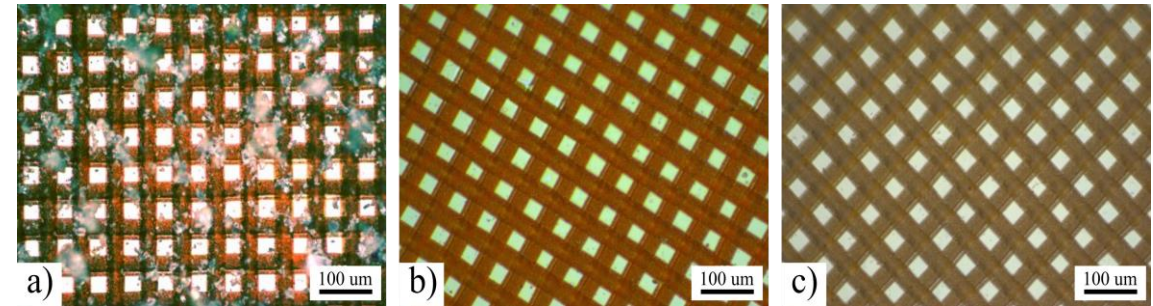
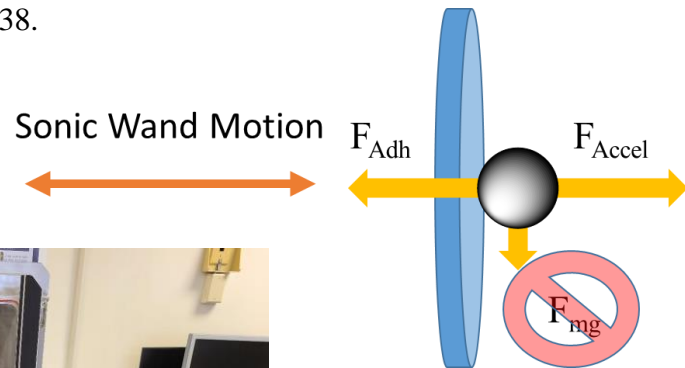
**Durable Epoxy Surfaces
(LAR-19483)**

- **Key point: reduction in accreted ice prior to detachment will potentially result in fewer stops, reduced mechanical wear, and decreased risk to human life and equipment.**

Dust Adhesion Testing

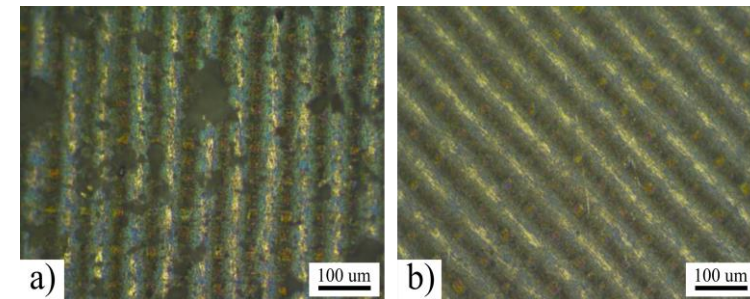
Particulate adhesion and erosion leads to deterioration in aerodynamics performance.

Renewable and Sustainable Energy
Reviews, 2009, 13, 428-438.



- **Polymeric Surface (LAR-17769)**

- (a) Contaminated surface, (b) cohesion removal, (c) full test



- **Titanium Surface (LAR-17769)**

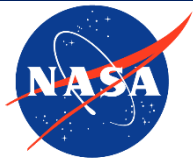
- (a) Contaminated surface, (b) cohesion removal

• **Key point: minimization of particulate adhesion strength will potentially diminish changes in aerodynamic performance and further contamination.**

Technologies for Contamination Mitigation

- ❖ Portfolio of 10 LaRC Technologies
- ❖ Potential benefits
 - ❖ Affordable
 - ❖ Low cost for integration
 - ❖ Scalable
 - ❖ Durability in operational environment
 - ❖ Environmental awareness





Questions

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