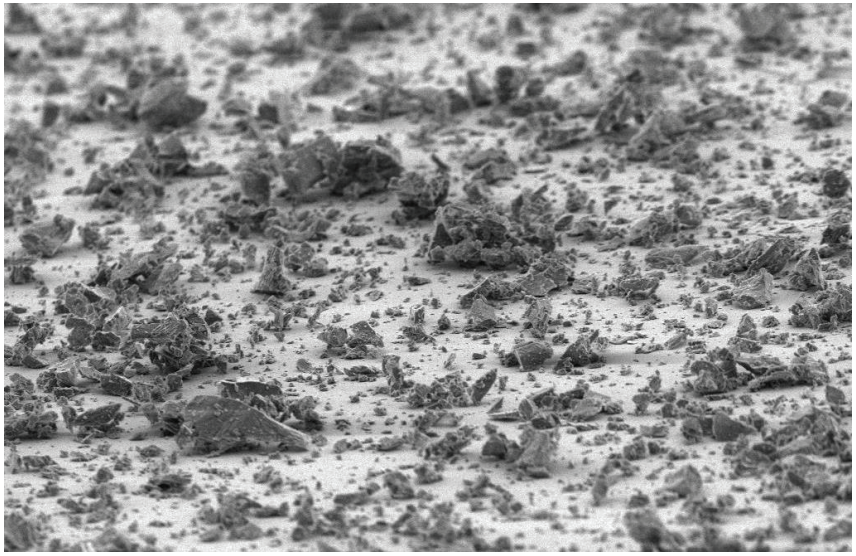
Passive Nano- and Micro-Textured Dust-Mitigation Surfaces in Space-Grade Materials Made with a Highly Scalable Fabrication Process

LSIC Lunch Meeting January 20, 2022

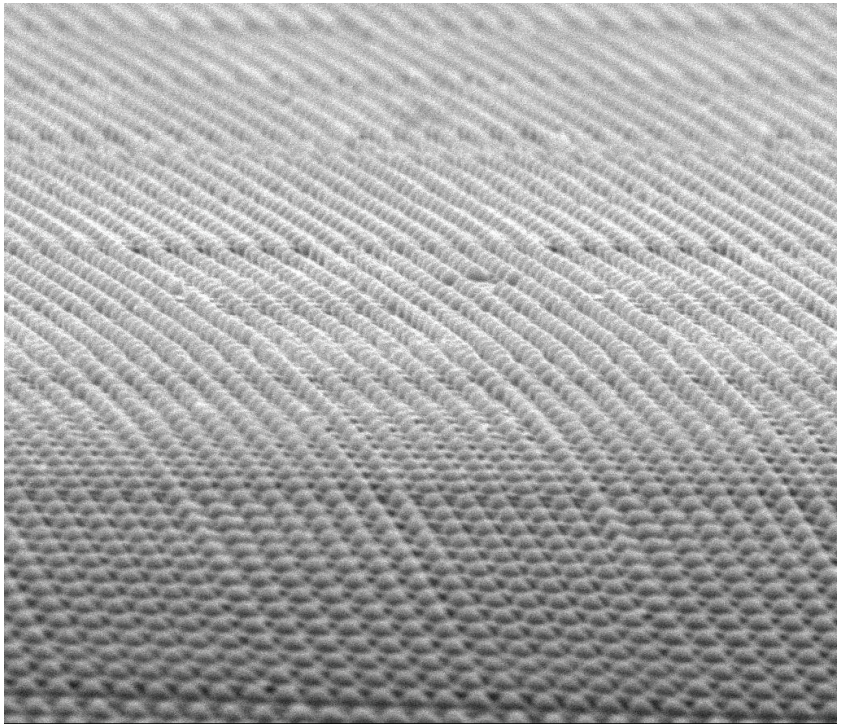
Smart Material Solutions, Inc.:
Dr. Stephen Furst (PI), CEO
furst@smartmaterialsolutions.com
Team: Nichole Cates and Lauren Micklow

University of Texas, Austin:
Dr. Chih-Hao Chang (co-PI), Asst. Prof. of Mech. Engr.
chichang@utexas.edu
Team: Samuel Lee, Suarav Mohanty, and Kun-Chieh Chien



Agenda

- Project goals
- Summary of achievements
  - Surface textures
  - Fabricated surfaces
  - Dust mitigation performance
- Proposed future work



NASA SBIR Phase I Project

Passive Nano- and Micro-Textured Dust-Mitigation Surfaces in Space-Grade Materials Made with a Highly Scalable Fabrication Process (5/19/21 – 11/19/21)

Smart Material Solutions

Dr. Stephen Furst (PI)
Founder and CEO
PhD in Mechanical Engineering specialized in precision engineering

Dr. Nichole Cates
Senior Scientist
PhD in Materials Science specialized in electronic materials

Lauren Micklow
Mechanical Engineer
BS in Mechanical Engineering

UT Austin

Dr. Chih-Hao Chang (co-PI)
Associate Professor Mechanical Engineering
Nanostructures and Nanomanufacturing Lab

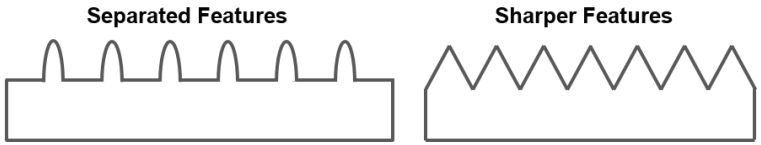
Students
Samuel Lee, Suarav Mohanty, and Kun-Chieh Chien

NASA

Glen King, Chris Wohl, and Lopamudra Das
NASA Langley Research Center

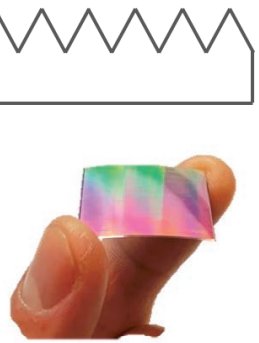
Project Objective and Tasks

Objective: *Use our scalable process to imprint "space grade materials" with passive structured surfaces that reduce dust adhesion.*



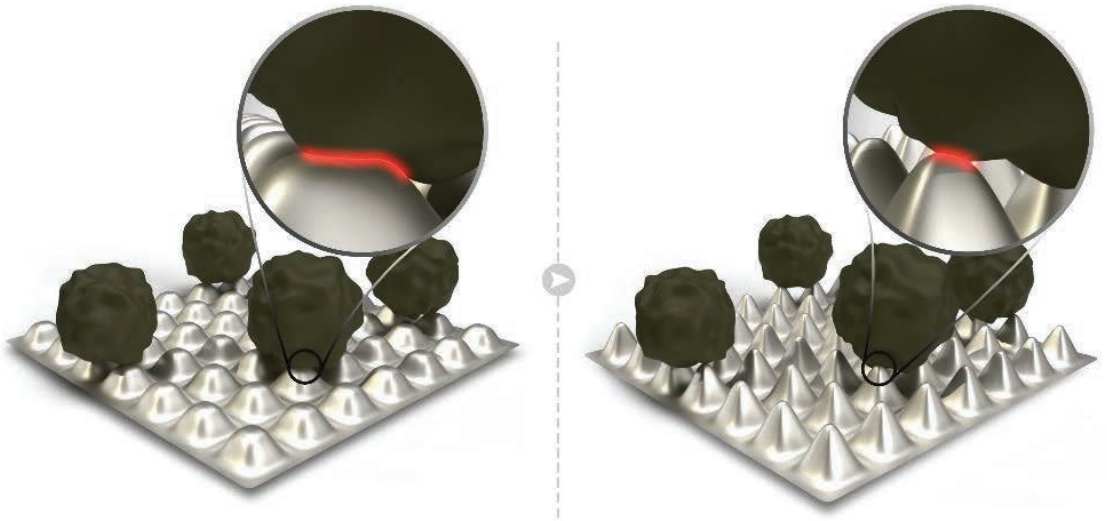
Tasks:

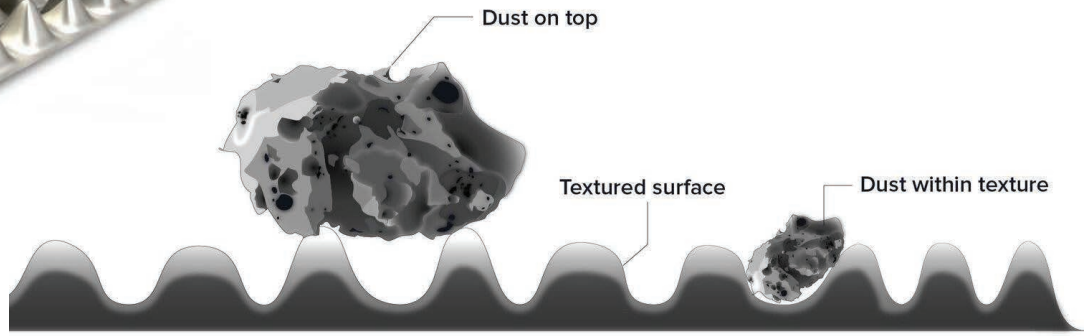
1. Texture Optimization
2. Flexible Mold Fabrication
3. Replication and Metrology
4. Chemical Treatment and Testing



Concept

Check out our Blog! www.smartmaterialsolutions.com/blog

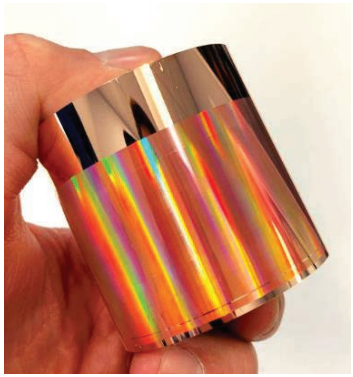


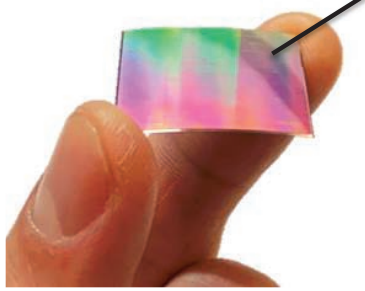


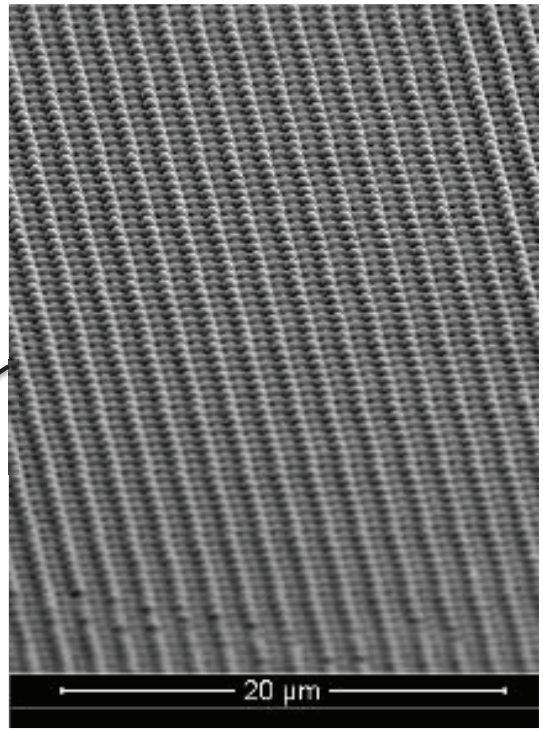
Enabling Technology

Nanoimprint lithography molds

- Seamless, roll-to-roll
- Batch, thermal embossing

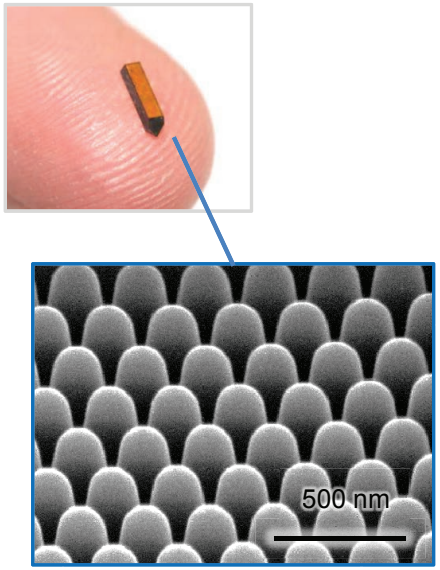




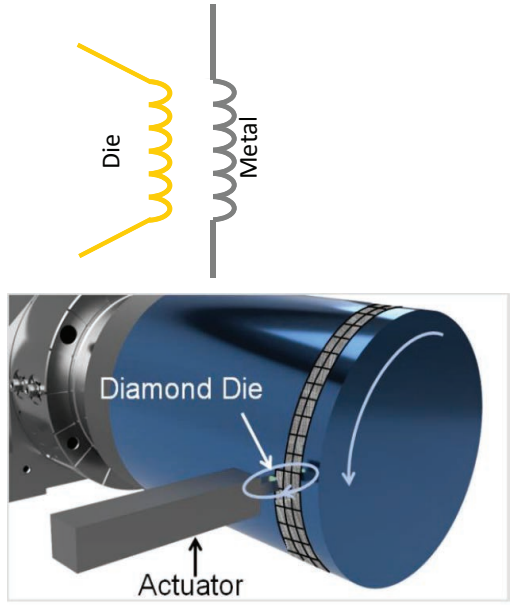


Nanopatterning Process

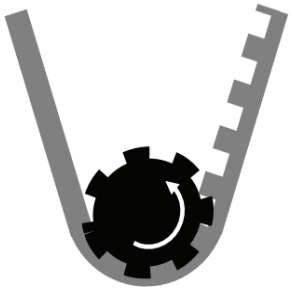
1. Diamond die

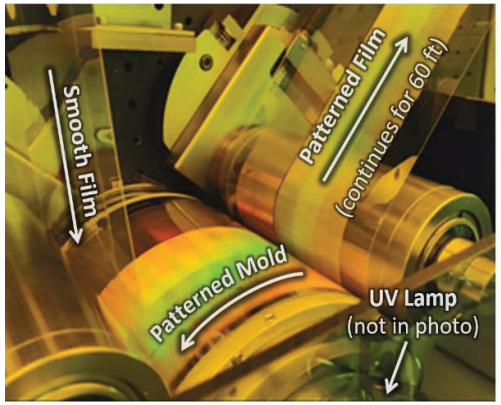


2. High speed indenting



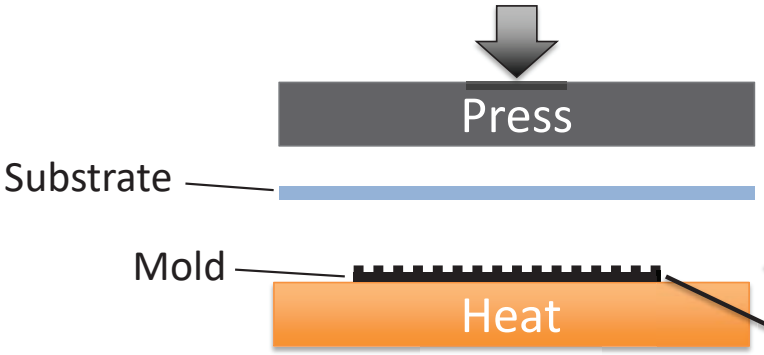
3. Imprinting

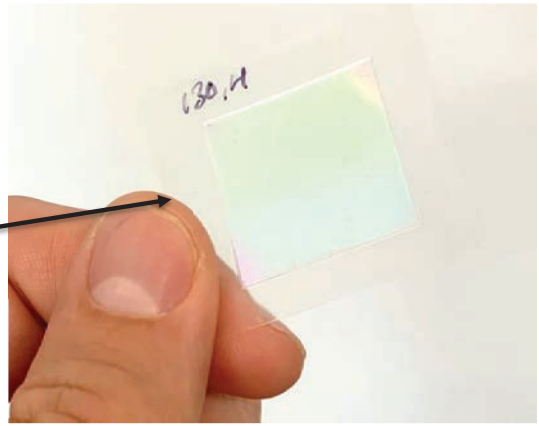


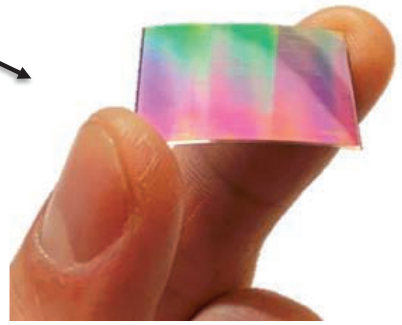


Nanocoining

Thermal NIL





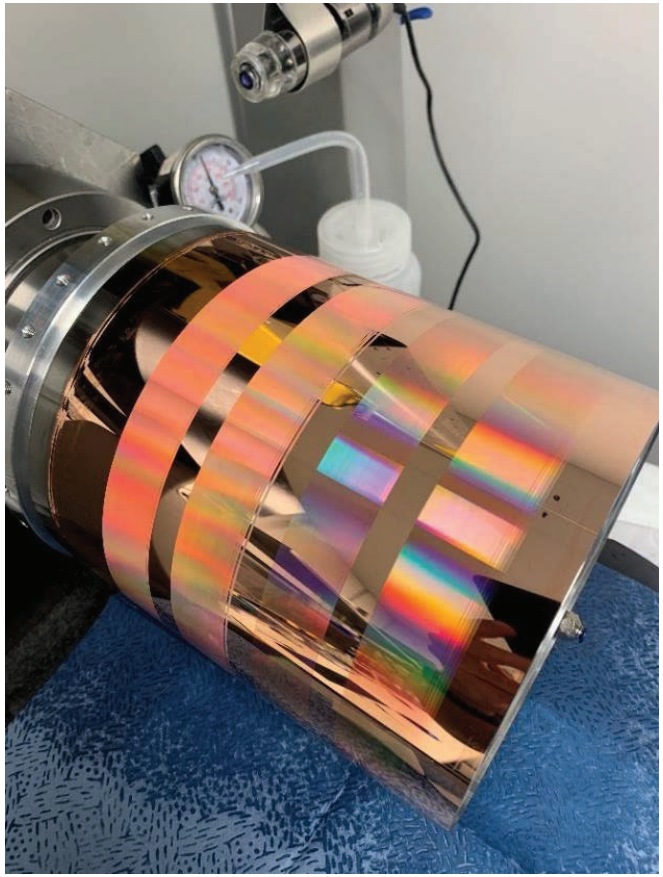


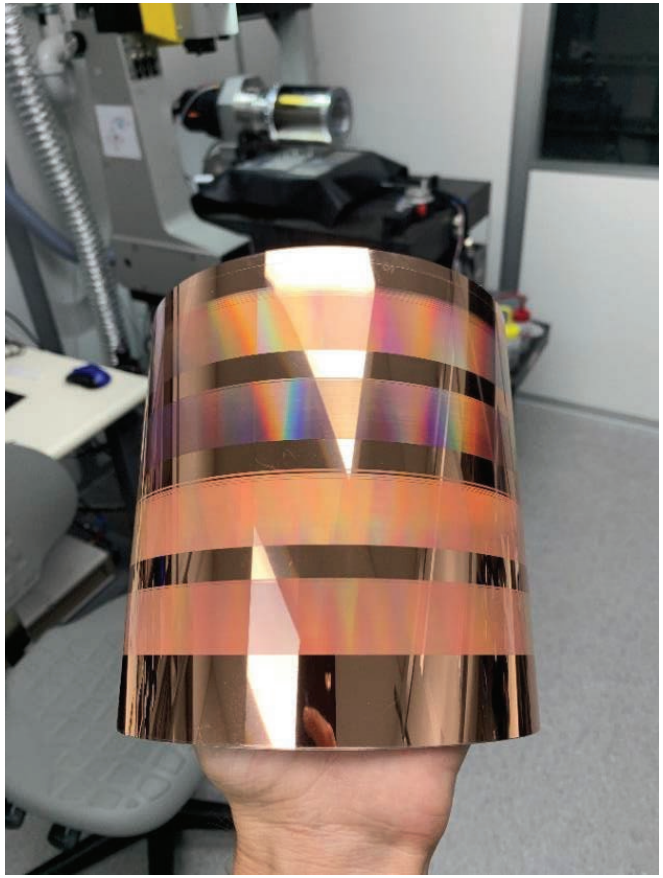
Materials of Interest

- **Polycarbonate (Markrofol N)**
- **ETFE (Tefzel 280)**
- **CoC (Zeonor)**
- PET (Mylar)
- Polyimide (Kapton)
- PTFE (Teflon)

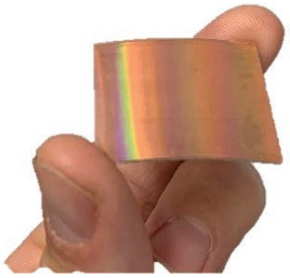
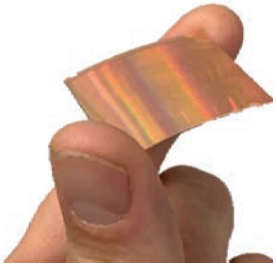
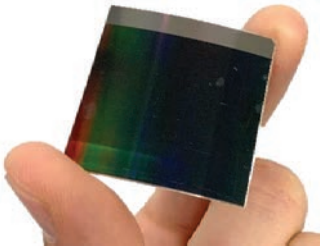
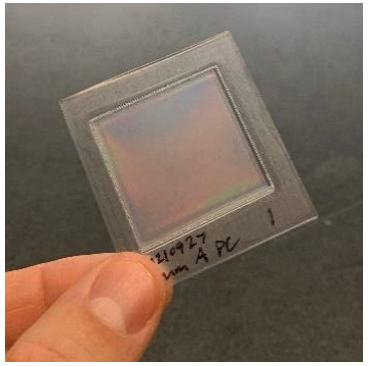
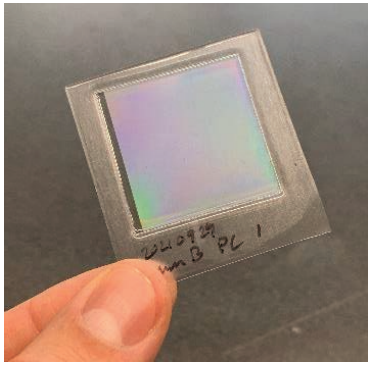
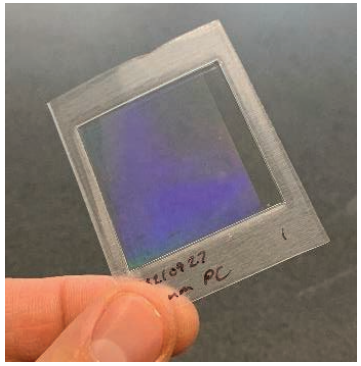
Key challenge – complete imprints into space grade polymers

Drum Mold with Test Patterns



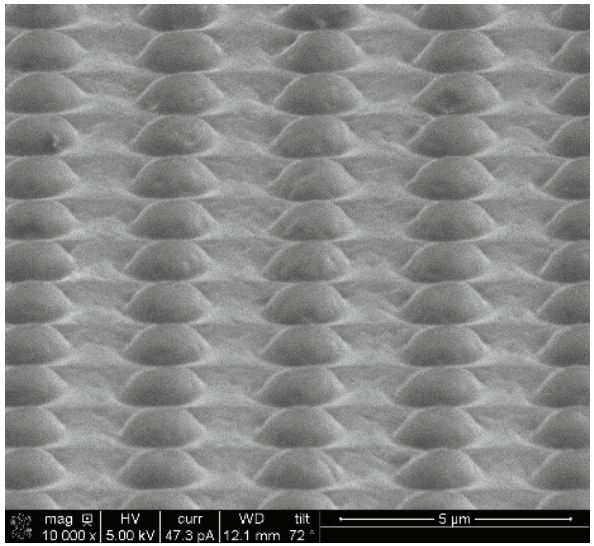
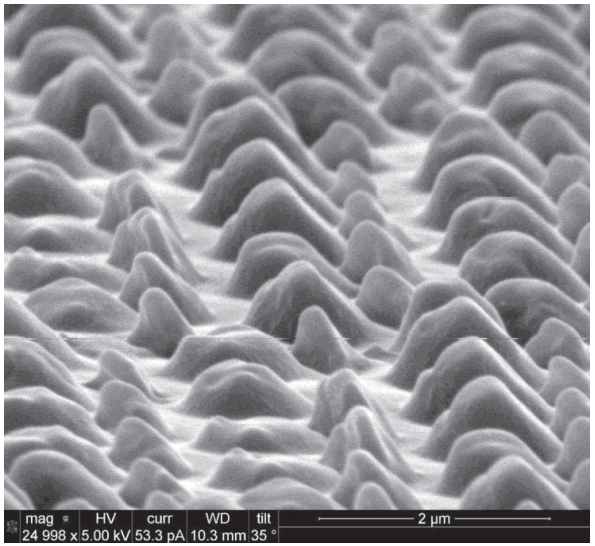
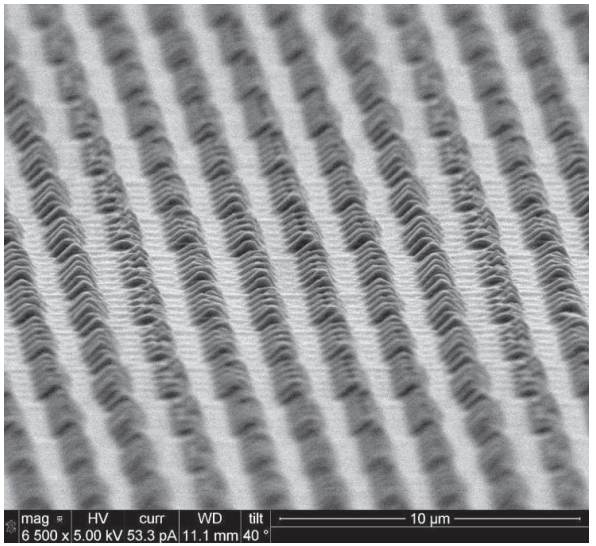


Molds and Replicas

	Sample 1	Sample 2	Sample 3
Mold			
PC Replica			

Example Patterns

Current capabilities: **250 nm to 5 µm pitch and 0.5 height:pitch**

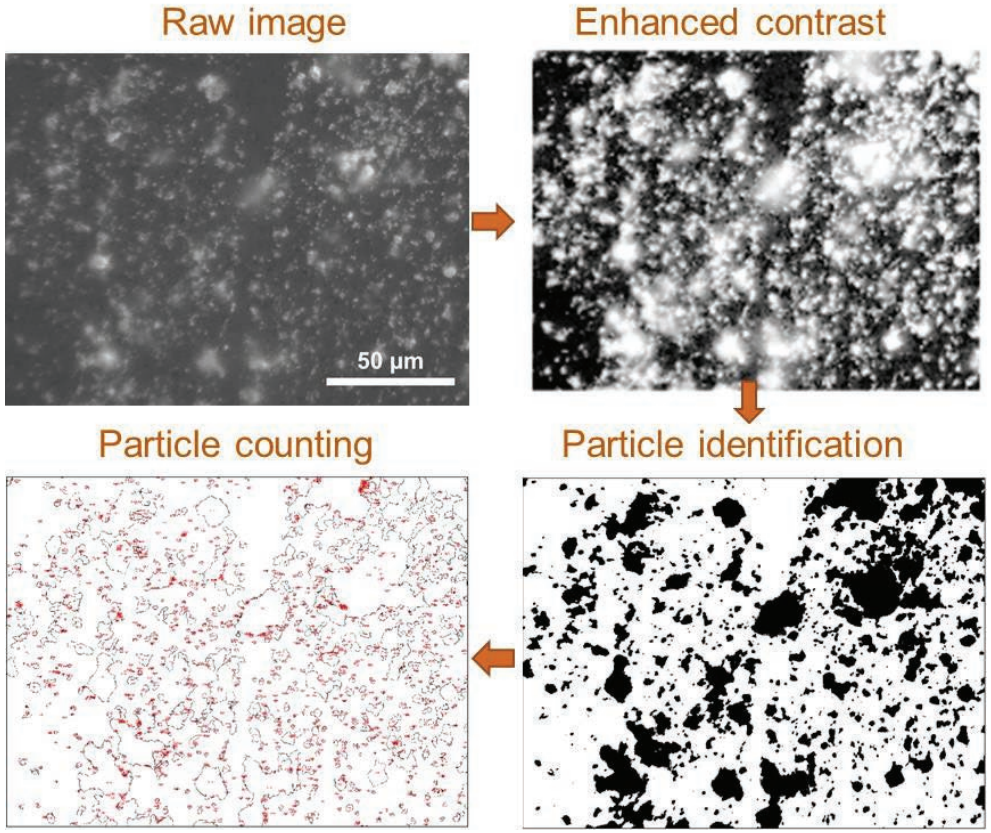
Rounded	Irregular	Sharper
		

Testing at UT Austin

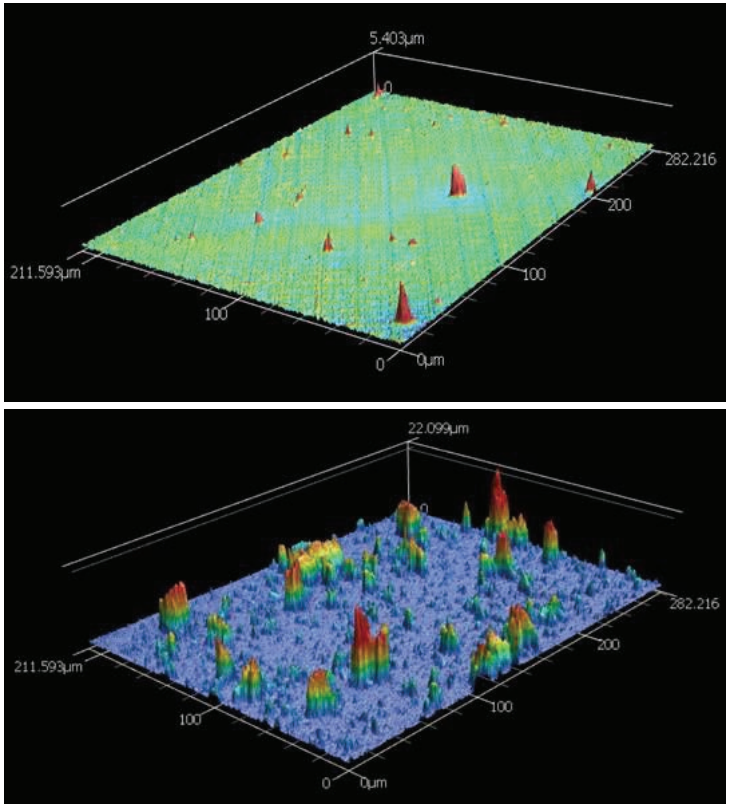
- Lunar Dust Simulant: Exolith Labs LMS-1
- Polycarbonate substrates w/ and w/out silane coating
- Procedure:
  1. Heap dust on surface
  2. Tilt to 90 degrees
  3. Take micrograph
  4. Spin on spin coater, 3G
  5. Take another micrograph
  6. Image analysis

Particle Counting

Visible Microscope

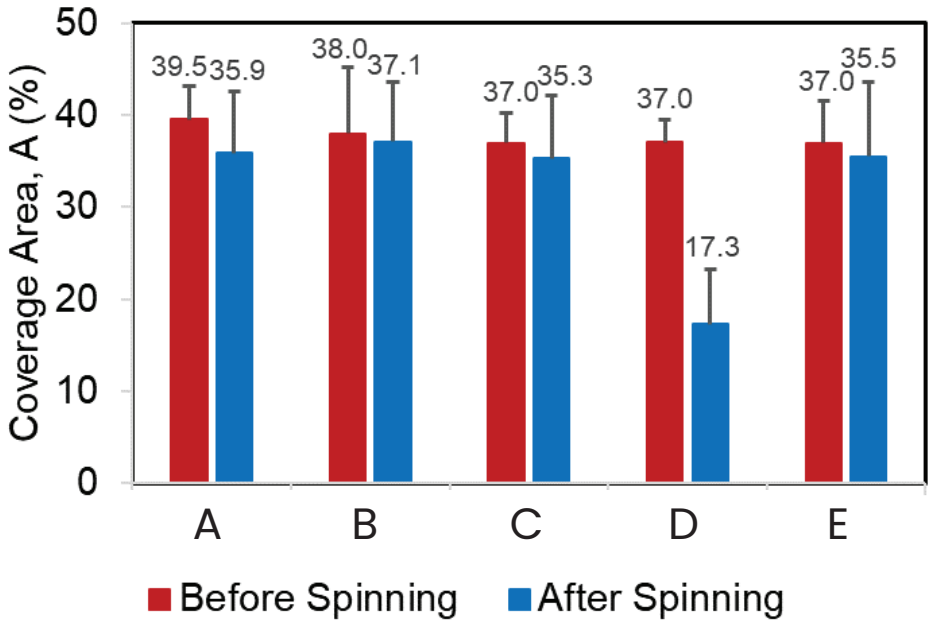


Laser Confocal

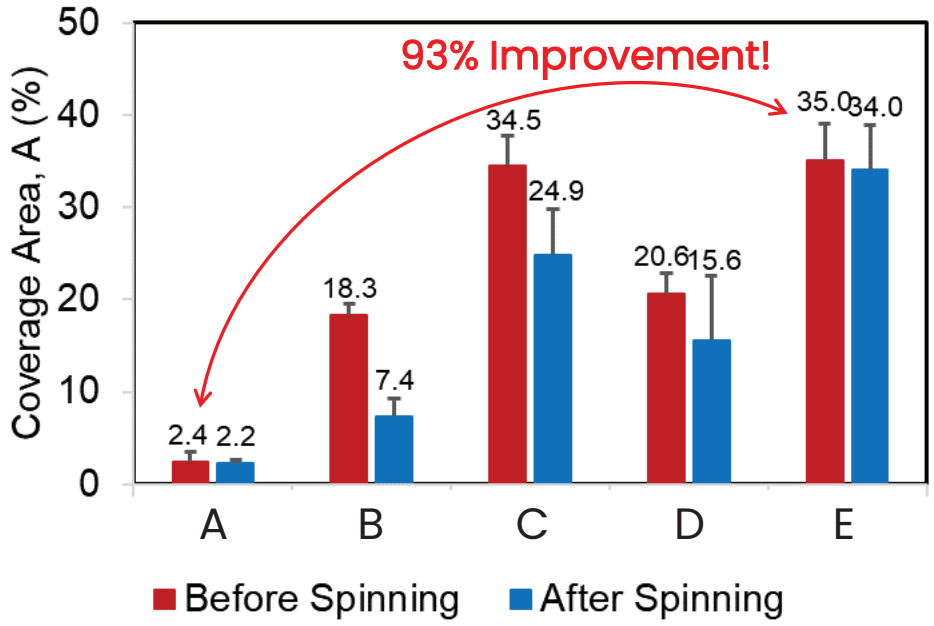


Effect of Silane Treatment

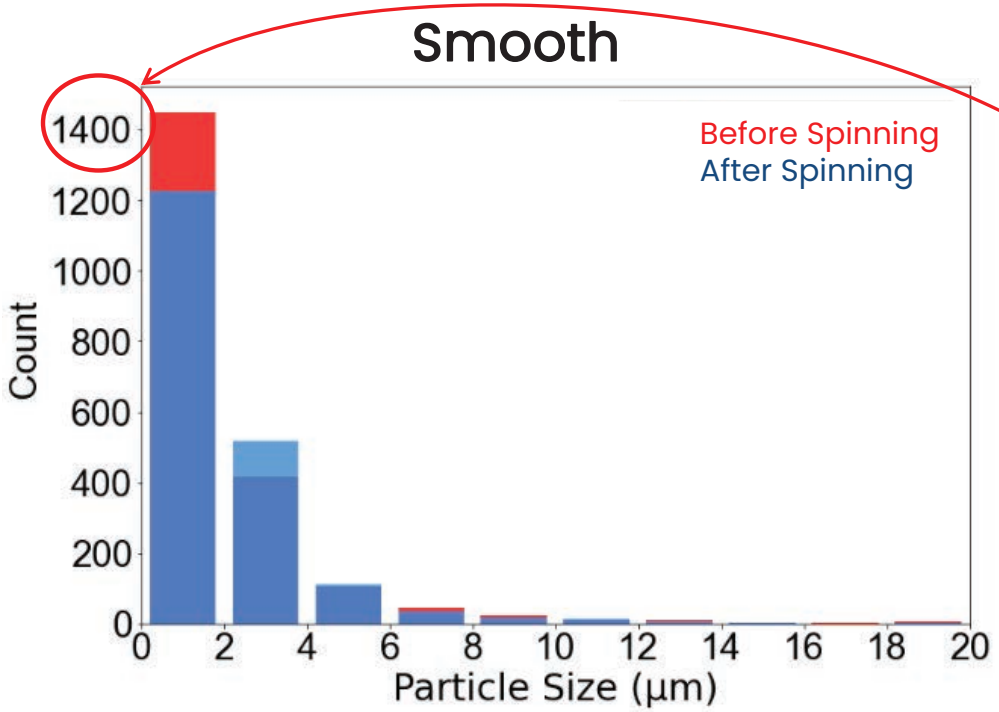
No Silane Treatment

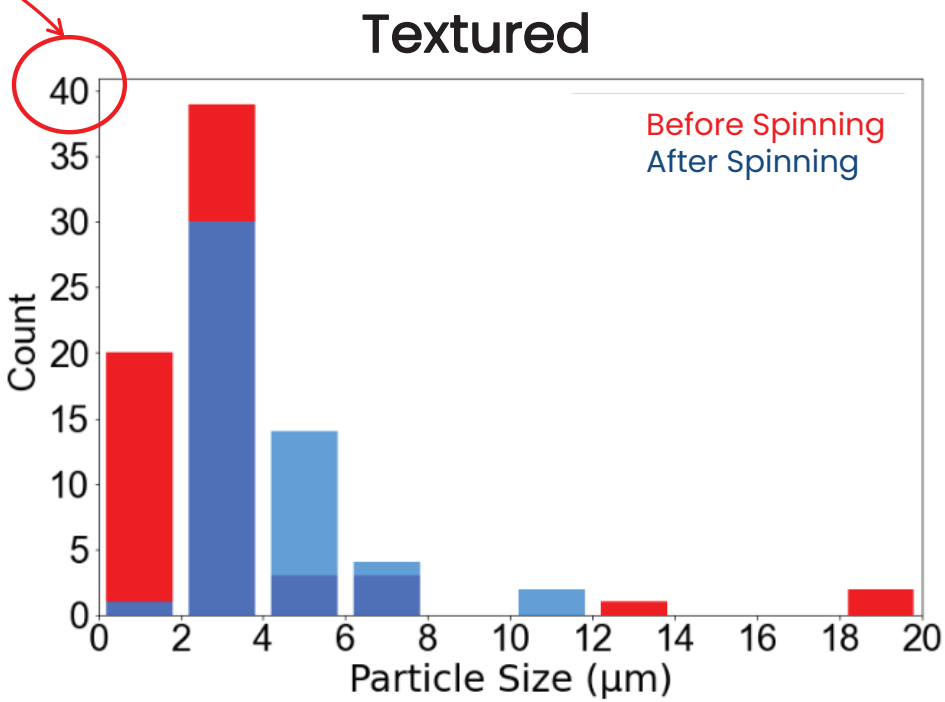


With Silane Treatment

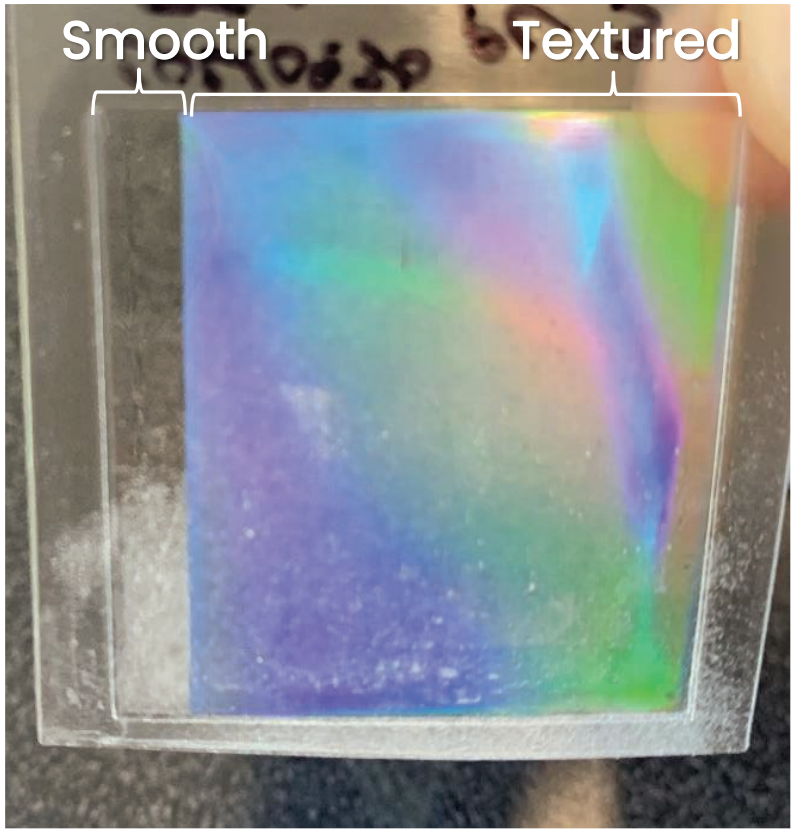


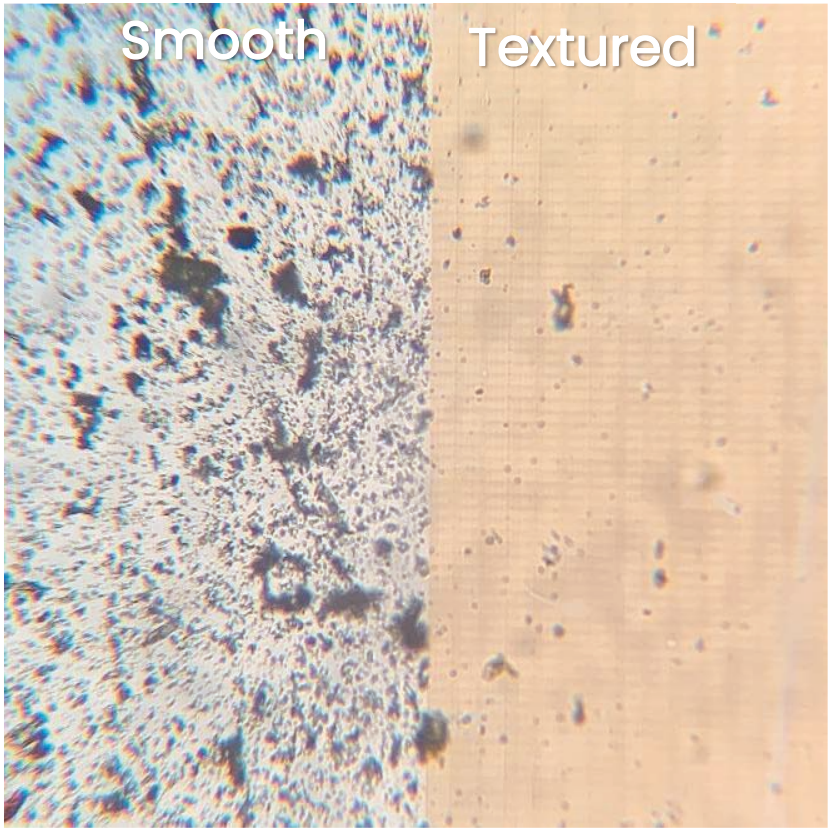
Particle Distribution



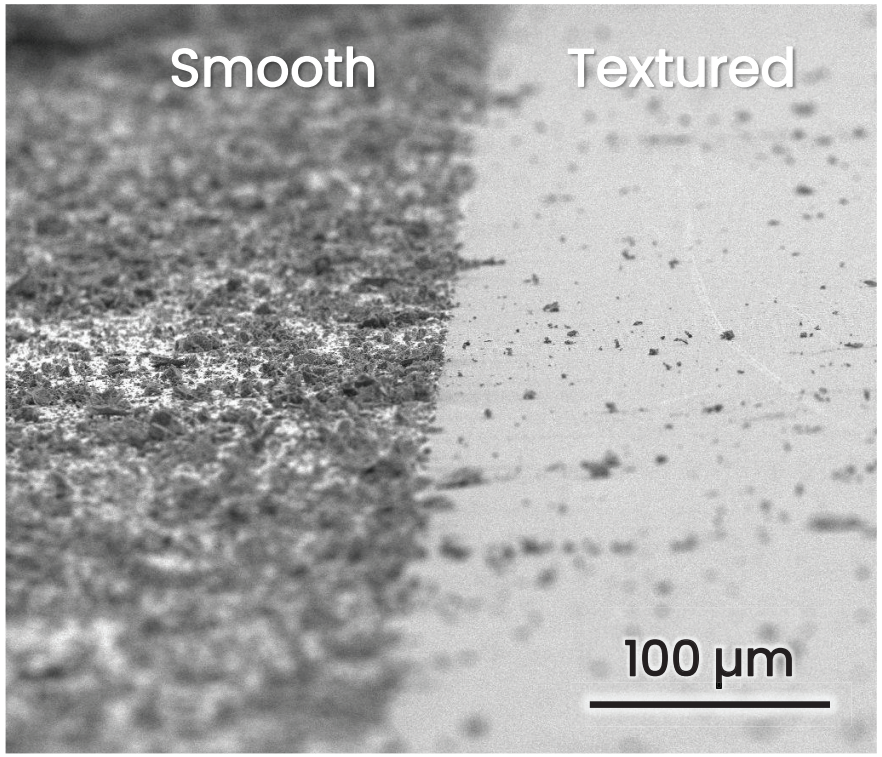


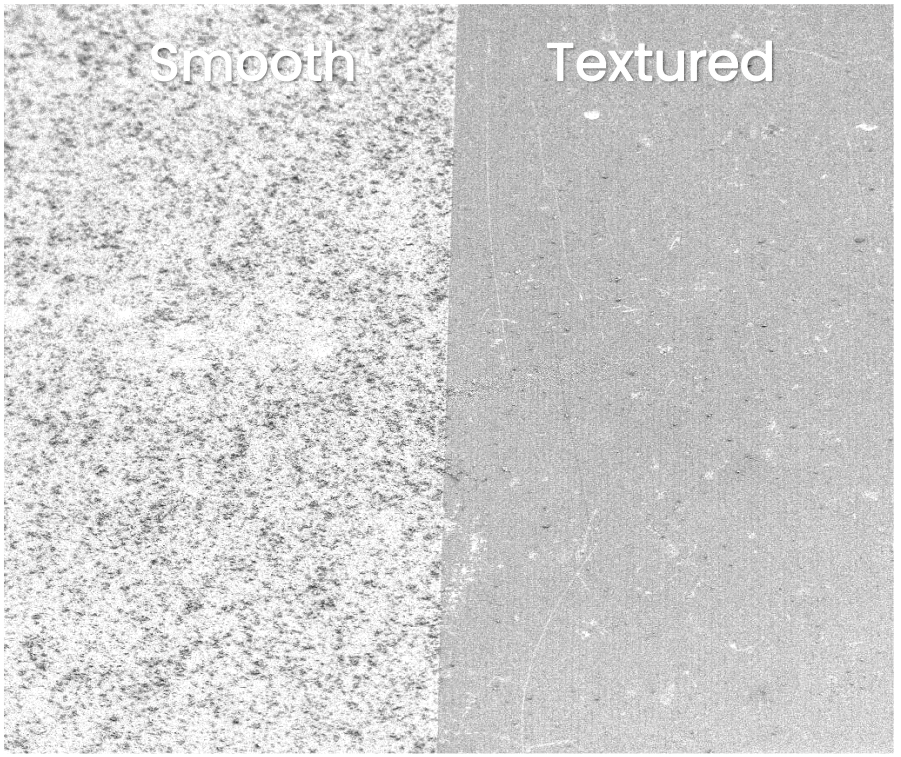
Seam: Transmission Microscopy



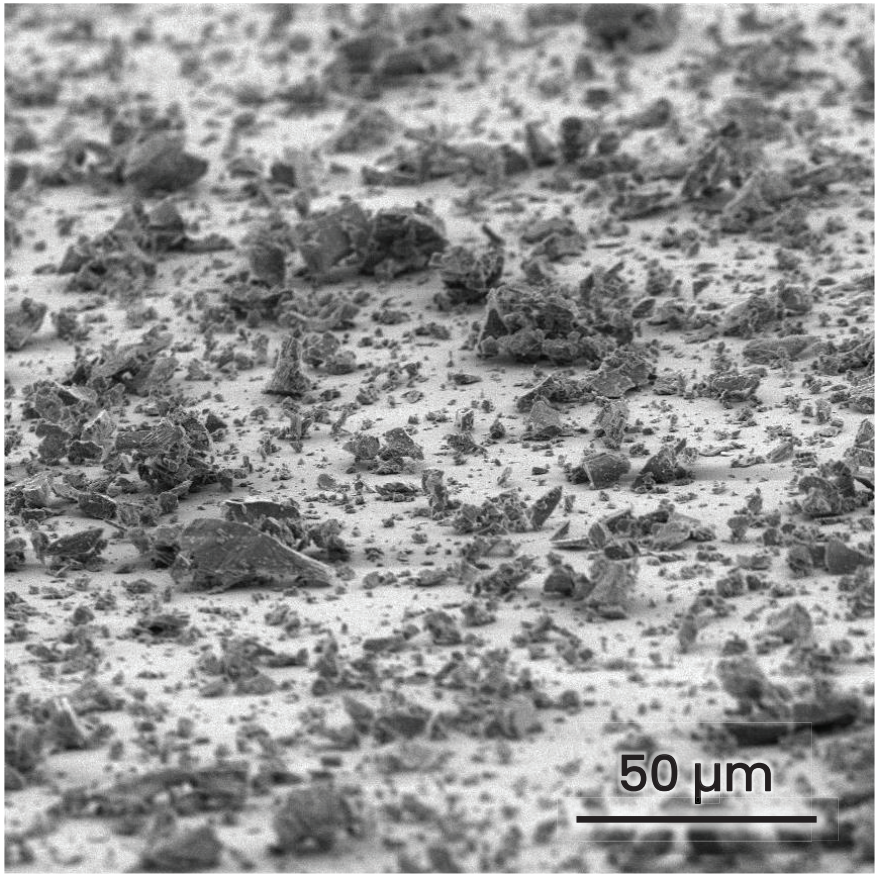


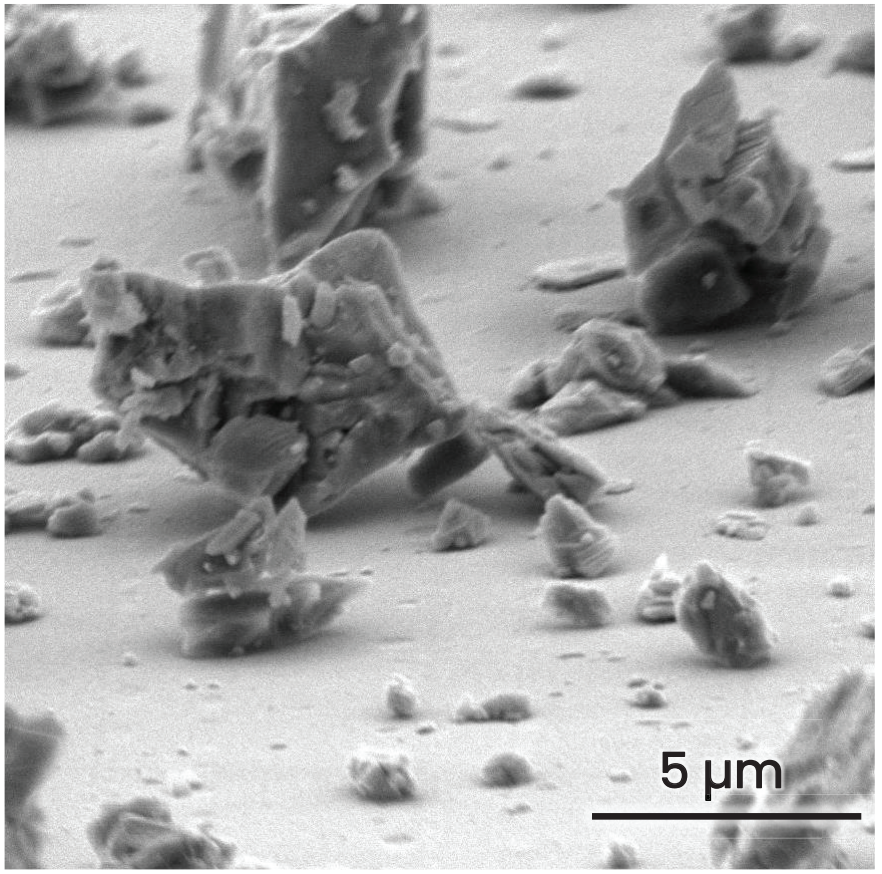
Seam: Electron Microscopy



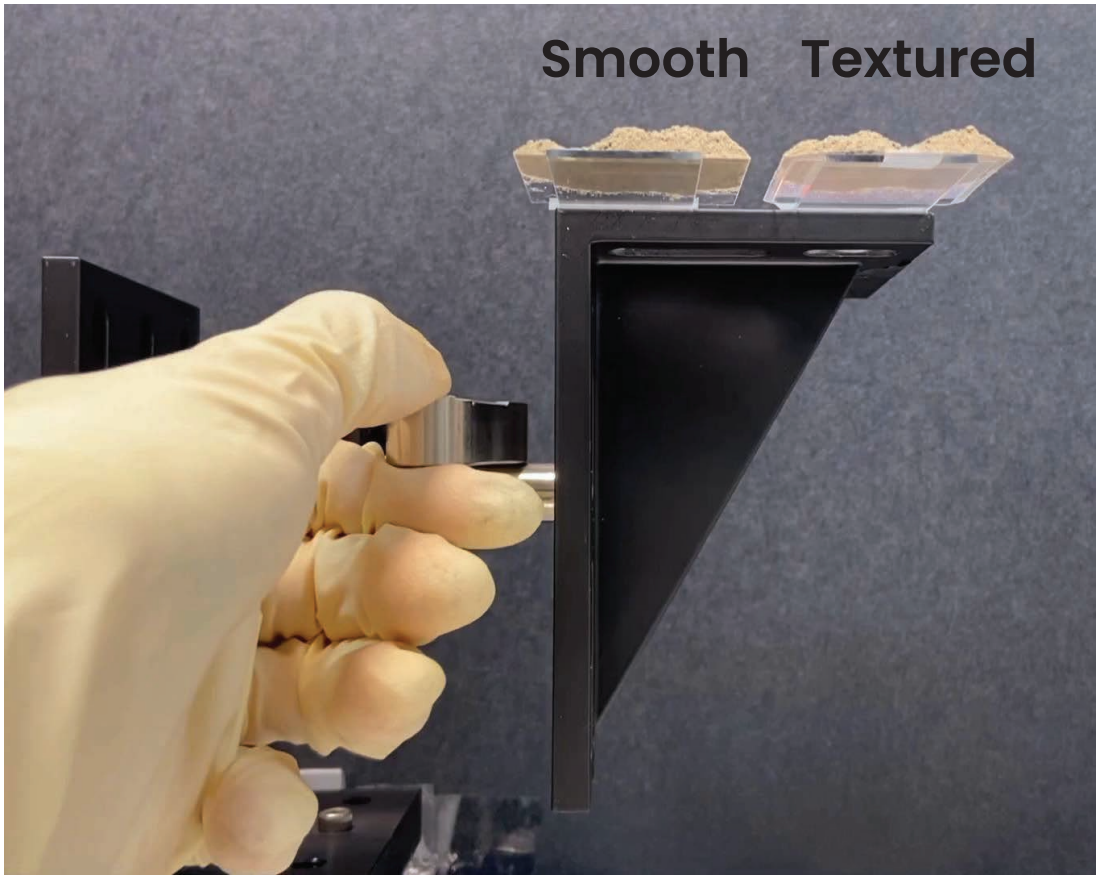


Dust on Smooth Polycarbonate





Dust-Mitigating Surfaces

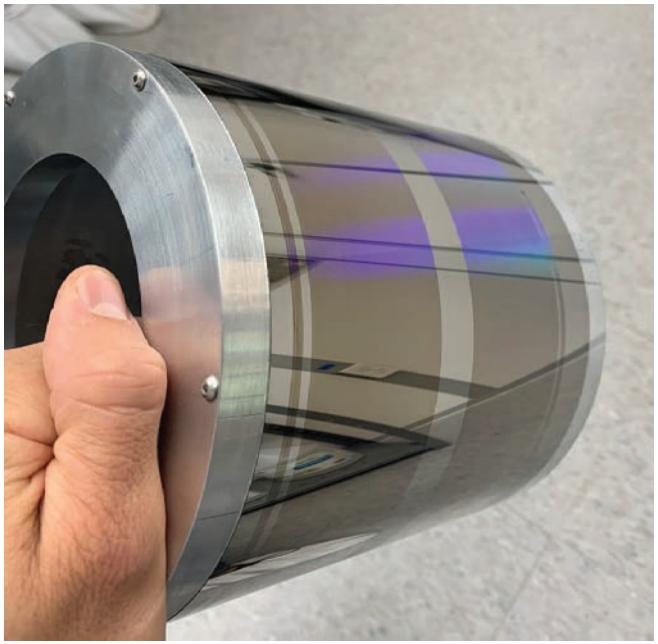


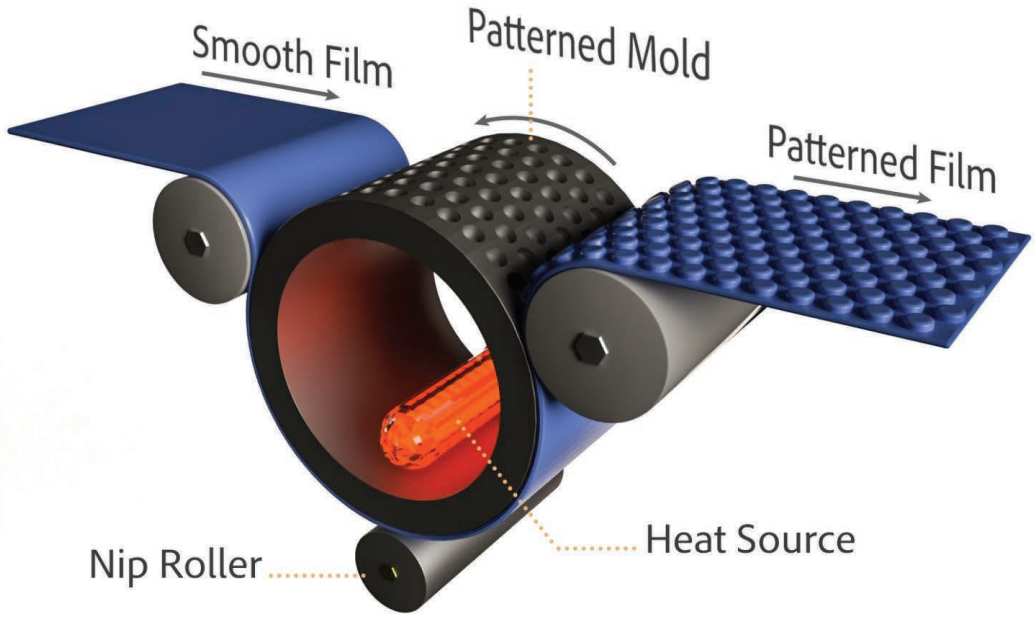
4x Speed

https://youtu.be/FBWk1OCg5dc

Roll to Roll Imprinting

- 6.5” drum with 300 nm features (SMS)
- Thermal NIL into PC, 1.5 m/min (MiCon)





https://youtu.be/2WzndwDG9SY

Proposed Phase II Work

1: Adhesion Physics

- What **geometric characteristics** matter?
- Will low **surface energy** materials demonstrate the dust-mitigating effect without a silane coating?
- What happens if we increase the **excitation force** ?

2: Scale and Form Factors

- Roll-to-roll imprinting
- Pattern transfer to PTFE, polyimide, PET, FEP via imprinting and etching
- Application to solar cells, radiator strips, food bags, and camera optics

3: Relevant Testing

- Vacuum, temperature, static charge, and humidity
- Repeated dust loading cycles
- Abrasion and thermal stress testing

Smart Material Solutions

Stephen Furst
furst@smartmaterialsolutions.com

Chih-Hao Chang
chichang@utaustin.edu