Superhydrophobicity in Power Applications

ICC - Sub B
Fall 2008

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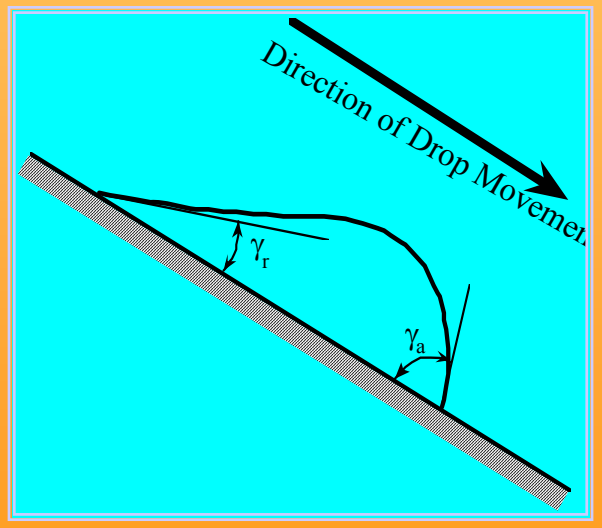
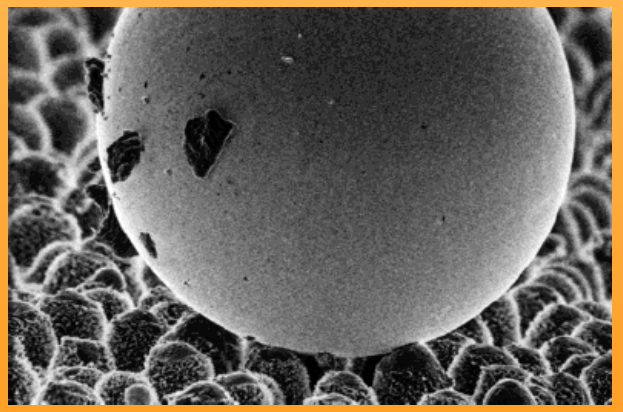
NEETRAC

Lotus Effect - Superhydrophobicity

Contact angle: > 150˚

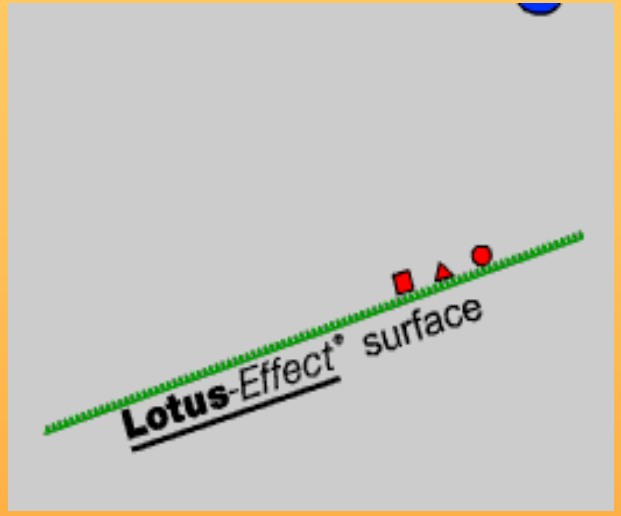
Hysteresis smaller than 10˚
(Hysteresis= $\gamma_a - \gamma_r$)

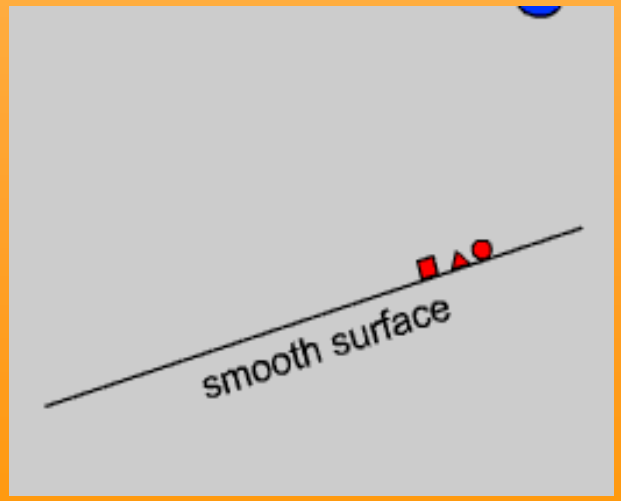




A droplet on a superhydrophobic surface: The droplet touches the leave only in a few points and forms into a ball. It completely rolls off at the slightest declination.

Why This Is Interesting





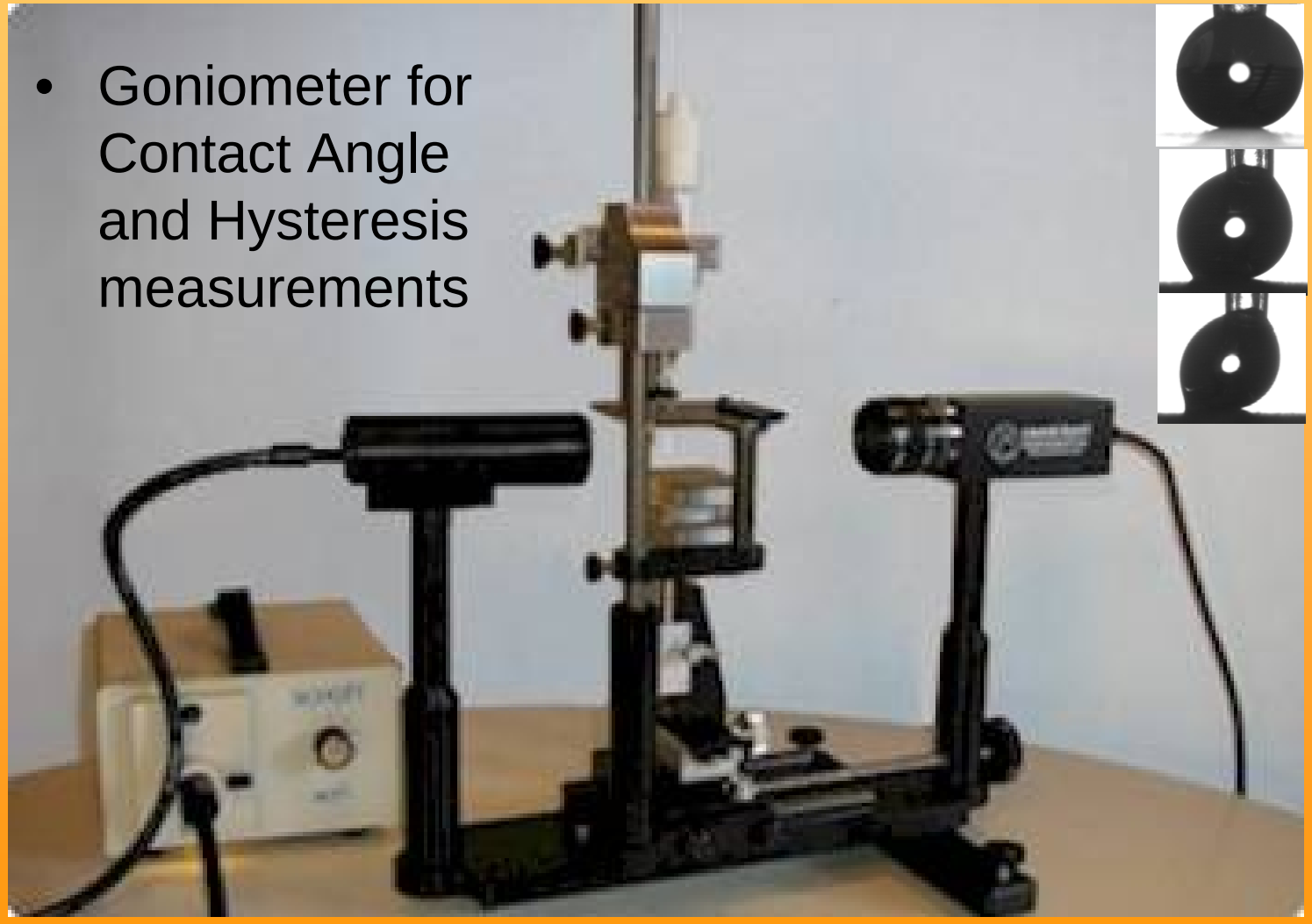
- Lotus effect surface:

  Dust with a particle size larger than the surface roughness is complete cleaned with a water droplet, rough surface in effect.

- Smooth surface:

  Dirt is only moved by the droplet.

Contact Angle Measurement



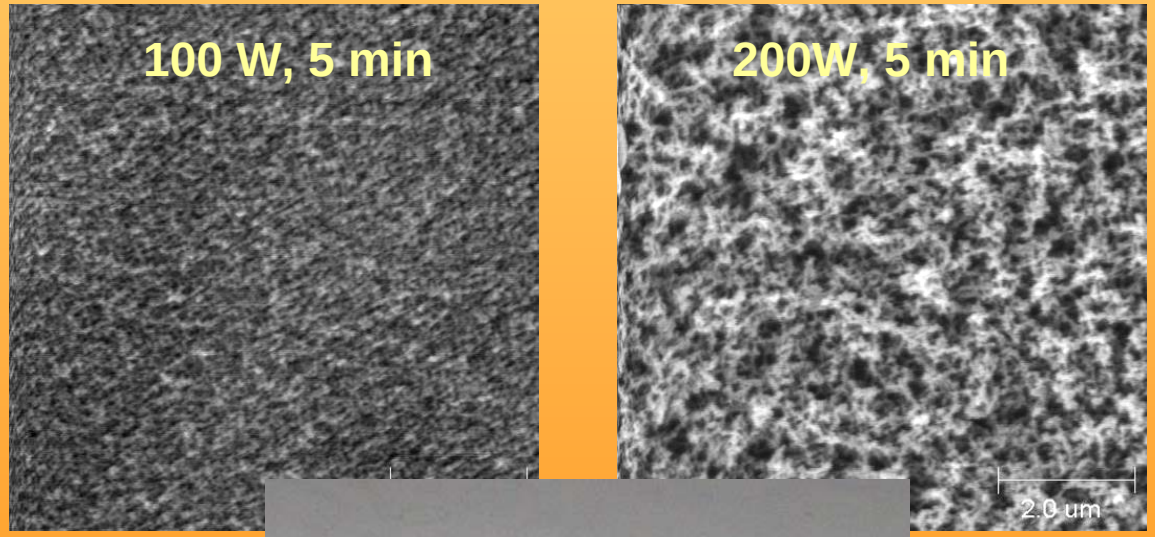
- Goniometer for Contact Angle and Hysteresis measurements

Scanning Electron Microscope

- Surface morphology
- Surface structure size / particle size measurement
- Surface elemental analysis

Starting Structures

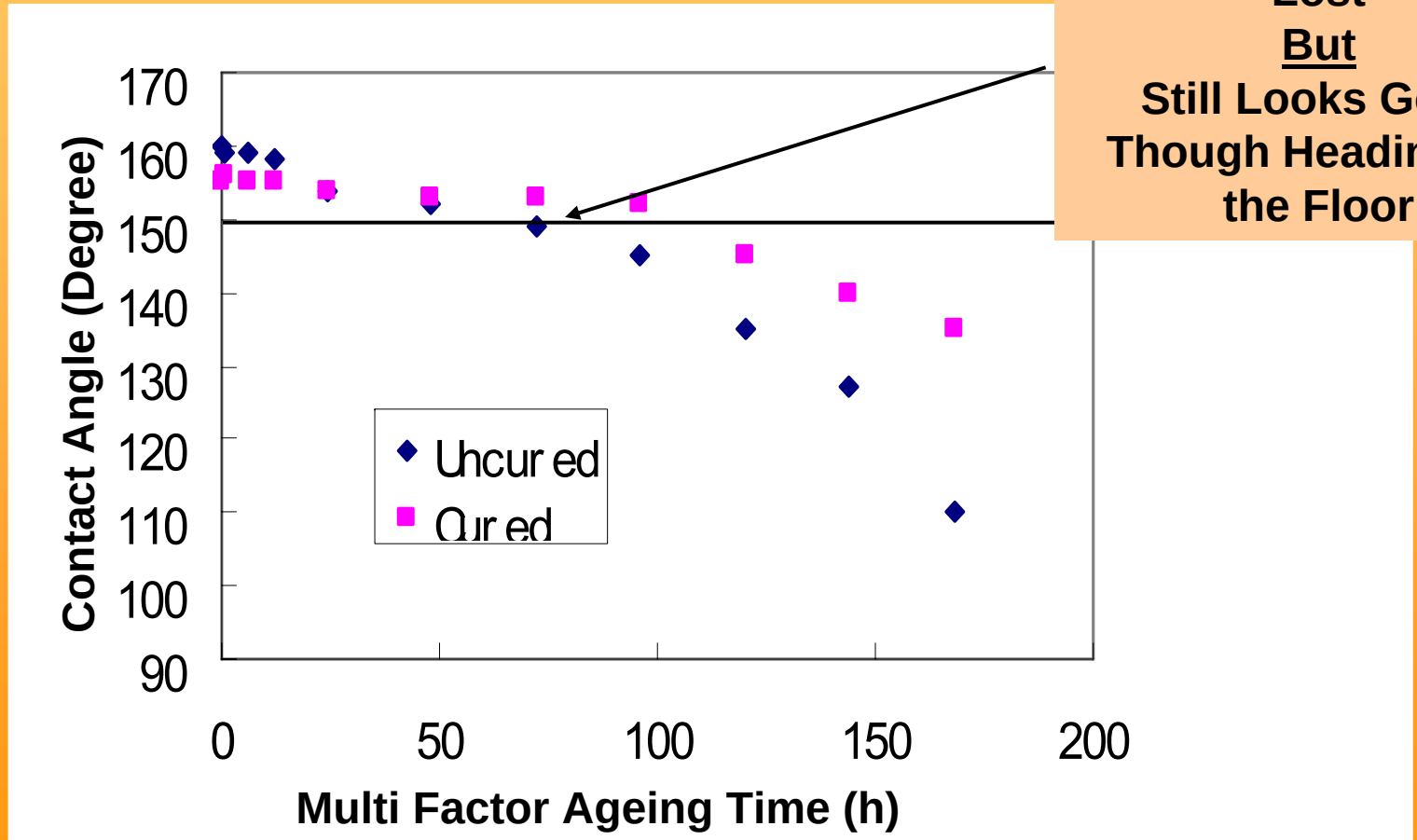
• Superhydrophobic coatings were prepared on various insulating polymer materials using CF_4 and SF_6 plasma etching.



Multi Factor Ageing

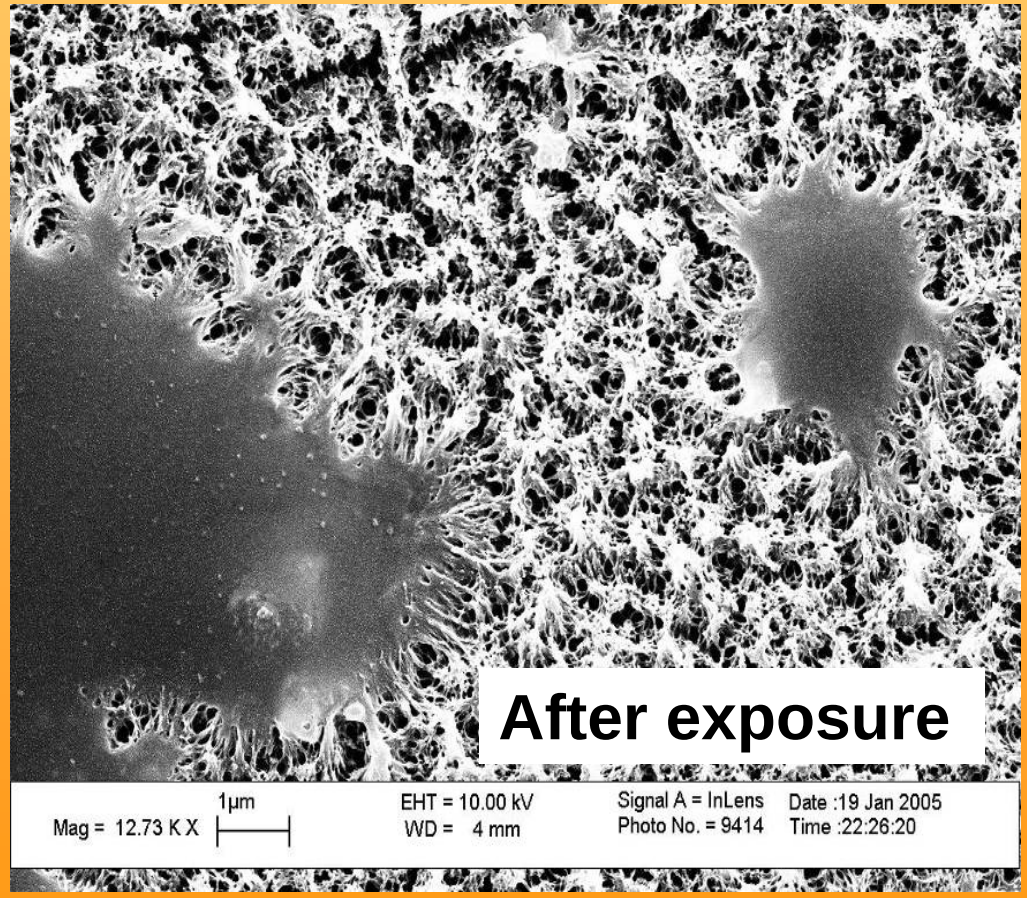
Looks Good But !!!!!!

Superhydrophobicity Lost
<u>But</u>
Still Looks Good Though Heading for the Floor



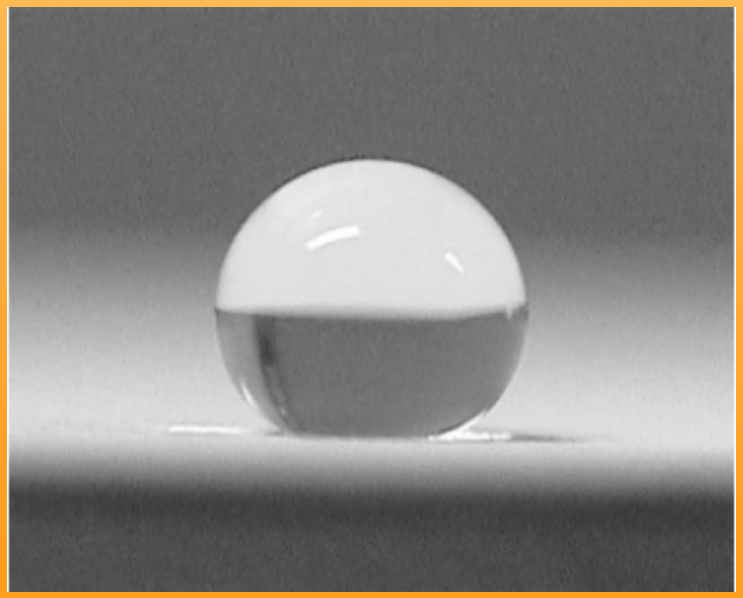
Degradation Of Polymer Film

- After 48 hours exposure the superhydrophobicity is totally lost. The contact angle drops from 160˚ to only 80˚.

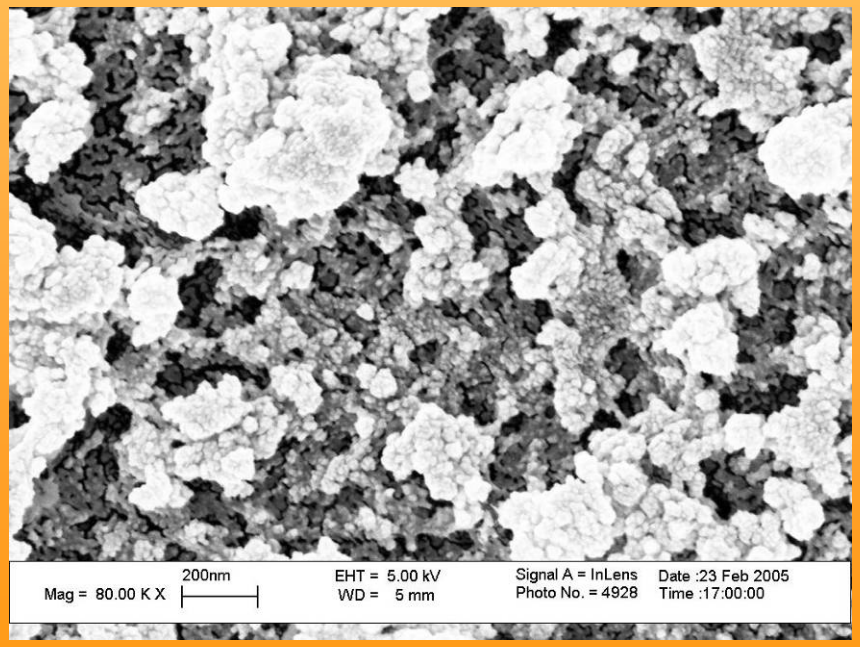


Next Step - An Inorganic Film

Inorganic material, stable under multifactor ageing.
Low energy surface can be achieved.
Roughness control through diameter control.

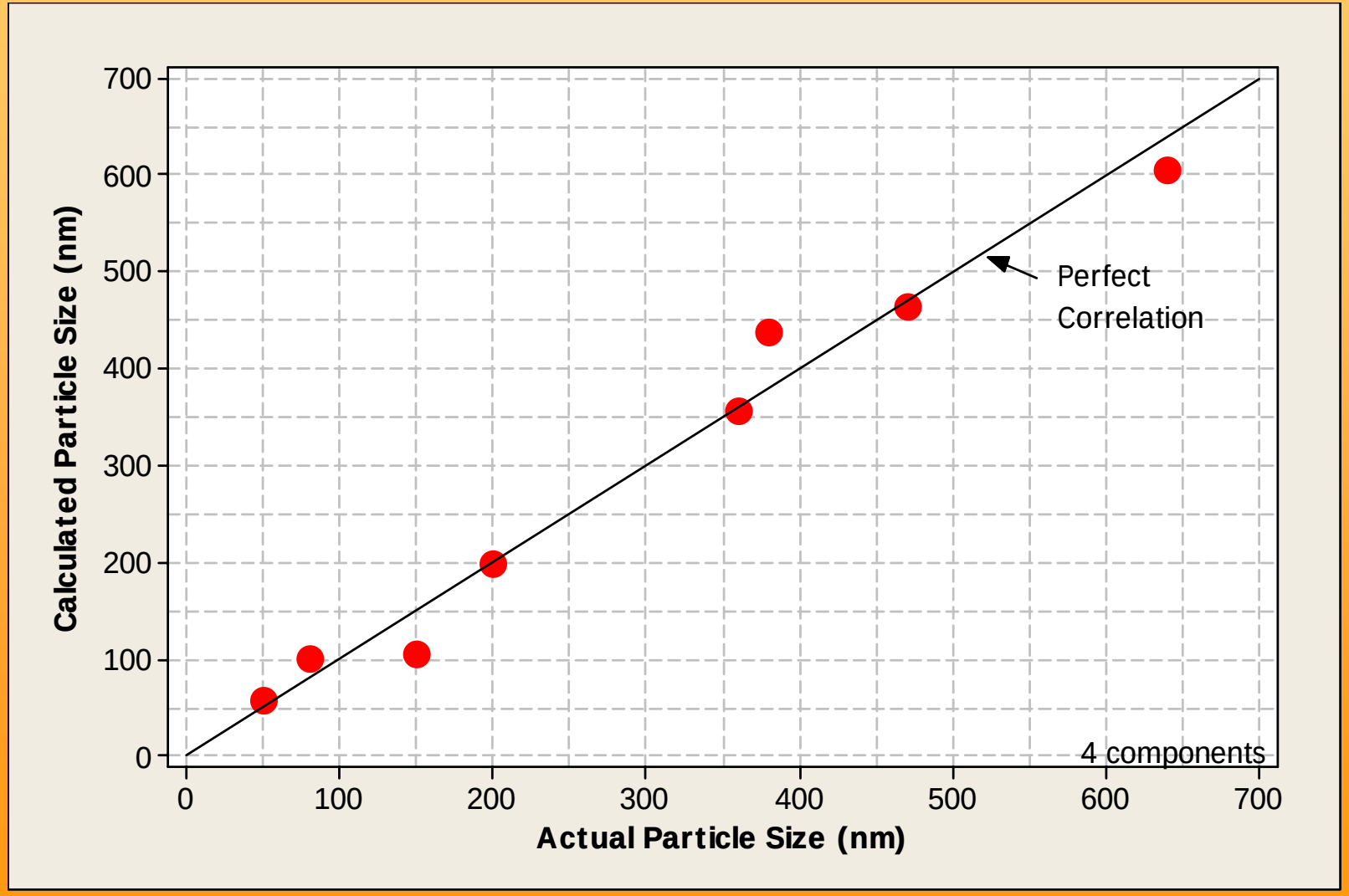


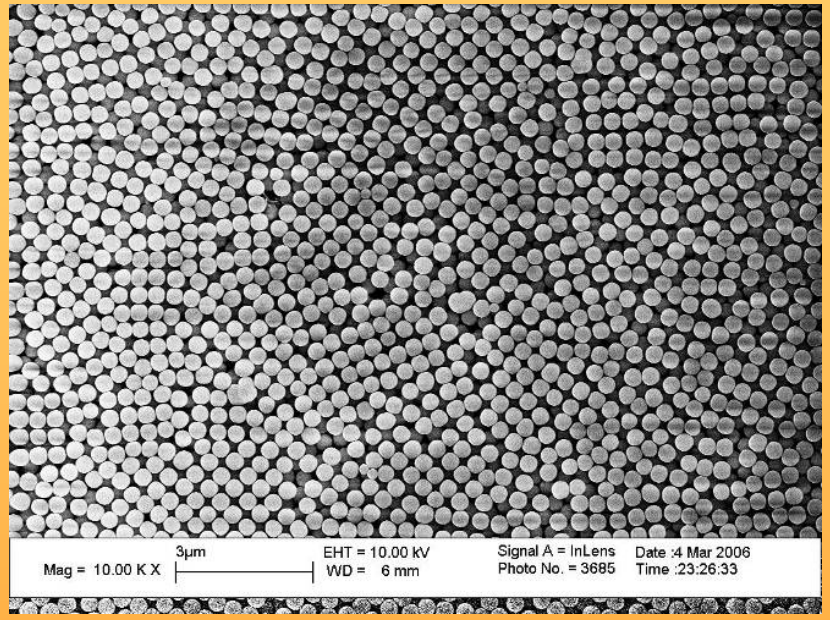
Contact angle: ~162˚ hysteresis: < 5˚



SEM image: Surface roughness

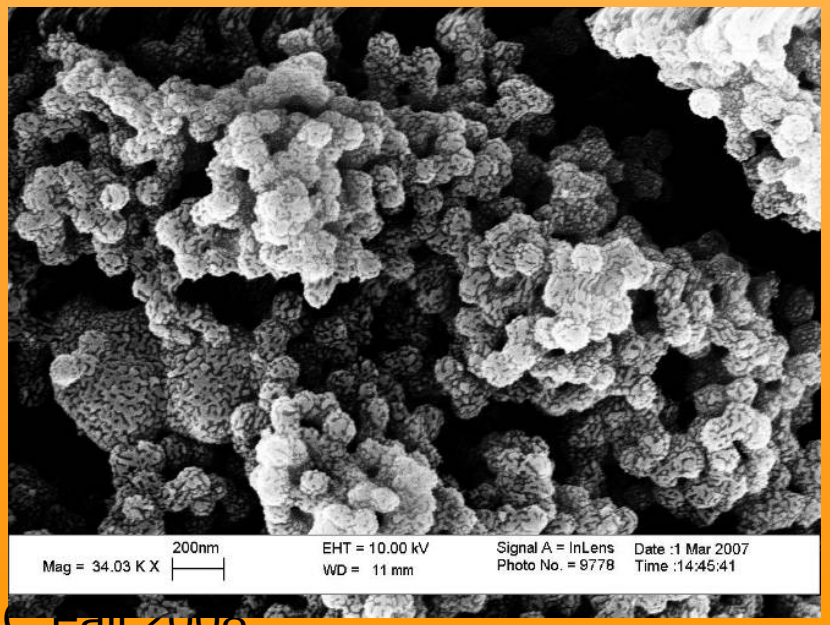
Can Control Particle Sizes





One species, too perfect packing, not enough roughness

Contact angle: 134˚



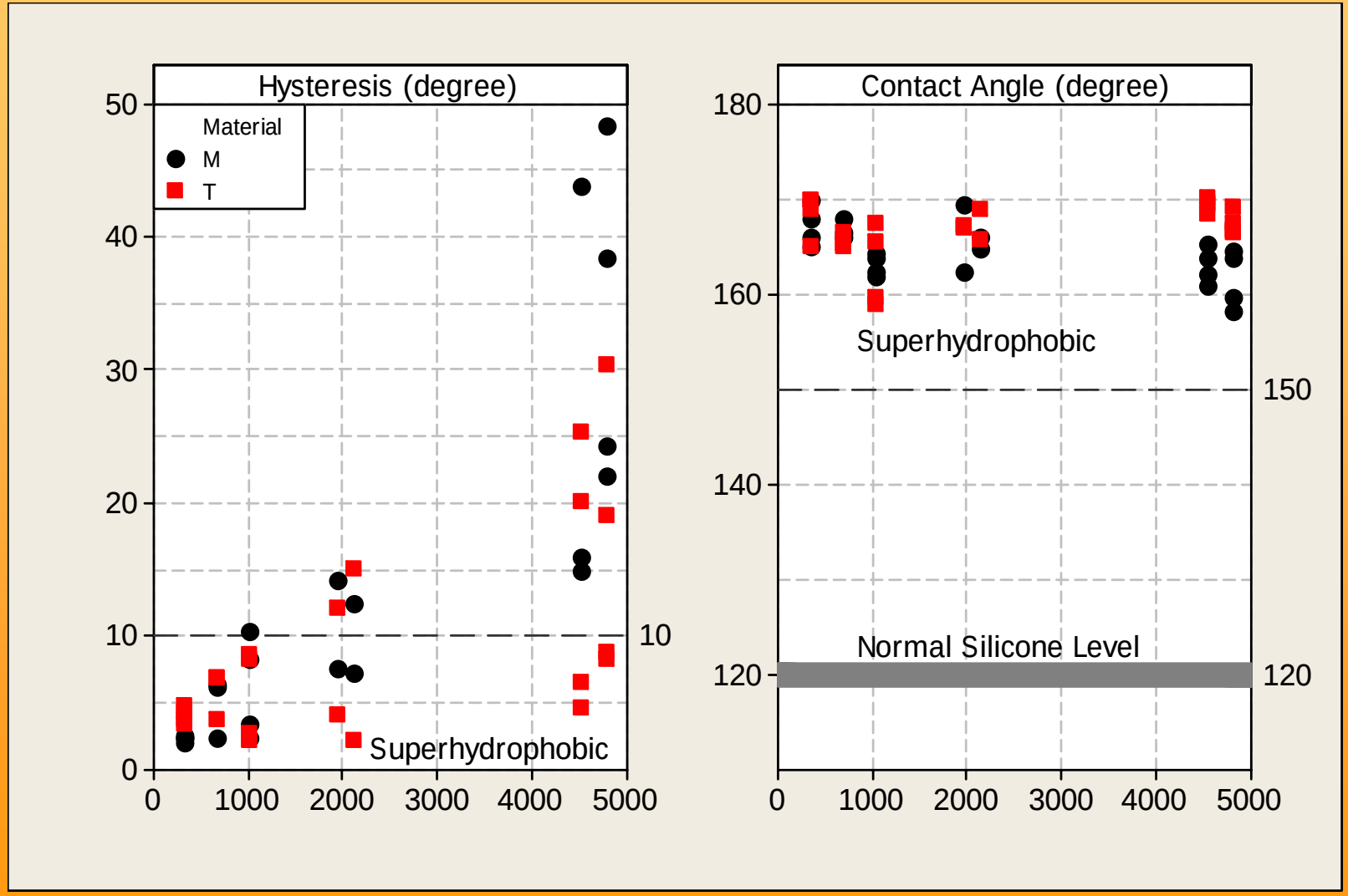
TiO_2: ~800 nm

SiO_2: 90 nm

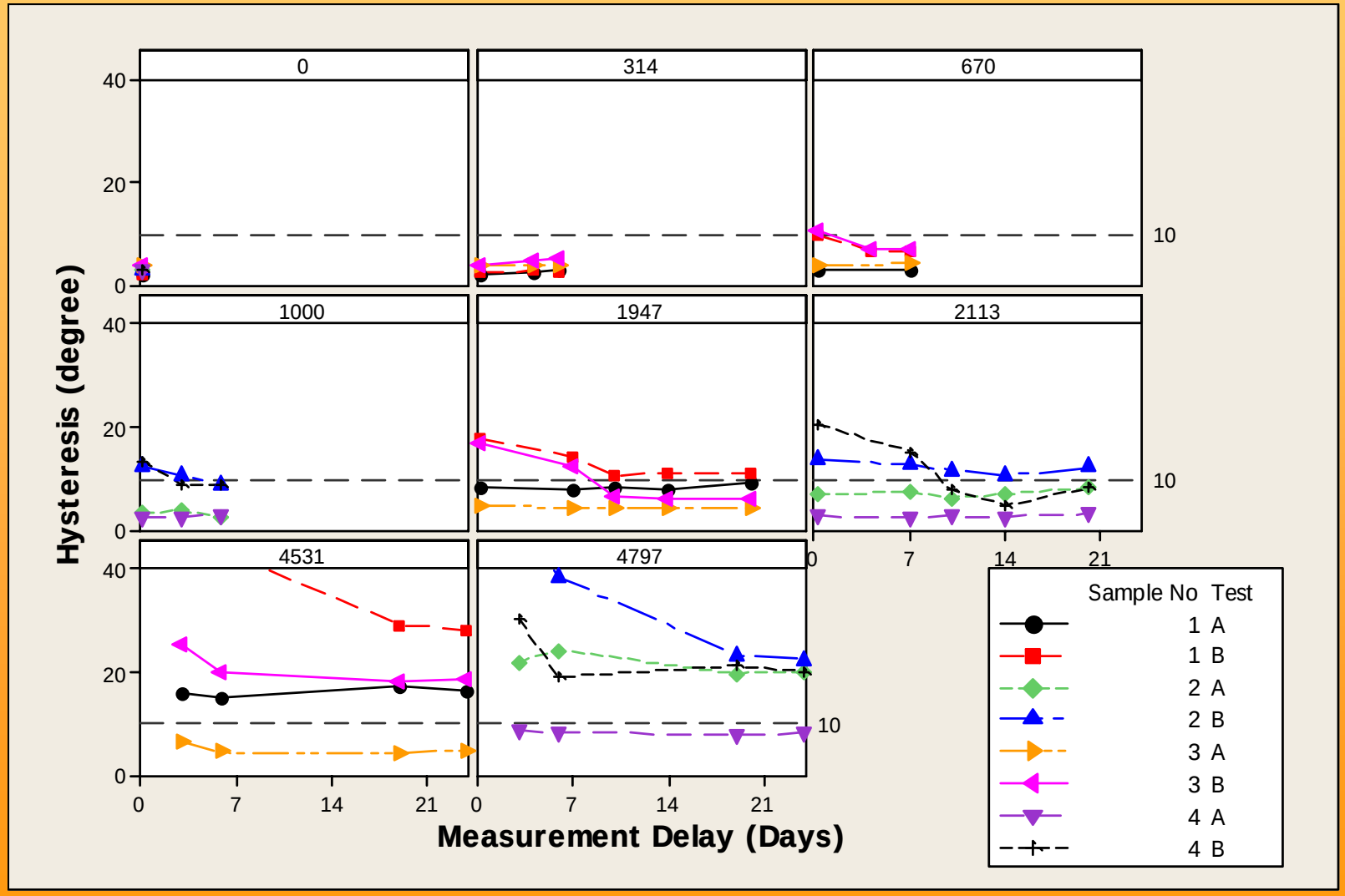
Enough roughness can be achieved

Contact angle: 168.3˚, hysteresis < 4˚

Multi Factor Ageing - Results

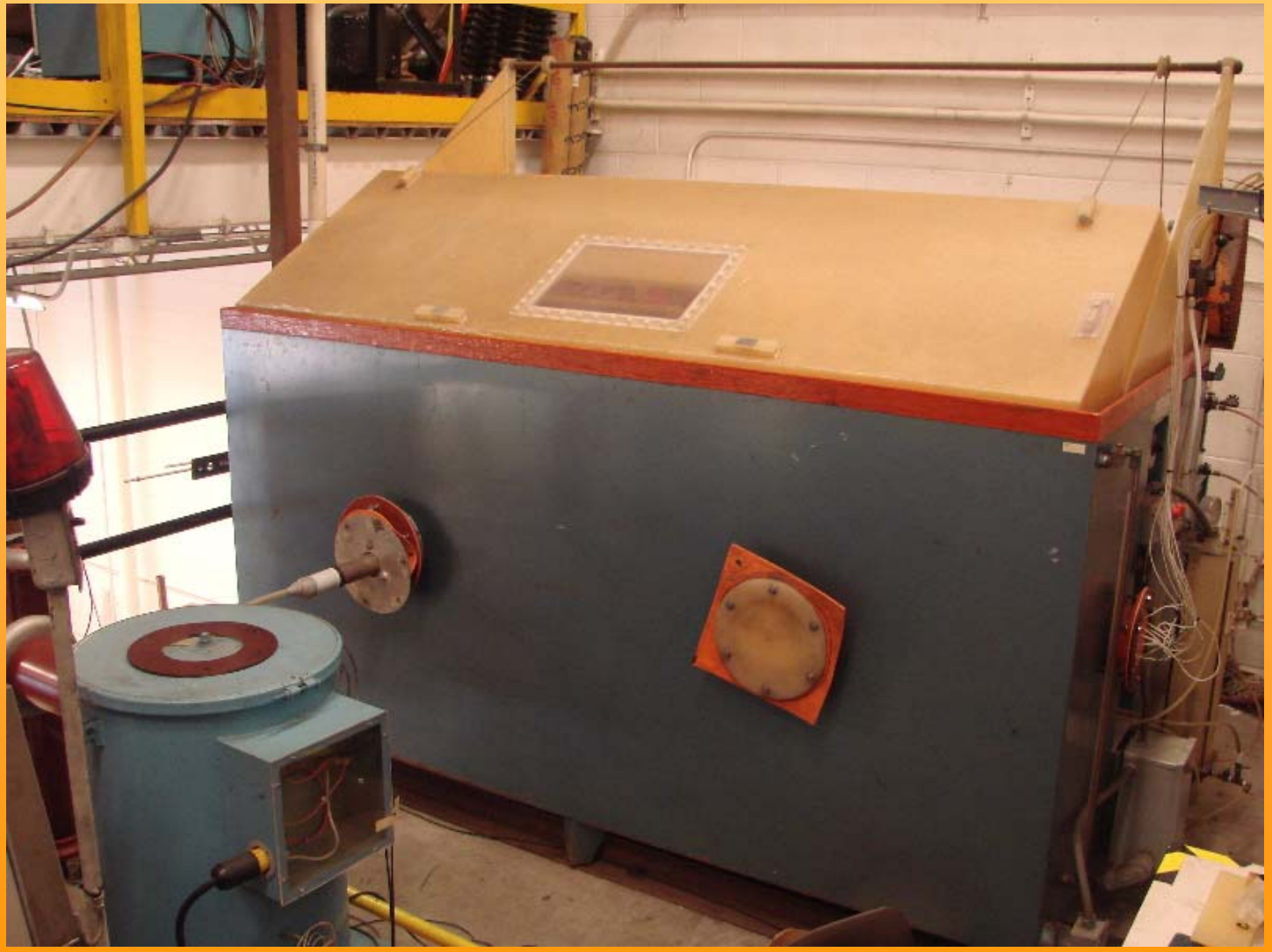


Recovery Hysteresis



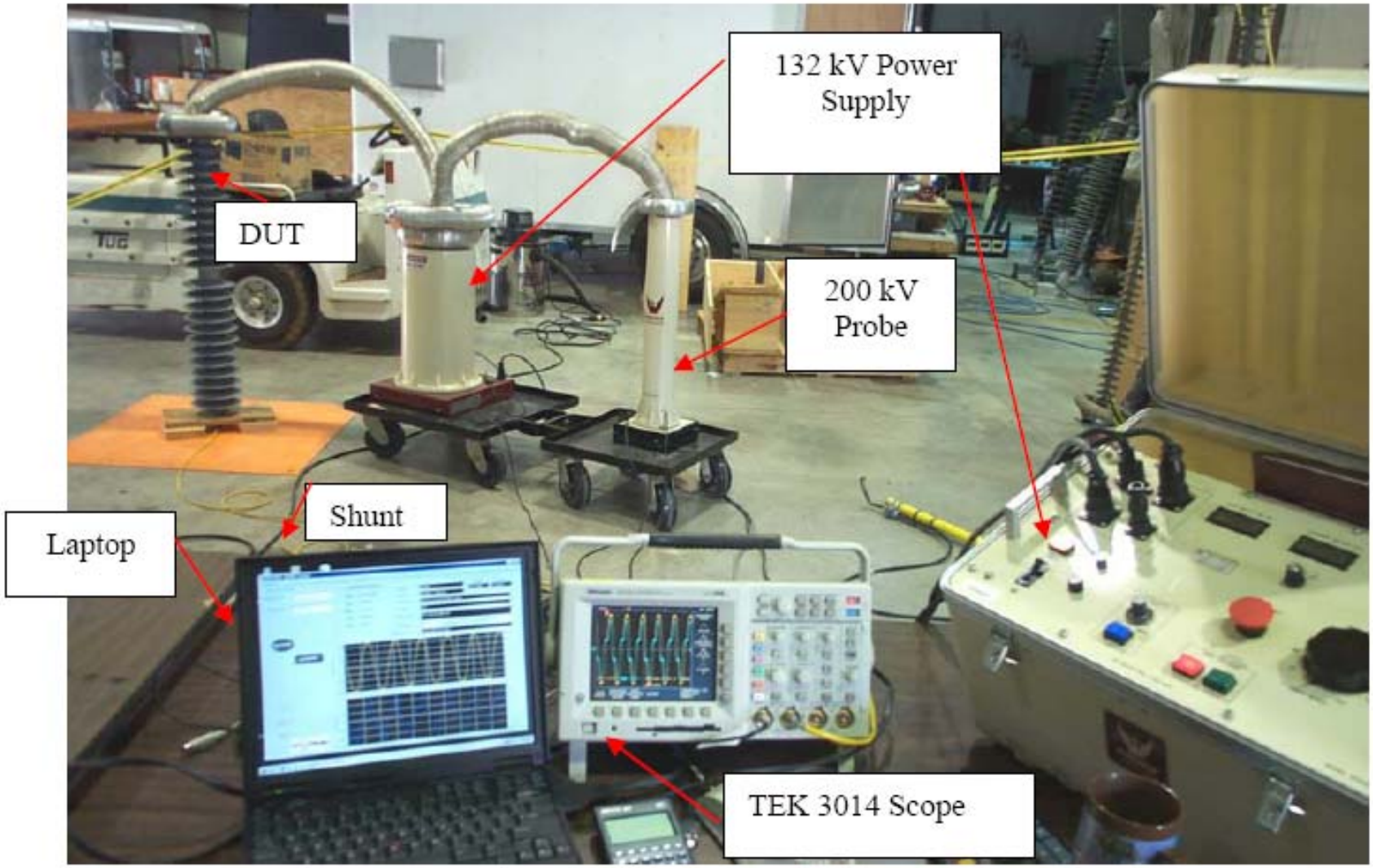
Transition to “Real Life”

Salt Fog

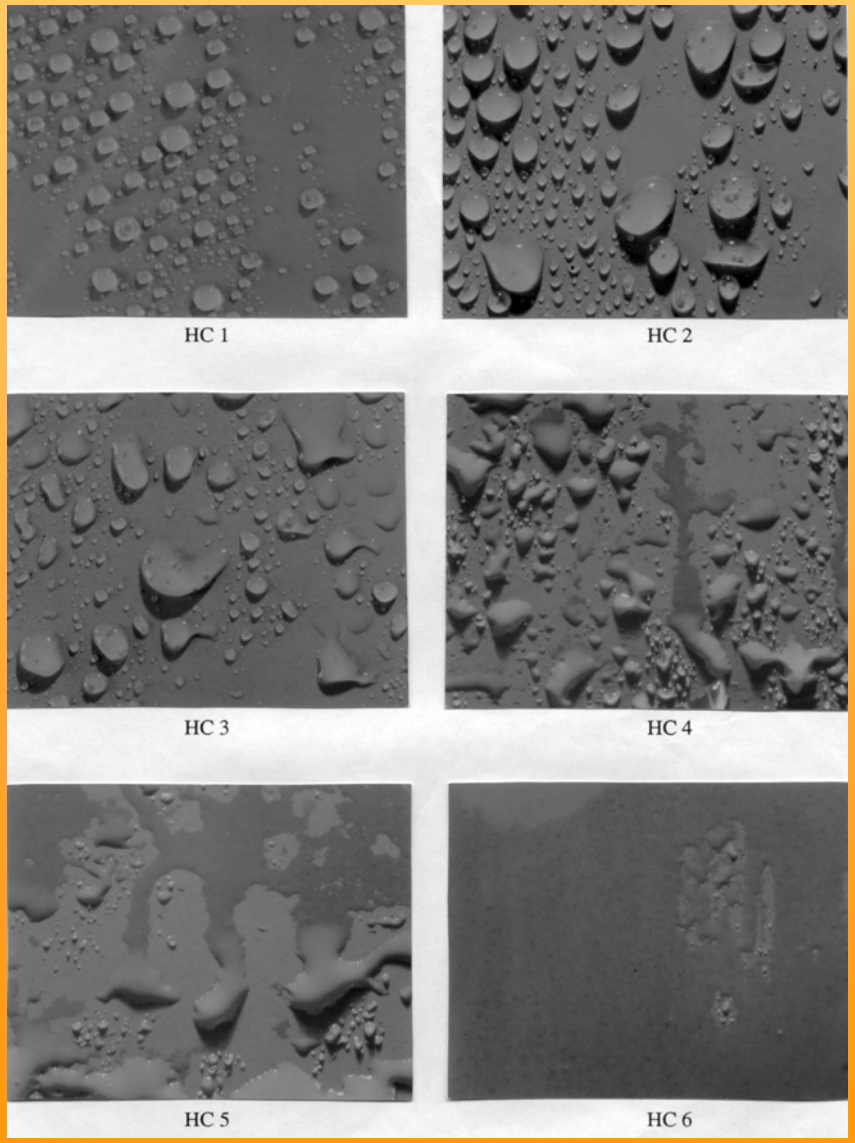


Salt Fog

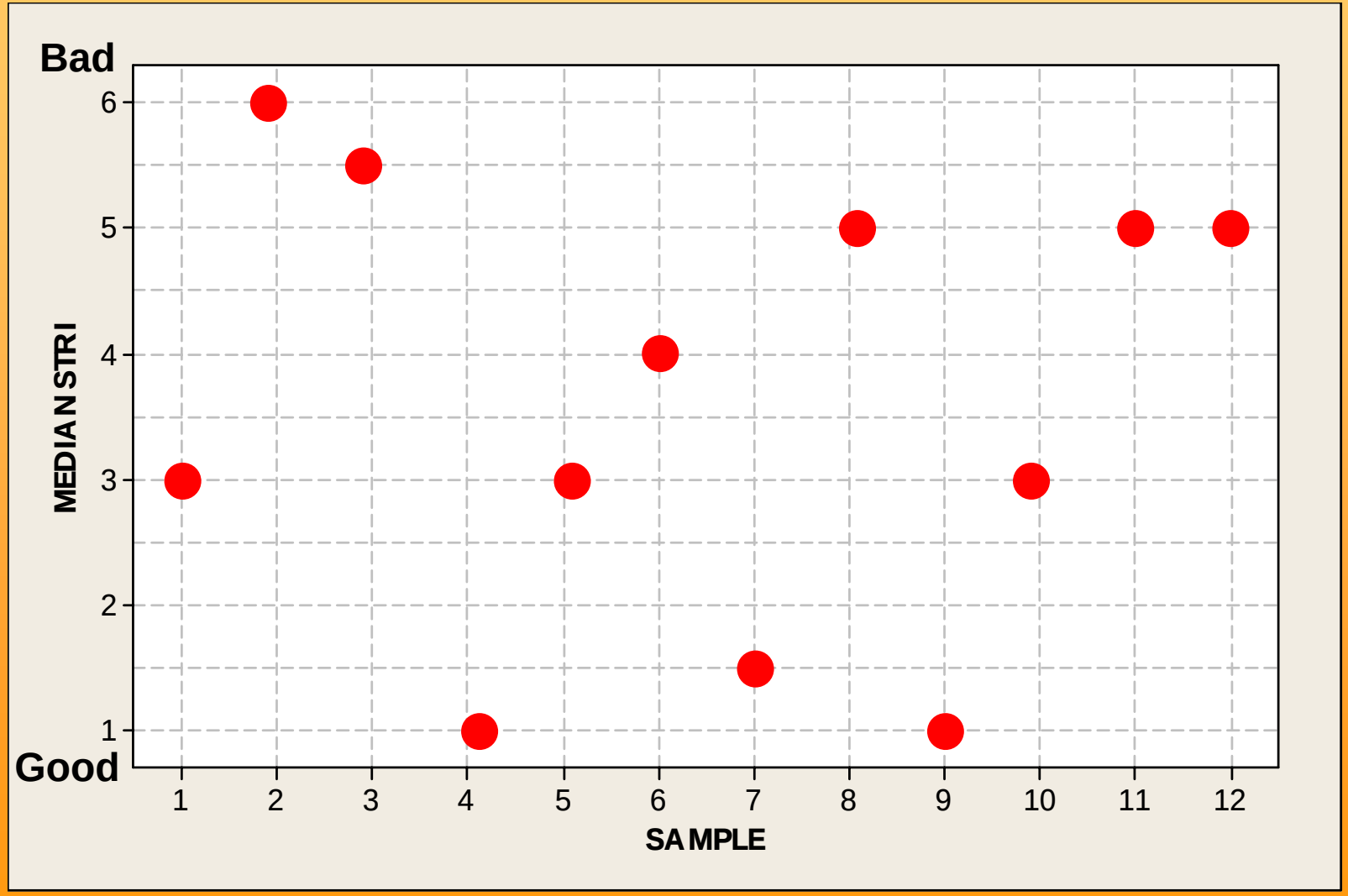
HiVARC


132 kV Power Supply
DUT
200 kV Probe
Shunt
Laptop
TEK 3014 Scope

Semi Quant STRI Classifications



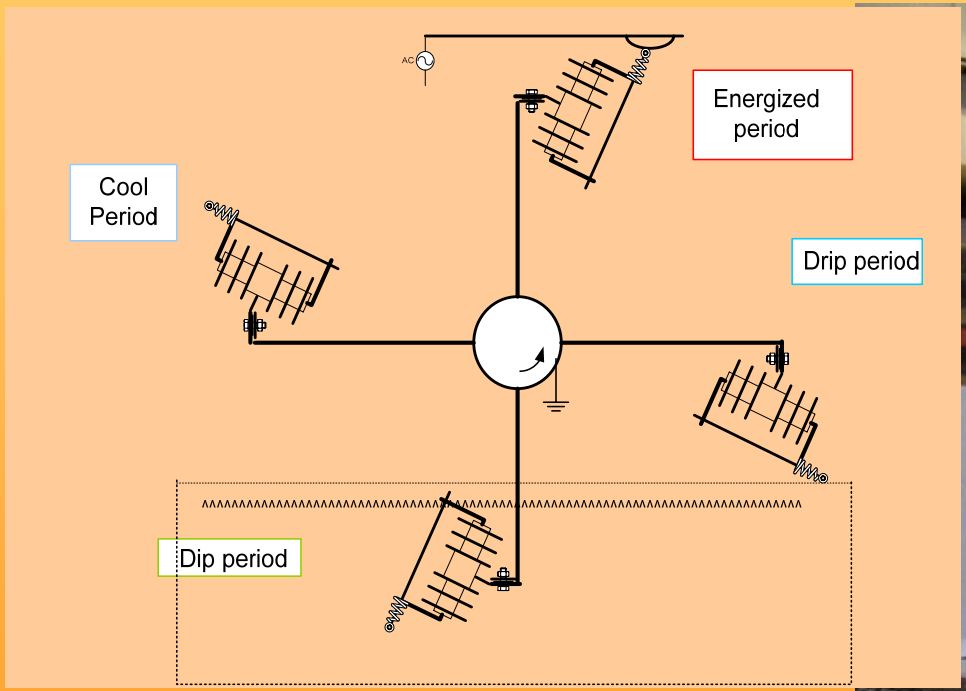
STRI Assessment

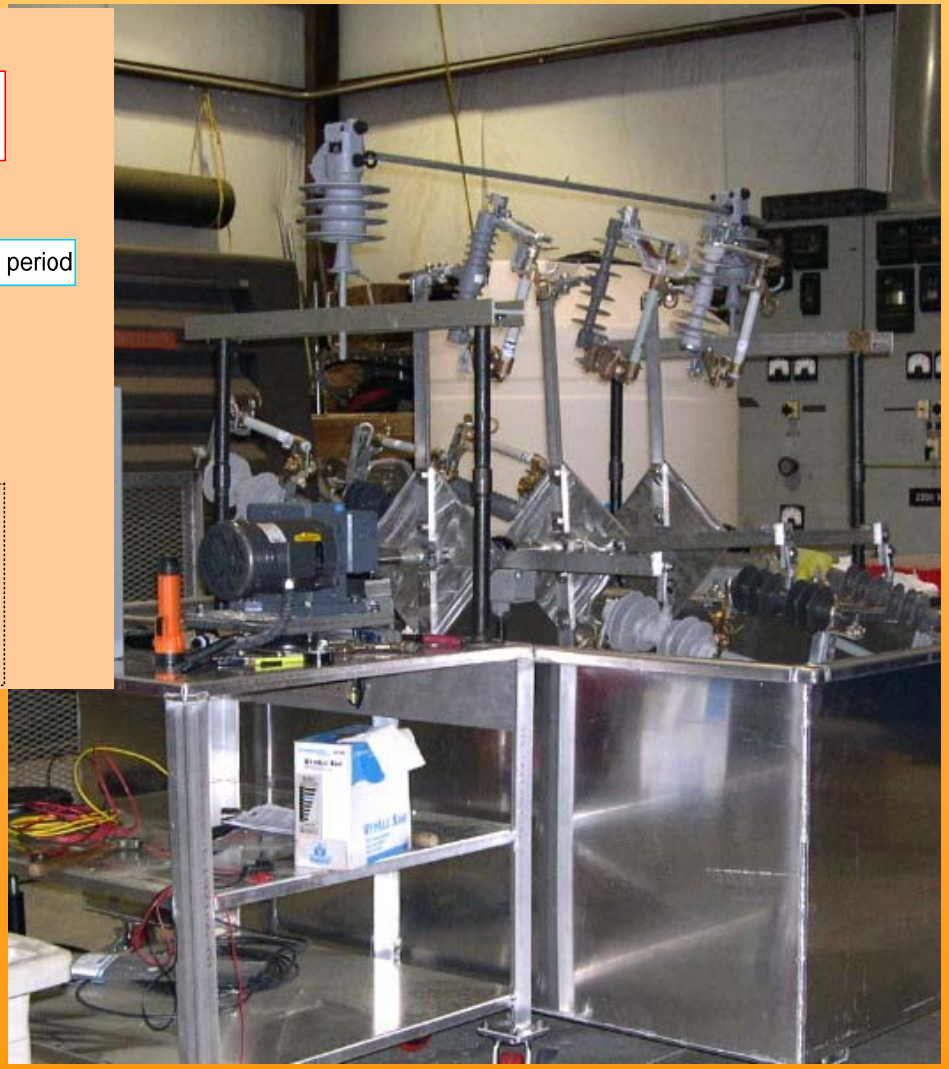


Full Size Insulator Test

Device	Salt Fog Endurance	HiVARC	STRI Hydrophobicity	Tracking Wheel Endurance
Suspension Insulator Phase I	12.5kV 1382 hours	YES	YES	-
Suspension Insulator Phase II	20kV 1233 hours	YES	YES	-
Polymer Cut Out	-	-	-	YES

Tracking Wheel

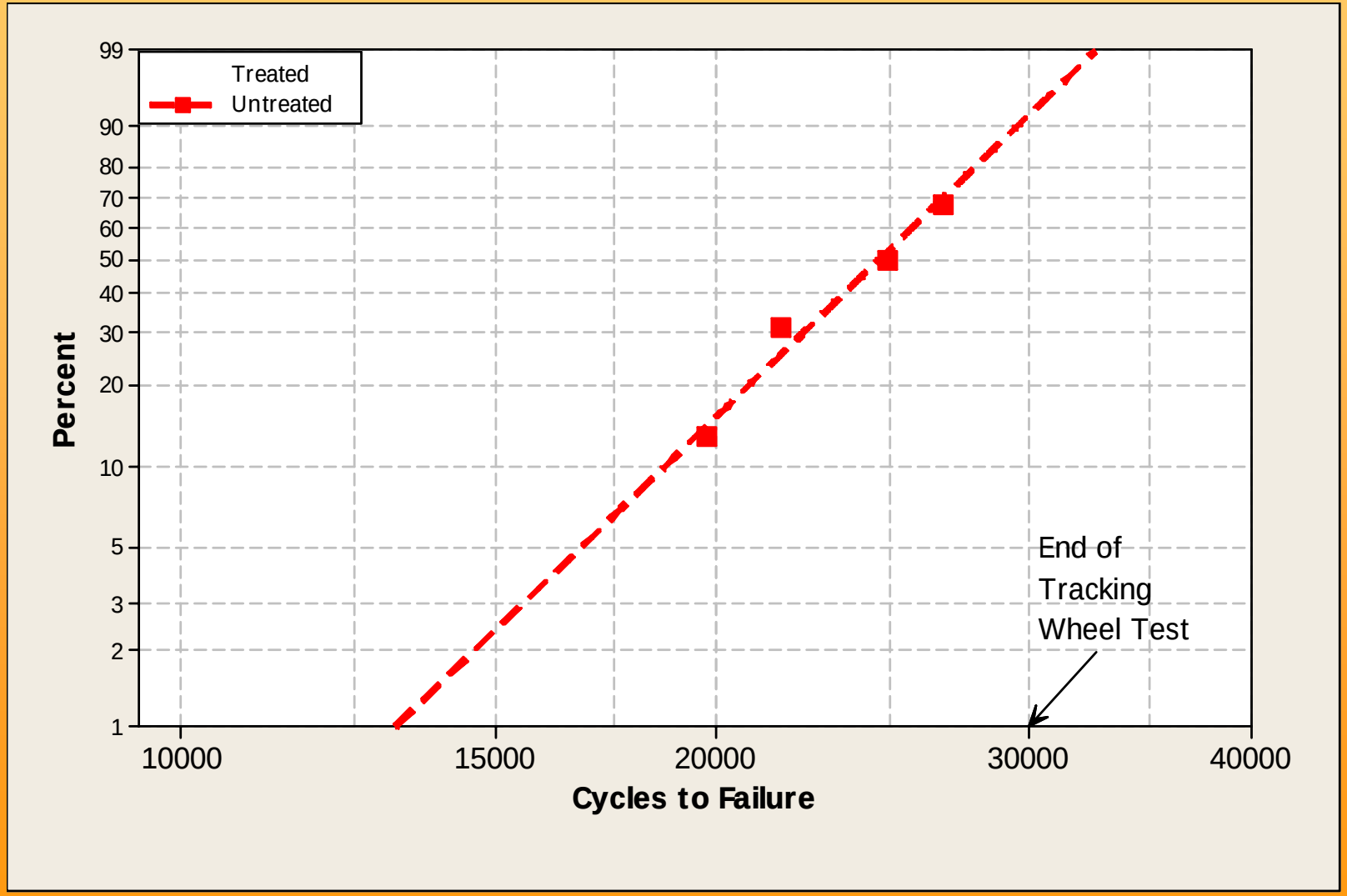




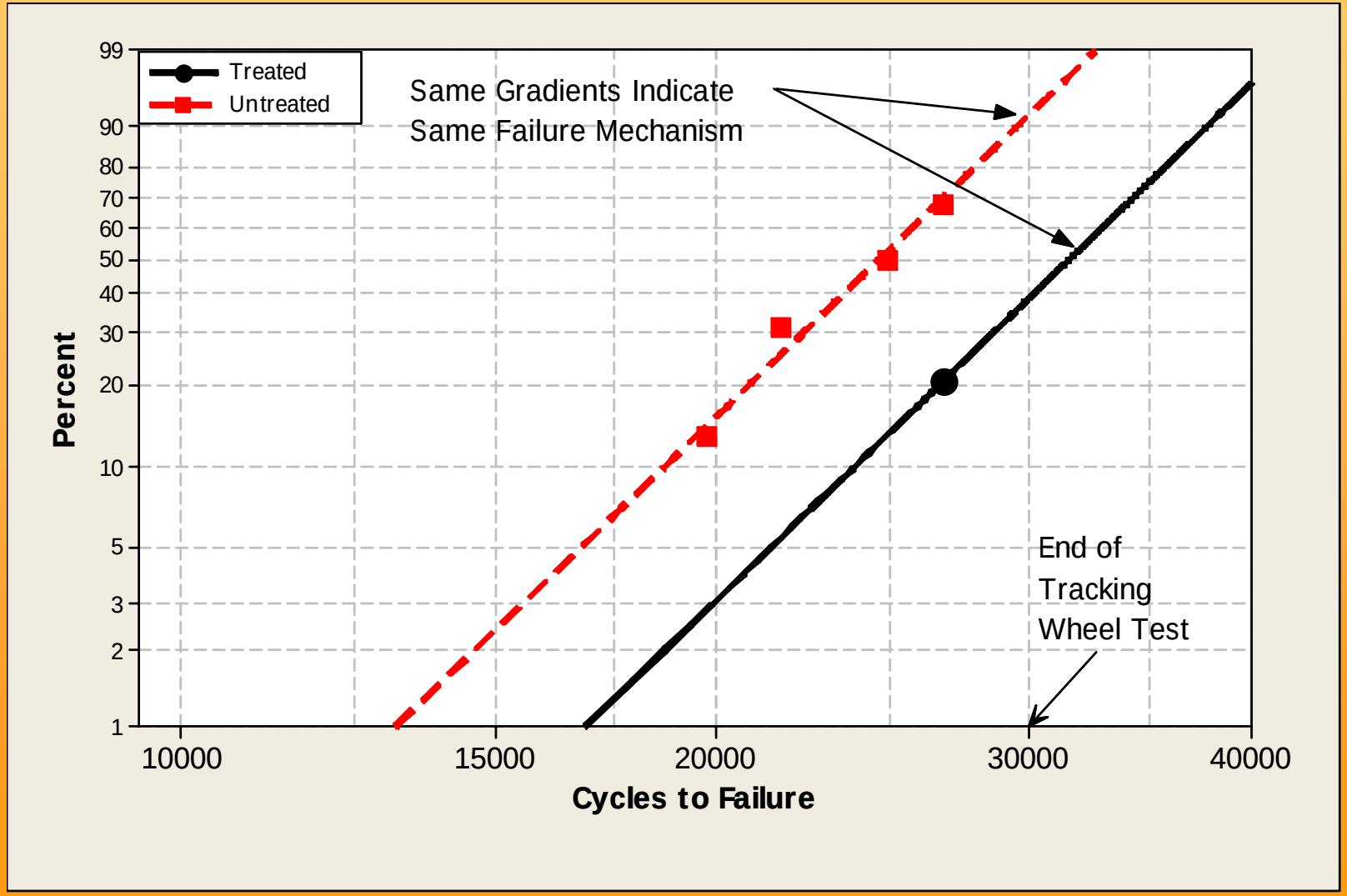
Let There Be Light

Tracking Wheel Failures

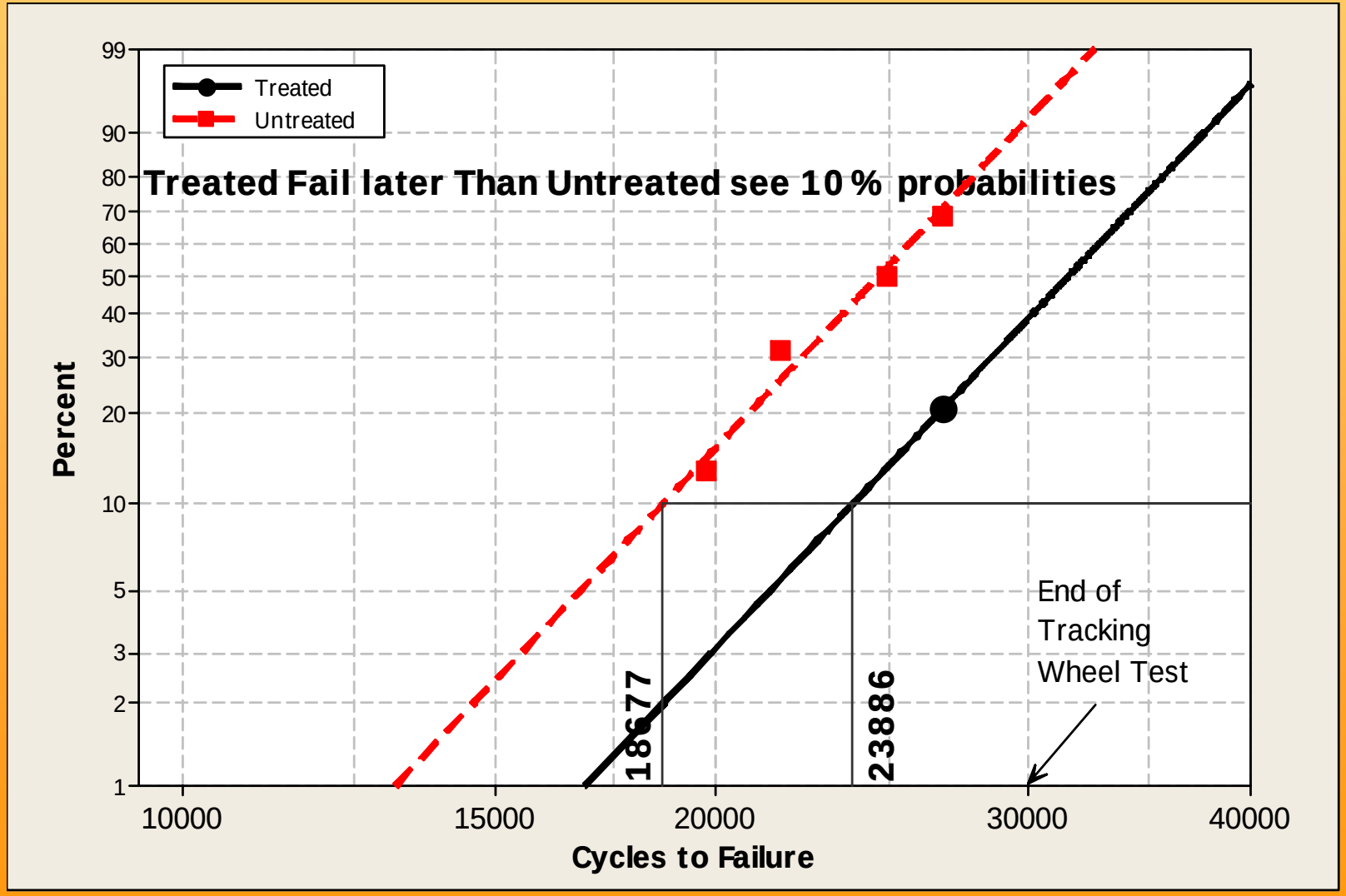
Tracking Wheel Test on Cutout



Tracking Wheel Test on Cutout



Tracking Wheel Test on Cutout



Field Test Participants

- **Polymer Silicone Insulators**
- **Southern Company Transmission Lines**
- **Hubbell**

Insulator Installation Site

Field Test Site

Solution Applied To New Insulators

Installing New Insulator At Str.# 54

Conclusions

- Robustness and longevity are very important
- Coatings work on all of the main insulations
- Accelerated tests are underway
- Coatings are in use at 15 & 115 kV
- Work planned for EHV