ETH zürich

Institute of Energy and Process Engineering

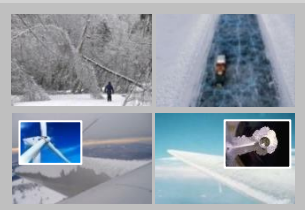
Nanomaterials for Water and Energy

Prof. Dr. Thomas M. Schutzius

Dept. of Mechanical and Process Engineering
Laboratory for Multiphase Thermofluidics and Surface Nanoengineering

critical ***water*** and
energy issues

Surface icing



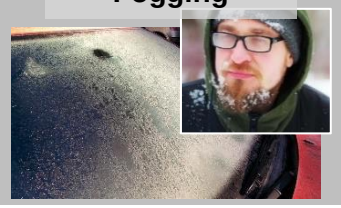
Water treatment and harvesting

Condensation Heat Transfer

Fouling

Electronics cooling

Fogging



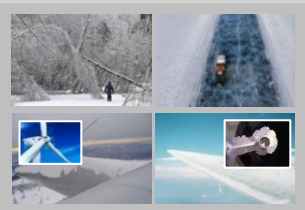
THERMODYNAMICS IN THE PRESENCE OF NANOENGINEERED MATERIALS

macroscale → meso-nanoscale

critical ***water*** and ***energy*** issues

future oriented, ***sustainable*** technologies

Surface icing



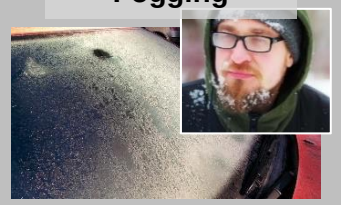
Water treatment and harvesting

Condensation Heat Transfer

Fouling

Electronics cooling

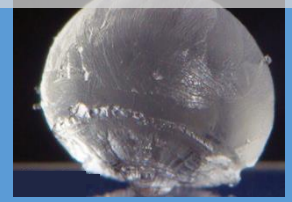
Fogging



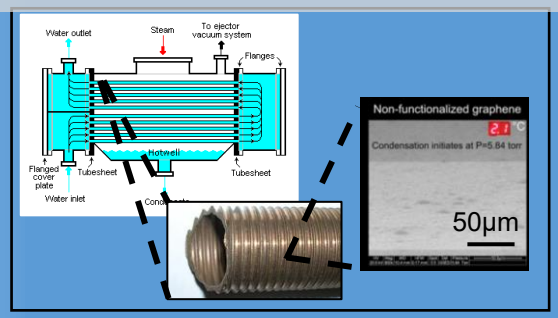
THERMODYNAMICS IN THE PRESENCE OF NANOENGINEERED MATERIALS

Intrinsically anti-fouling surfaces

Intrinsically icephobic surfaces

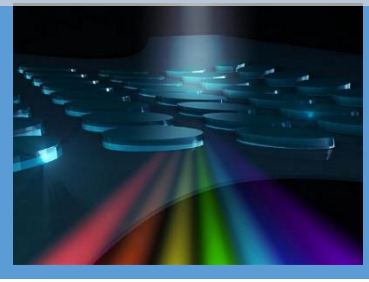


Resilient nanoengineered coatings for condensation



Enhanced dew harvesting materials

Metasurfaces for Energy



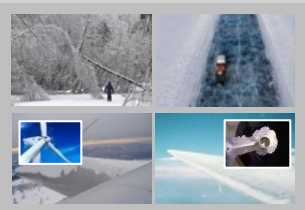
macroscale

meso-nanoscale

critical ***water*** and ***energy*** issues

future oriented, ***sustainable*** technologies

Surface icing

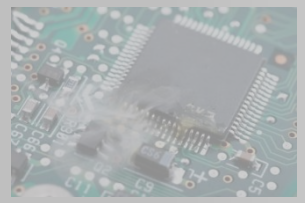


Water treatment and harvesting

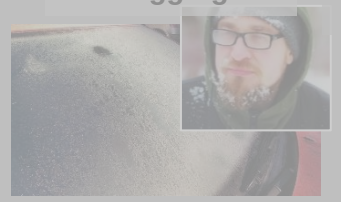
Condensation Heat Transfer

Fouling

Electronics cooling

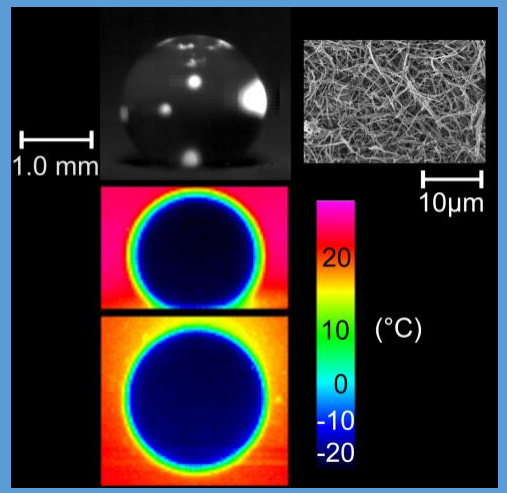


Fogging

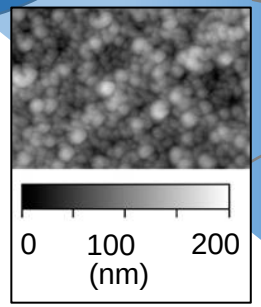


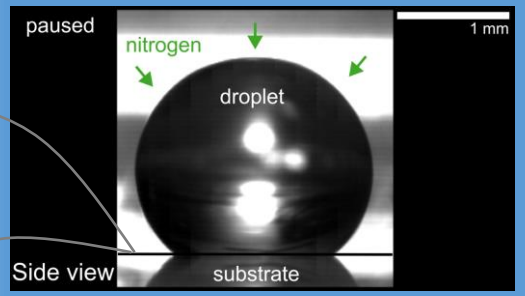
THERMODYNAMICS IN THE PRESENCE OF NANOENGINEERED MATERIALS

Intrinsically icephobic surfaces



Schutzius, T. M.; Jung, S.; et al. *Nature*, **2015**, *527*, 82-85





Graeber, G.; Schutzius, T. M.*; et al. *PNAS*, **2017**, *114*, 11040-11045

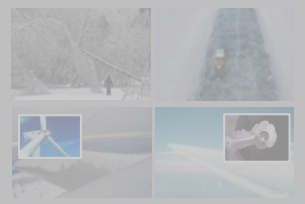
macroscale

meso-nanoscale

critical ***water*** and ***energy*** issues

future oriented, ***sustainable*** technologies

Surface icing

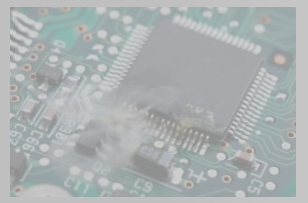


Water treatment and harvesting

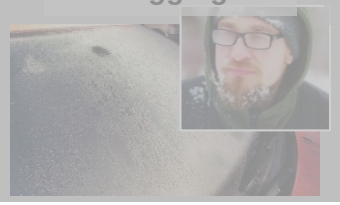
Condensation Heat Transfer

Fouling

Electronics cooling



Fogging

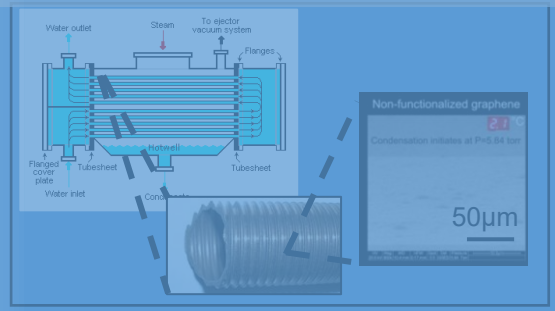


THERMODYNAMICS IN THE PRESENCE OF NANOENGINEERED MATERIALS

Intrinsically anti-fouling surfaces

Intrinsically icephobic surfaces

Resilient nanoengineered coatings for condensation



Enhanced dew harvesting materials

Metasurfaces for Energy

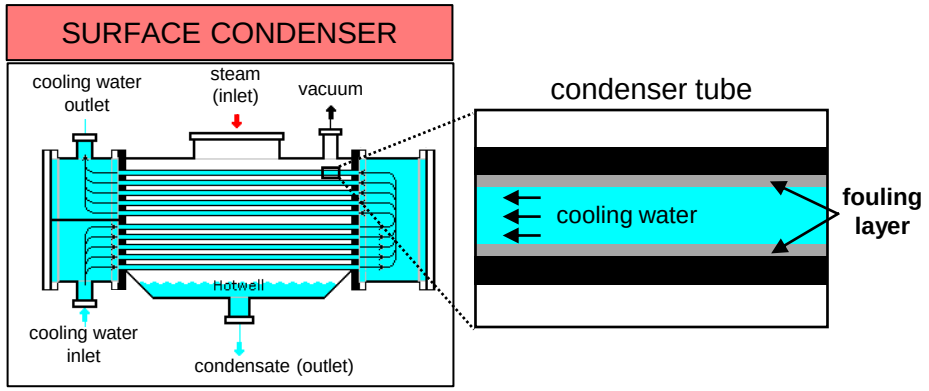
macroscale

meso-nanoscale

Importance of fouling

Energy: Power Stations

Steam-electric power plants: 49% of electricity production (EU).
Water is used to cool surface condensers.

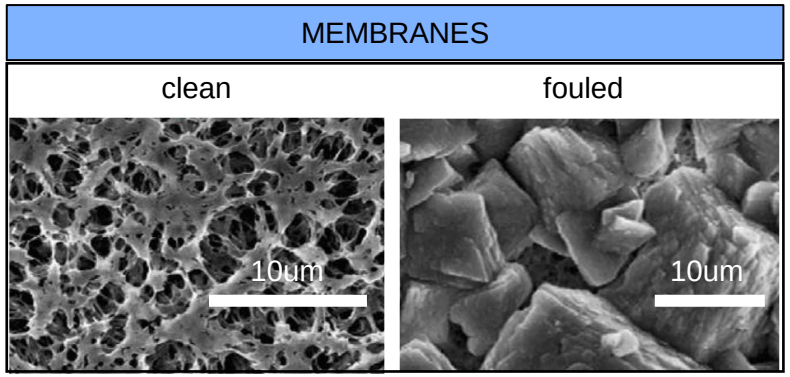


1 mm thick fouling layer ≅ 1.5 % reduction in plant efficiency.
2017: 691 TWh of electricity generated from coal (EU).
Efficiency reduction = 8.7 million tons of hard coal (EU).

https://www.eea.europa.eu/

Water Treatment

Water scarcity: 1% of the water on earth is usable freshwater—has to support all terrestrial life and industries.

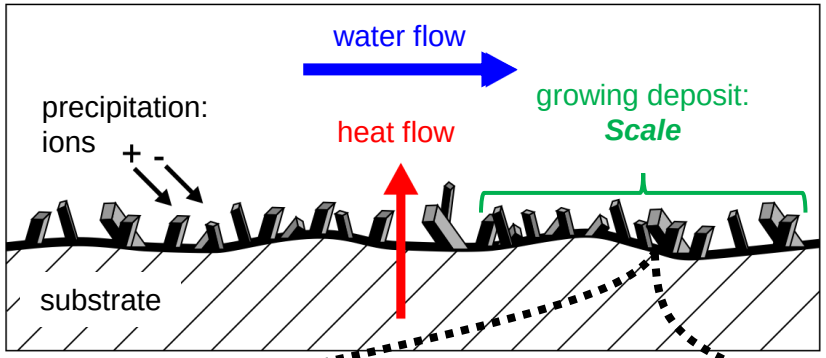


Membrane fouling:
Major barrier for emerging desalination technologies based on solar energy.

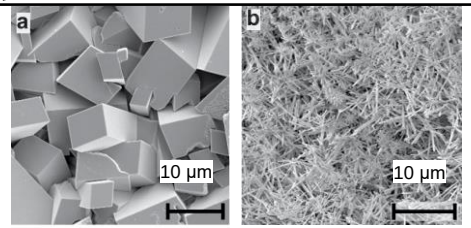
Tijing et al. / J. of Membrane Sci. 475 (2015) 215–244

Can we rationally engineer surfaces to be intrinsically *Scale-phobic*?

Critical Fouling Process: ***Scaling***



Important *Scale*:
Calcium carbonate



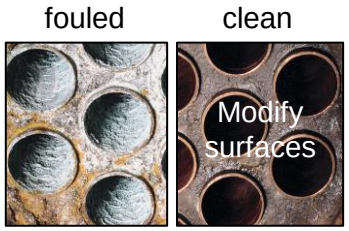
Polymorphs: Different solubility, mechanical properties, and stability

State-of-the-art, Aim, and Challenge

State-of-the-art: Acids, antiscalants, limewater, ion exchange, etc.

Aim: Develop a surface that is intrinsically ***Scale-phobic***.

Targeting a passive, ***sustainable*** approach.

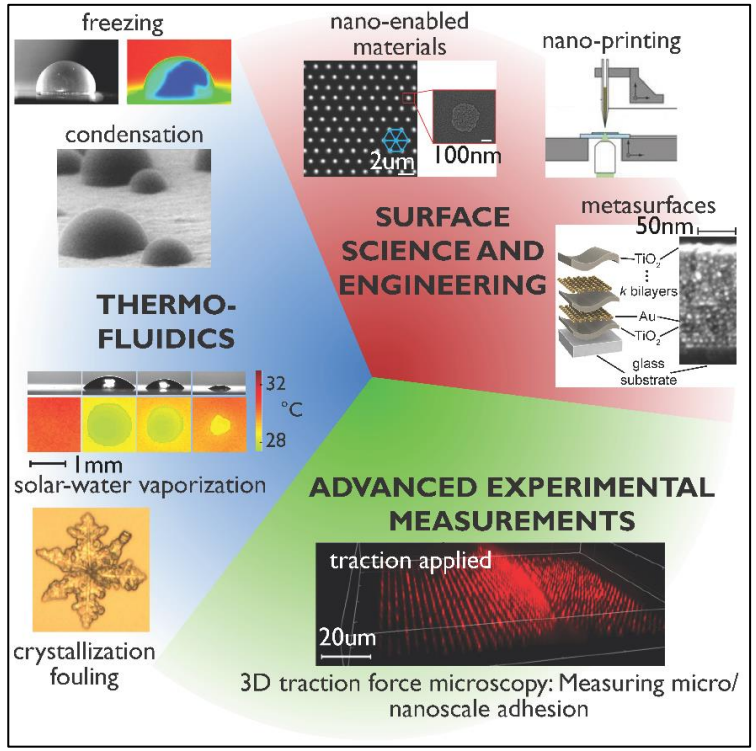


Challenge: Unclear relationship between substrate, environment, and scaling.

We lack detailed knowledge on individual ***crystallite layer behavior*** and related interfacial transport phenomena on surfaces.

Background

Knowledge-base



Research Approach

Fundamental investigations on interfacial transport phenomena and ***thermodynamics*** (***phase change***) in the presence of nanoengineered surfaces.

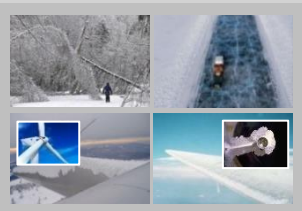
Rational Surface Nanoengineering: Intrinsic icephobicity, anti-fogging, and condensation enhancement.

Goal: Produce transformational performance enhancements for ***water*** and ***energy applications***.

critical ***water*** and ***energy*** issues

future oriented, ***sustainable*** technologies

Surface icing

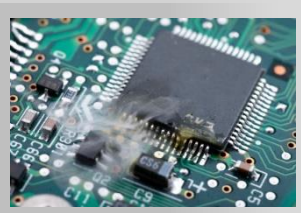


Water treatment and harvesting

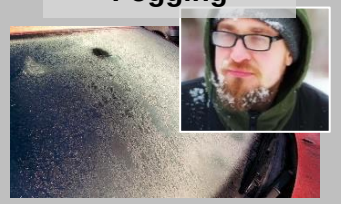
Condensation Heat Transfer

Fouling

Electronics cooling



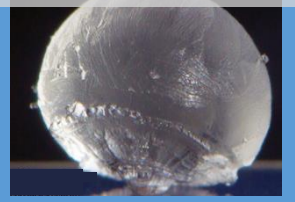
Fogging



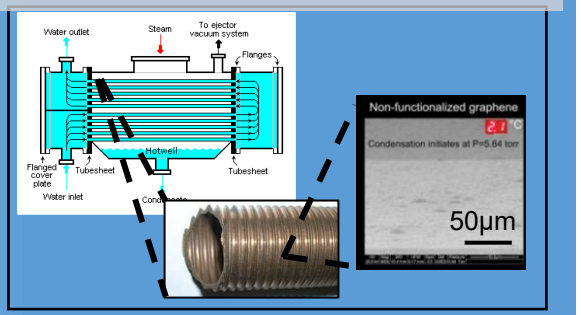
THERMODYNAMICS IN THE PRESENCE OF NANOENGINEERED MATERIALS

Intrinsically anti-fouling surfaces

Intrinsically icephobic surfaces

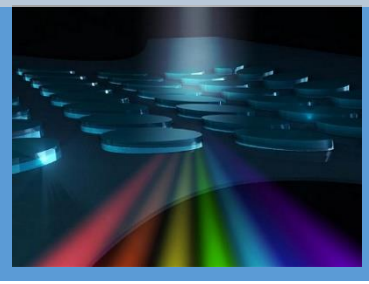


Resilient nanoengineered coatings for condensation



Enhanced dew harvesting materials

Metasurfaces for Energy



macroscale

meso-nanoscale

ETH zürich

Thank you for your attention!

Professor Thomas Schutzius
thomschu@ethz.ch

ETH Zurich
Institute of Energy and Process Engineering
ML J 27.2
Sonneggstrasse 3
8092 Zurich

www.thermofluidics.ethz.ch