NICE-Project

NICE

Reduction of ice formation by nanostructuring of surfaces with an ultrashort pulse laser

FFG- Research Project No. 871733

Lead: TU Wien, Institut für Fertigungstechnik und Photonische Technologien
Partner: Energiewerkstatt

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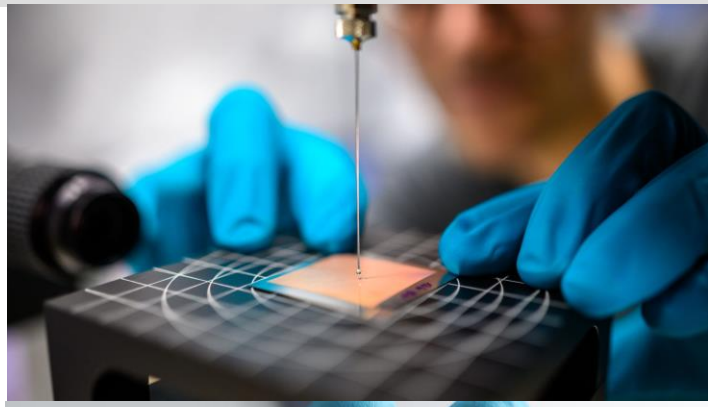
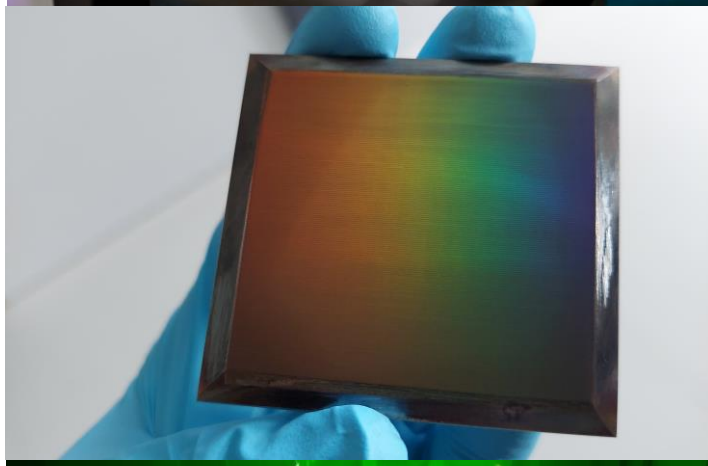
Overview

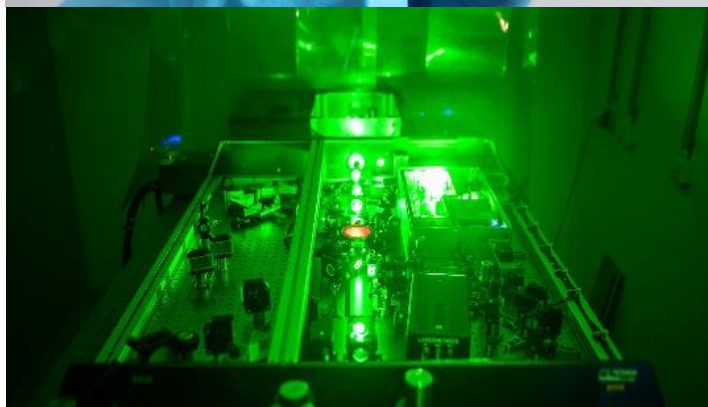
- NICE Project (2019-2023)
- Motivation:
  - Wind power generation losses due to icing
  - Site-dependent up to 20% due to shutdown obligation (AUT)
- Activities:
  - Development of Laser generated hydro- & icephobic surfaces
  - Significant reduction of ice adhesion
  - CFD simulation of the wetting of laser structured surfaces
  - Laboratory testing of the wetting & icing behaviour
  - Wear resistance tests in alpine terrain
  - Field performance tests a under icing conditions

Surface Treatment

- Generation of fine surface structures
  - Ablation of grids, pyramids, holes/dimples
  - Laser induced periodic surface structures (LIPSS)
- Use of ultrashort pulse lasers
  - Pulse duration: 30 fs (= 3*10-14 s)
  - Pulse rate: 1 kHz
  - Pulse energy: up to 0.8 mJ
- Chemical post-treatment with hydrocarbons/vacuum to
  - Acceleration of chemical conversion
  - Enhancement & stabilization of the water-repellent and ice-repellent effect

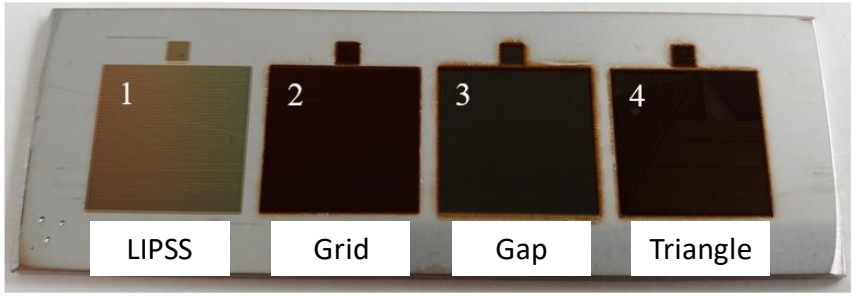


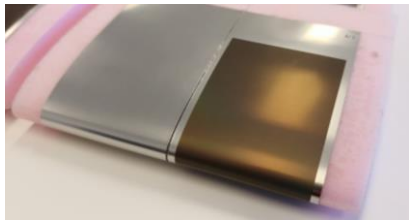


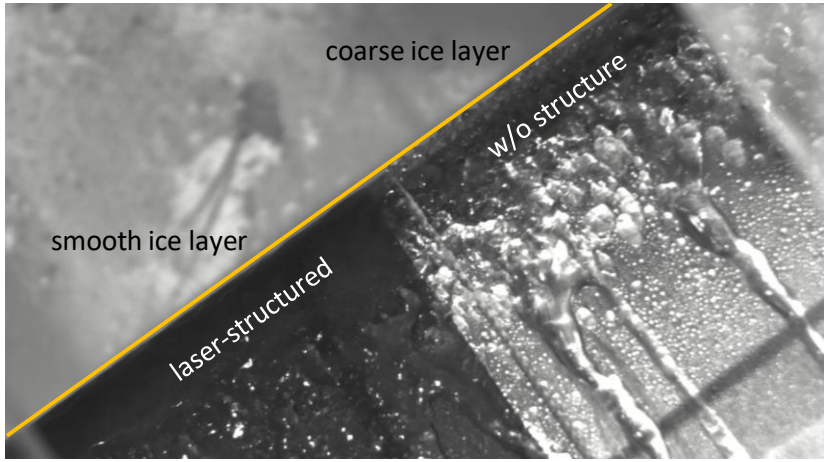


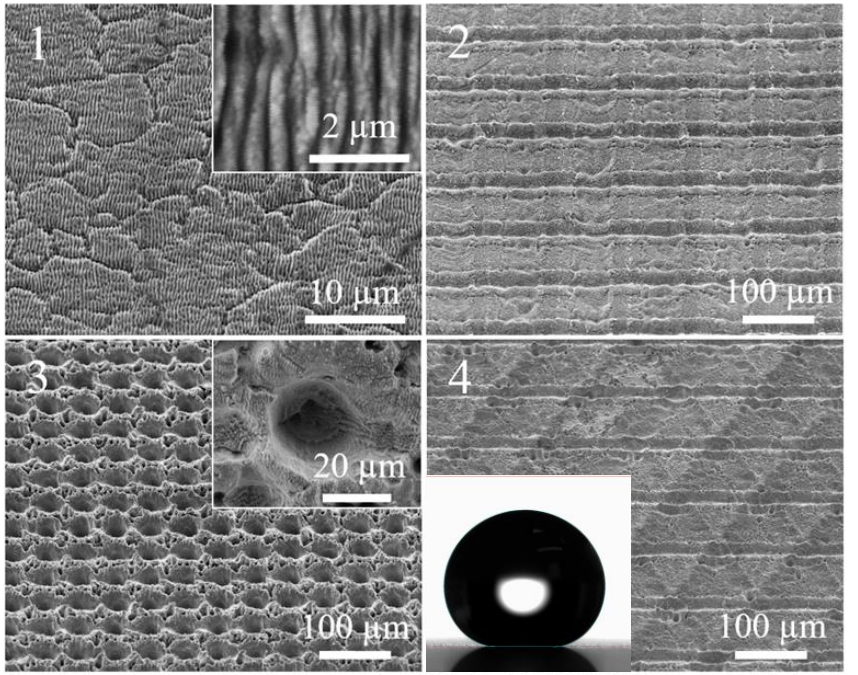
Sample Properties

- Super-hydrophobic surfaces, contact angle > 150°
- Reduction of ice adhesion from 800 kPa to 250 kPa
  (multiple-hour storage in vacuum and conventional petrol)
- Delay of ice accretion in icing wind tunnel







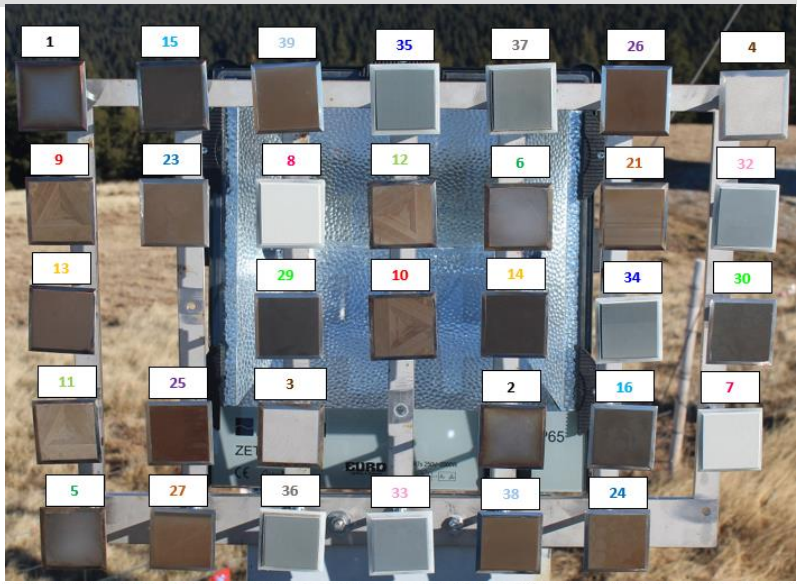


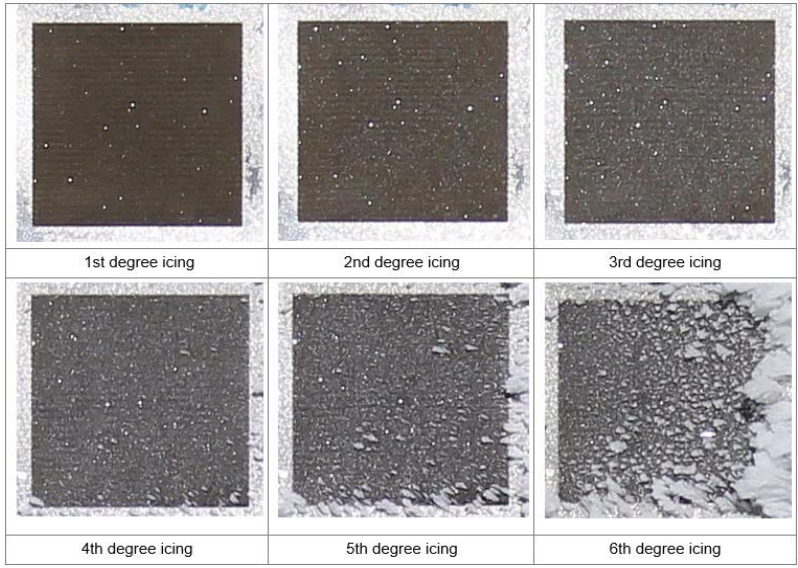
Test location and setup

- Test site located in Styrian wind farm “Pretul”
- Alpine location on a mountain ridge in 1.655 m altitude
- IEA Icing Class 2 to 3
- Mast for measurement of meteorological data
- Mast with static sample rack, camera, lighting and heating
- Small wind turbine for dynamic field test
- Data management equipment

Static Field Test

- Tested Surfaces: Steel and Gelcoat
- Various hydrophobic surface patterns (triangle, grid, LIPSS vs. untreated)
- Icing behaviour recorded by camera
- Anti-icing properties of nanostructured surfaces
- **Visual analysis:** Degree of icing was determined using manual analysis and automated image recognition (ImageJ)
- **Statistical analysis:** Mean icing over all samples as reference compared to each surface (avg. of 2 probes)
  Assessment regarding meteorological site conditions





Dynamic Field Test

- Samples were put on the leading edge of a small wind turbine at the field test site
- Test of durability of these nanostructures when exposed to environmental influences and rotational movement
- Analysis of wear and abrasion
- Lifetime estimation of structured surfaces

Thanks for your attention!

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