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

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NICE

- Collaborative research project of TU Vienna and Energiewerkstatt

- Nanostructures in the sub-µm range generated on technical surface samples with an ultrashort pulse laser

- Analysis and simulation of wetting behavior

- Investigation of icing behavior in icing wind tunnel

- Most promising samples exposed to harsh weather conditions in different field tests at wind turbine site

- Icing behavior evaluated qualitatively and quantitatively

- Concluding lab-evaluation of changes and durability of exposed nanostructures
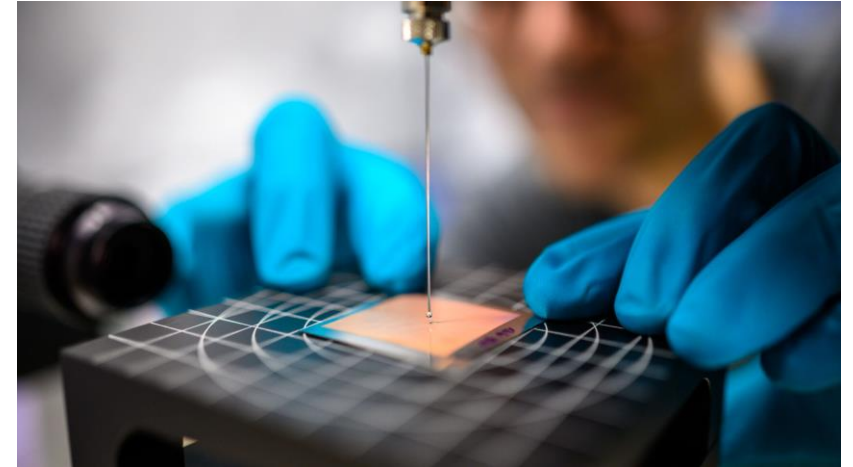
Results

- 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

➡ Effect of grid and gap structure
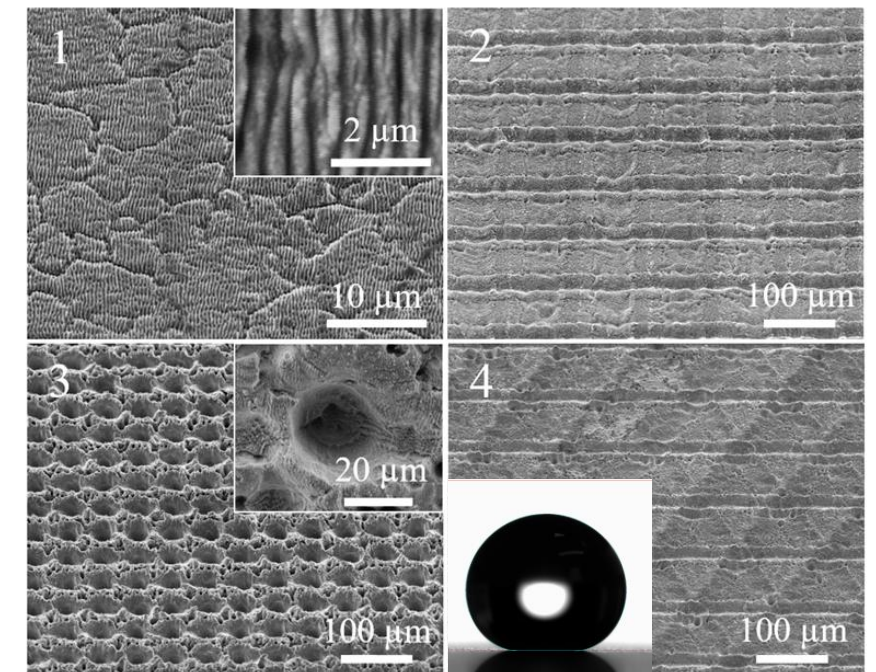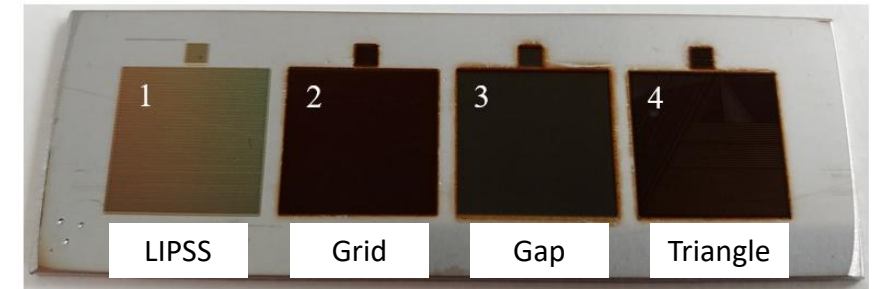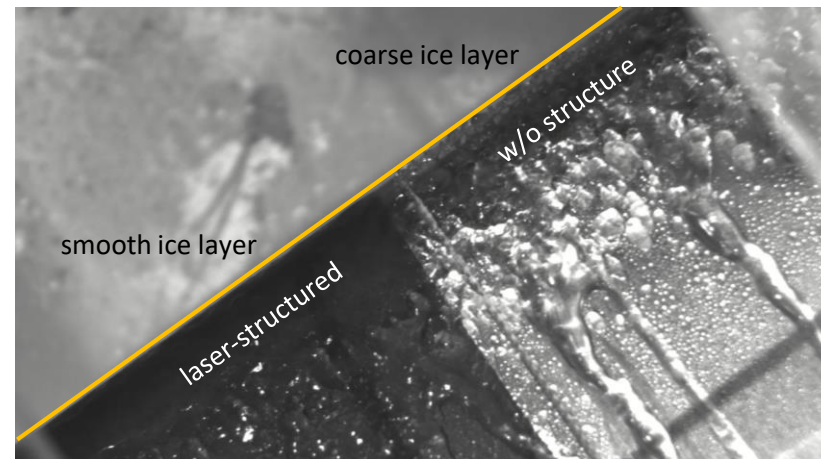
Test location and setup

- 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 wind speed and direction
- Mast with sample rack, camera, lighting and heating
- Small wind turbine for dynamic field test

Static field test

- Materials: Steel and Gelcoat

- Various hydrophobic surface patterns (triangle, grid, LIPSS vs. untreated)

- 13 different patterns mounted on heatable rack (2 probes each)

- Icing behaviour recorded by camera

- Anti-icing properties of nanostructured surfaces
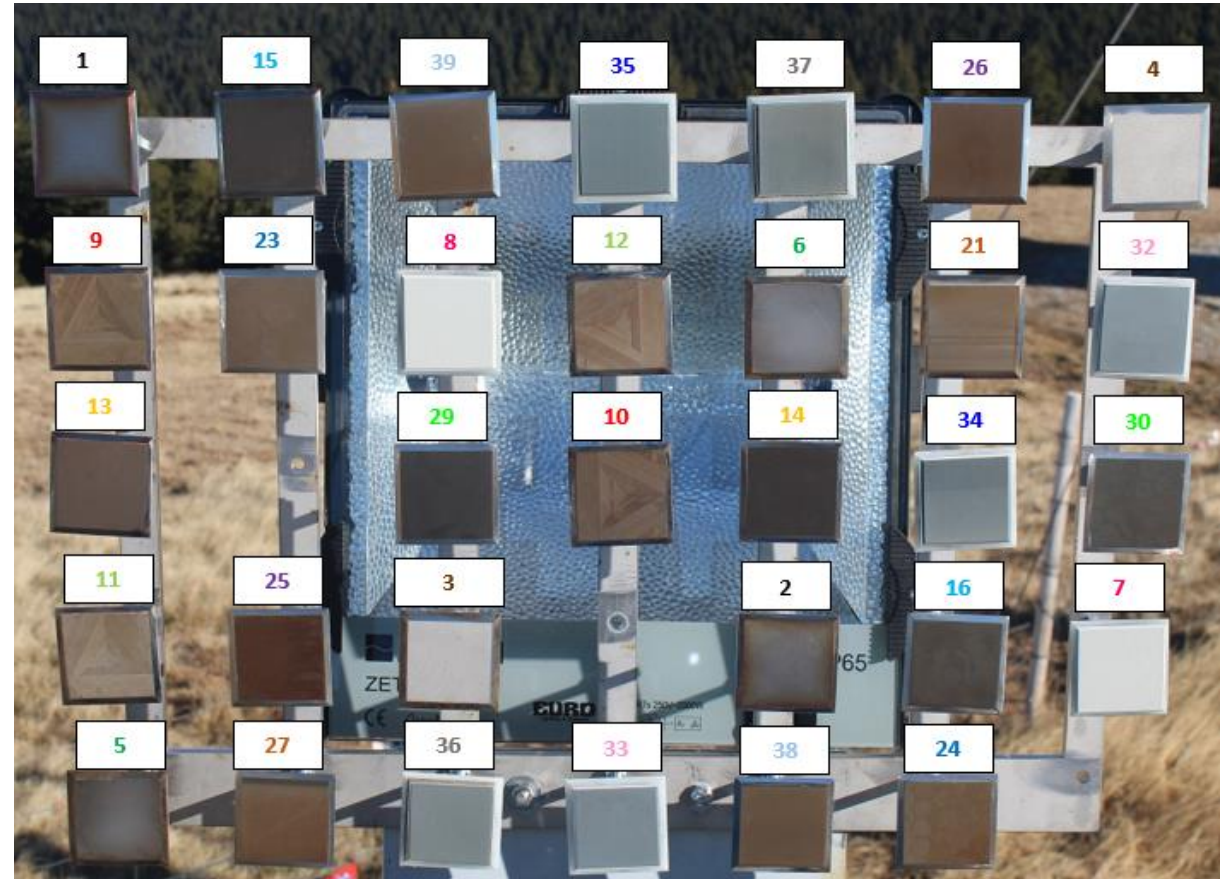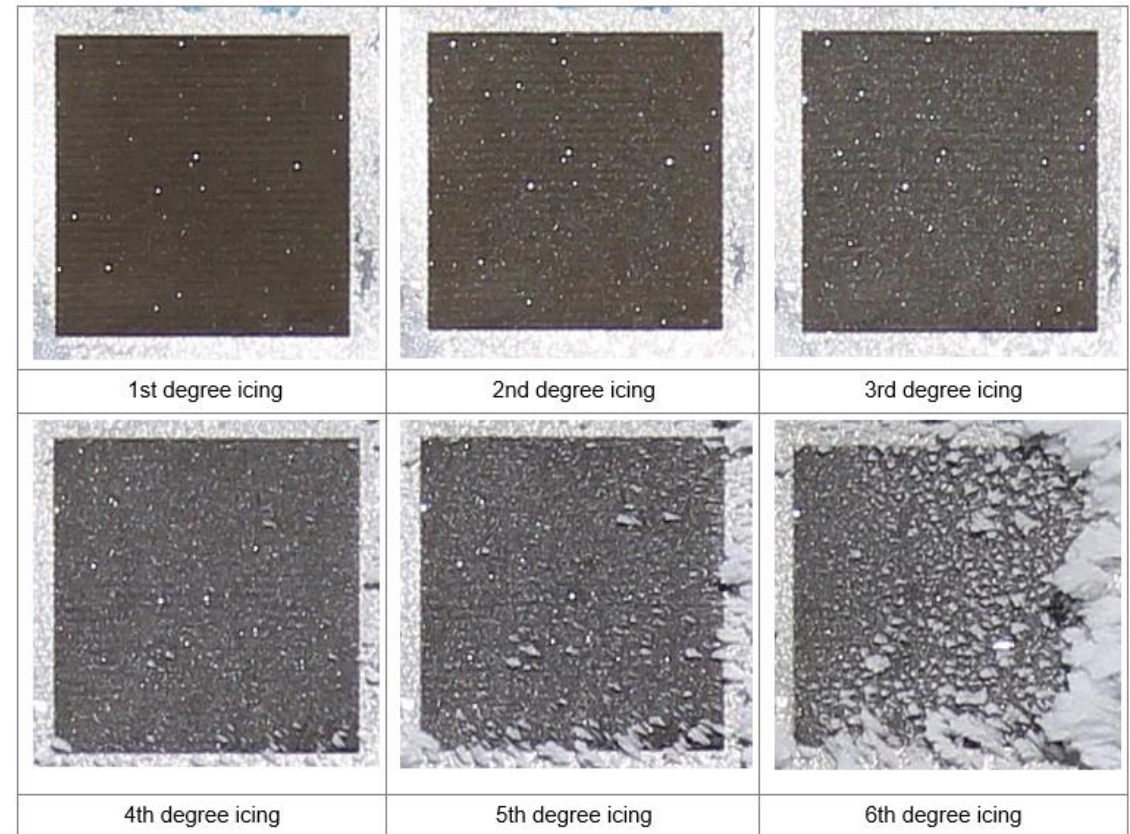
Static field test

(1) Visual analysis:

- Degree of icing was determined using automated image recognition (ImageJ)

- Ordinal scale: 0 (no icing) to 6 (strong icing)
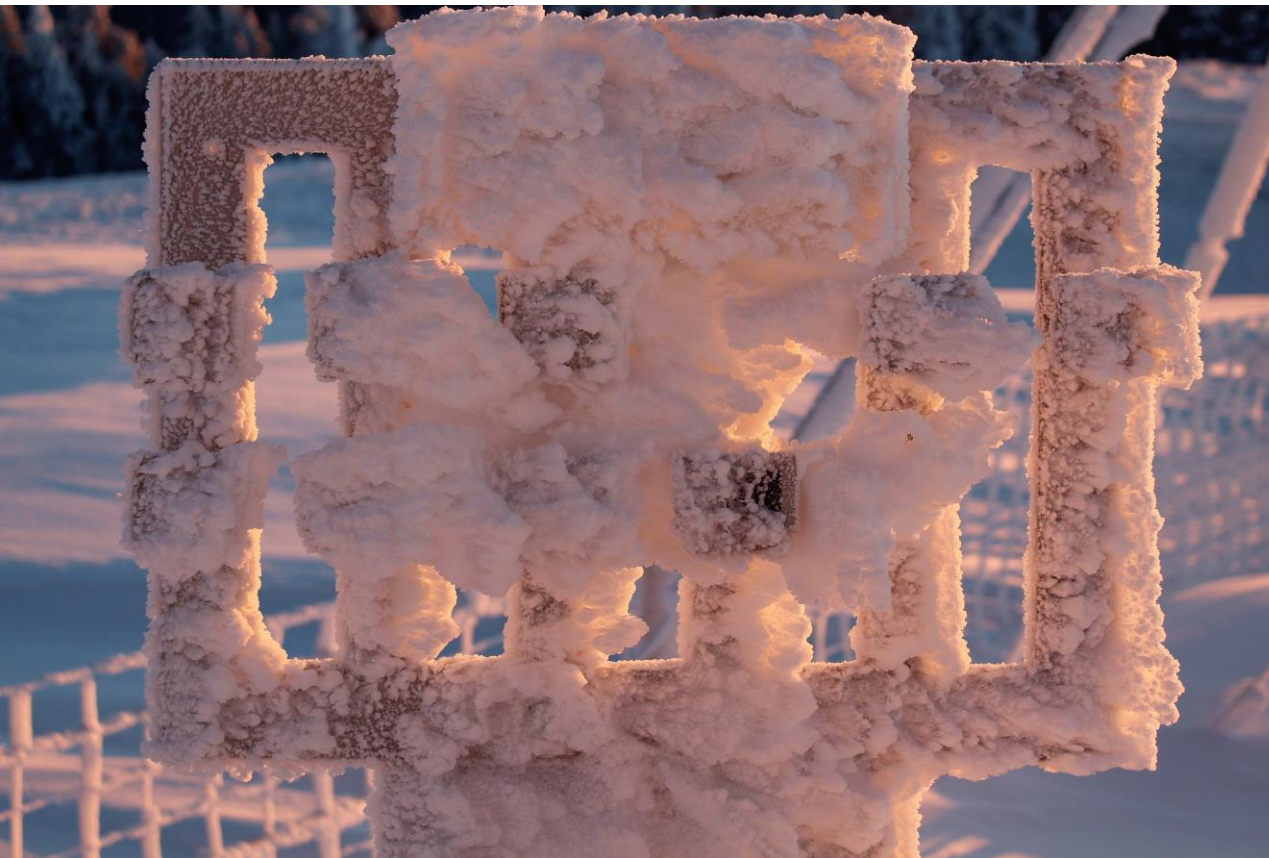
(2) Statistical analysis:

- Mean icing over all samples as reference compared to each surface (avg. of 2 probes)

  ➡ Any samples with significantly less icing?

  (Kruskal-Wallis & Dunn-Bonferroni Tests)

- Assessment regarding meteorological site conditions

  (Temperature, wind speed, wind direction)

| 1st degree icing | 2nd degree icing | 3rd degree icing |
| 4th degree icing | 5th degree icing | 6th degree icing |

Static field test

Static field test

On average:

- Gelcoat shows better results than steel

- Treated surfaces show better results than untreated materials

- 2 samples show significantly better icing behaviour (pink & gray lines)
  - Probe 32&33 – Steel with gap structure
  - Probe 21 – Gelcoat with grid structure

Gelcoat (dashed) and steel (continuous)
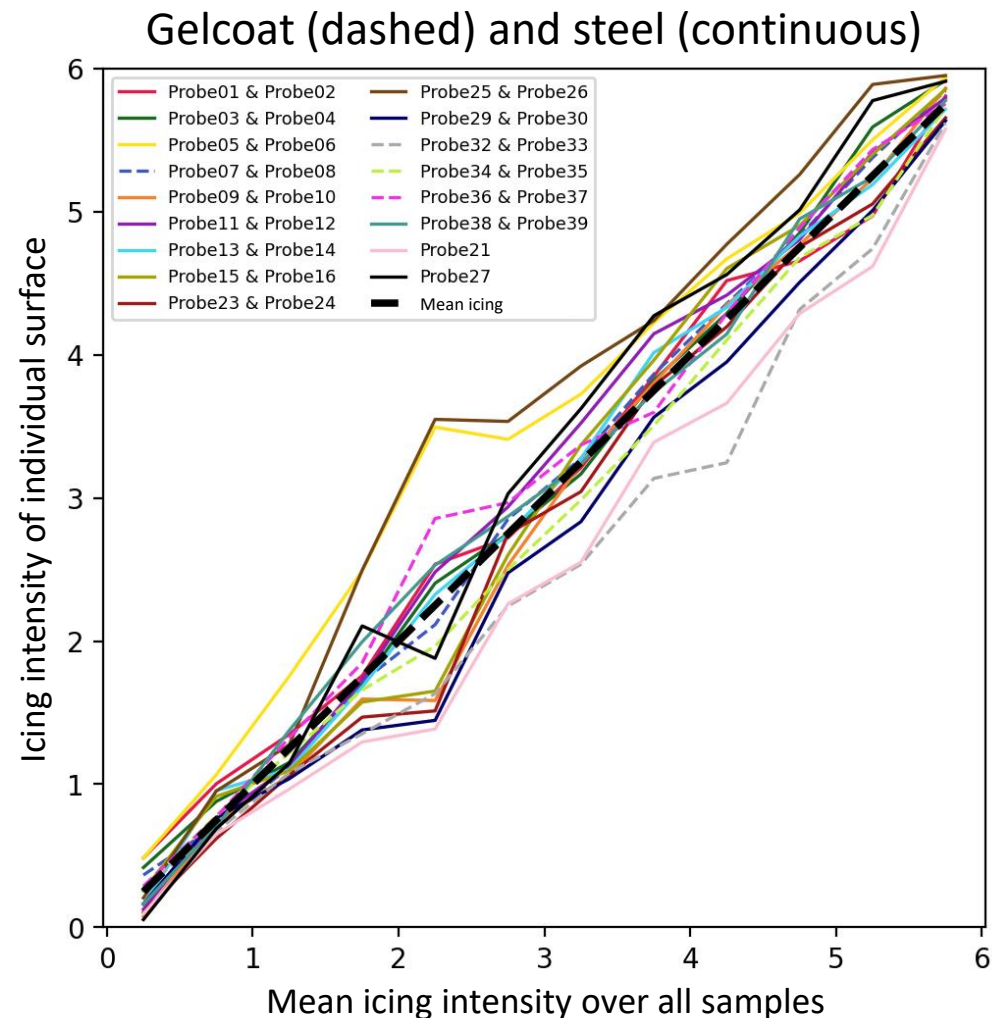
Static field test

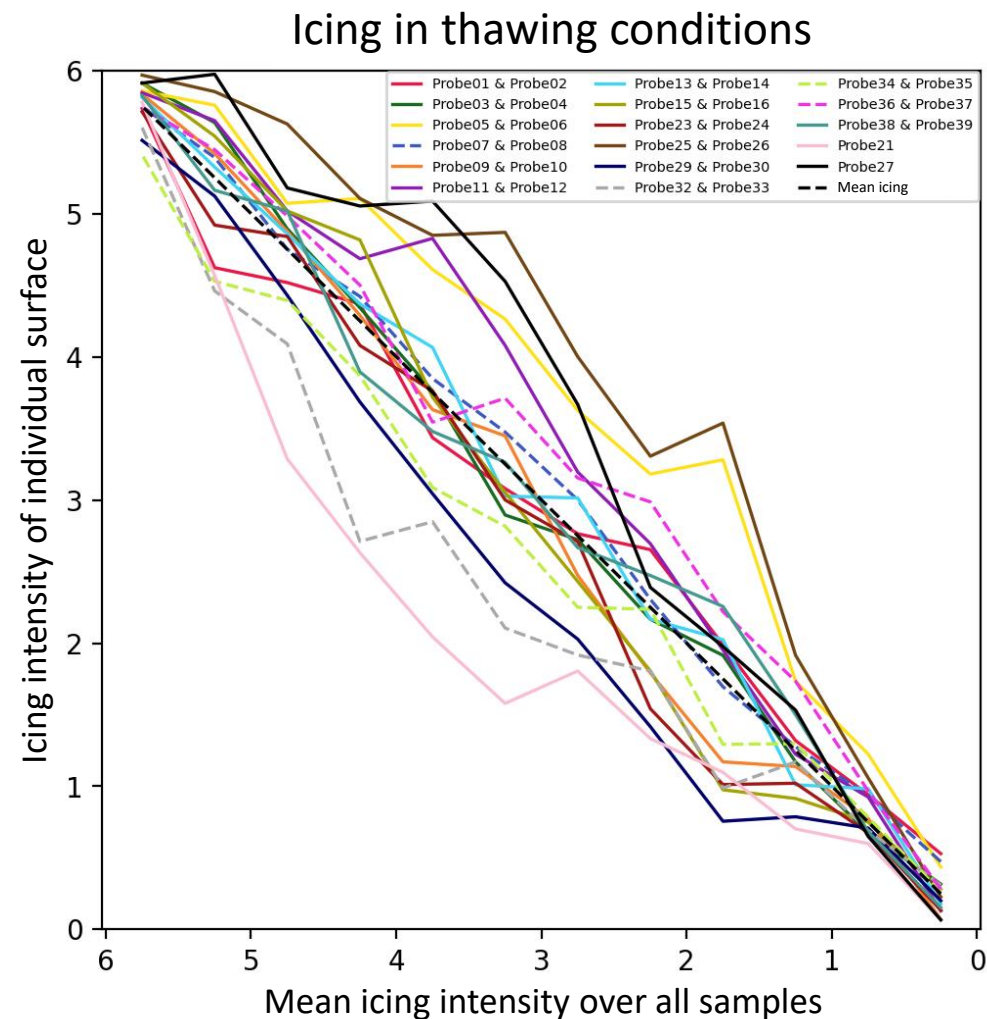- Differences mainly stem from faster de-icing of these surfaces in thawing conditions

- Results based on the averages of sample pairs look promising

BUT: Very high intra-variance

- E.g., Probe1 & Probe2 show vastly different results

➡ Further testing required

Icing in thawing conditions

Dynamic field test

- Samples were put on the leading edge of a small wind turbine at the field test site

- Durability of these nanostructures when exposed to environmental influences AND rotational movement?

➡️ Abrasion?

- Evaluation of dynamic field test data is ongoing…

- Check out www.nice-project.at

Thanks for your attention!

CHECK OUT:

www.nice-project.at

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