Fabrication of Nanostructured Polymer Surfaces and Characterization of their Wetting Properties

Fabrication of Nanostructured Polymer Surfaces and Characterization of their Wetting Properties: Enabling mass fabrication of superhydrophobic surfaces

In the past decade, there have been numerous examples of surfaces created with novel functionalities. These functional surfaces are predicted to have a massive impact on a range of commercial sectors within the next five years. Most realized functional surfaces rely on tailored micro- and nanoscale roughness, which cannot be produced with current mass fabrication technologies. The technology platform needed to create these surfaces has to be directly compatible with current mass production platforms, to commercially realize micro- and nanotextured surfaces. This comparability can be achieved by direct micro- and nanostructuring of commercial injection molding tools to create the desired surface structures directly in the molding process.

The aim of this project was to enable the fabrication of surfaces with controlled wetting by injection molding. During the project, I have demonstrated improvements in many of the fields related to mass-fabrication of water repellent surfaces. Including:

• Basic research in wetting phenomena; studying the role of multiple heights, irregular structures, and the transition to hierarchical structures.
• Development of algorithms for improved contact angle fitting.
• Simulations of wetting transitions.
• Clean room fabrication of functional surfaces, and production of micro- and nanostructured mold inserts.
• Injection molding of micro- and nanostructured polymer parts on a commercial injection molding machine.
• Co-invented a patented technique for microstructuring steel molds able to produce superhydrophobic polymer parts.

The patented microstructuring technique generates microstructures similar to those found on the leaf of the lotus flower, without the overlaying nanostructure. Despite the lack of hierarchical structures, the microstructured surface shows excellent water repellent properties. The demonstration of a single level, superhydrophobic, structure with low aspect ratio, served as inspiration for studies in the underlying wetting mechanisms. This resulted in two published studies. The first study concerns the differences between lattice based clean room structures and the irregular structures produced by the patented microstructuring technique. The second study bridges the gap between silicon structures produced by planar processes in the clean room and the smooth multi-height structures often found in nature.

Finally I have demonstrated a novel type of hierarchical structures to get a better understanding of the role of hierarchy in wetting phenomena. I have produced and characterized hierarchical structures with the same surface coverage achieved in several different configurations. This leads to an interesting finding, not covered by modern wetting theories, where the local configuration of nanostructures governs the wetting behavior of the hierarchical structure.