2024 Summer Projects
Soft Matter and Wetting research group
Group leader: Prof. Robin Ras

Soft Matter and Wetting (SMW) is a multidisciplinary research group consisting of physicists, biophysicist and chemists (https://www.aalto.fi/department-of-applied-physics/soft-matter-and-wetting). Our research is focused on functional soft materials and wettability of the surfaces. Many of the materials we work on are inspired by nature, such as superhydrophobic biological surfaces (e.g., lotus leaf, butterfly wings). We are offering summer positions for students that are highly motivated and interested to work on synthesis, state-of-the-art experimentation and advanced data analysis in the field of soft matter and wetting. The summer student will work in a fully supportive atmosphere surrounded by highly ambitious and talented researchers. The offered projects are listed below.

Project 1. Studying wetting behavior on microtextured superhydrophobic surfaces

Instructor: Dr. Bhuvaneshwari Karunakaran

Superhydrophobic surfaces are highly water repellent, and exhibit a water contact angle of larger than 150deg. Such surfaces show potential applications in self-cleaning, anti-icing, anti-fogging, etc. Understanding their wetting behavior is important to design new surfaces with improved properties. There are many ways to characterize wetting, and over the years, our group has pioneered in this field.

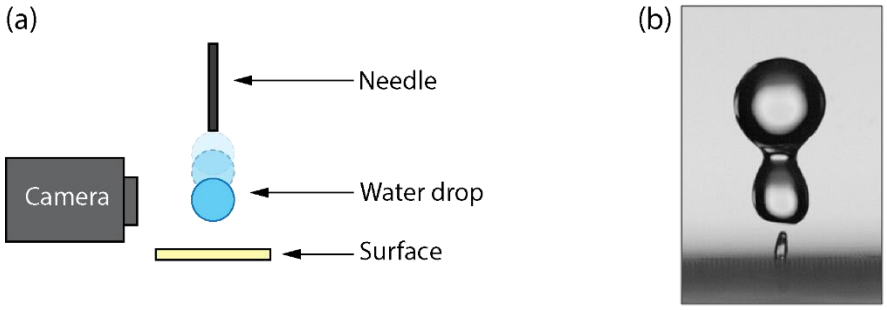


Figure 1. Wetting characterization by drop impact. (a) Schematic illustration of the concept of the setup. (b) Image of the bounce captured by the camera.

In this project, you will study the response of a surface to a drop of water. You will do this by two methods: drop impact and evaporation. To study the drop impact dynamics, surface is hit by a drop of water at various speeds (Fig. 1a), and the bounce is studied (Fig. 1b). To study the evaporation dynamics, a drop of water is made to evaporate

and the contact angle of the shrinking drop is monitored. In this project, you will develop skills to handle a custom-made setup, high speed camera, image to data extraction, data analysis and understanding the physics. A background in physics, engineering or material science is required. Experience in MATLAB, Python or LabVIEW is appreciated.

For more information, contact bhuvaneshwari.karunakaran@aalto.fi

Project 2. Surface characterisation by forced droplet wetting

Instructor: Dr. Juuso Korhonen

Surface wetting characterisation is done using either a sessile droplet or a submersion method. The sessile droplet method probes one location and the submersion method probes the average of the submerged contact line.

A novel method for surface characterisation employing random array of droplets is proposed. The droplet array is deposited using either a water spray, a mist, or by forced condensation. The wetting properties are characterised with camera using custom algorithms and machine learning algorithms.

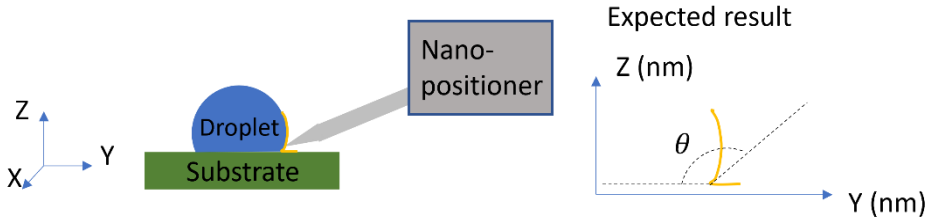
The summer job topic will be to build a prototype of the system, develop algorithms, and characterise and verify the performance of the system.

The task is suitable for a B.Sc. thesis or an M.Sc. thesis.

More information available from: juuso.korhonen@aalto.fi

Project 3. Measuring static contact angle with nanometer resolution for both conductive and non-conductive substrates using a novel method based on scanning probe microscopy technique

Instructor: Dr. Ali Afzalifar



Schematics of the experiment and the expected results

In this project, you will learn to work with a complex optomechanical experimental setup. The project includes working with nano-positioning and low electrical current measurement (in range of fA). The student will do the programing and experimental pilot testing to automate and synchronize the low current measurement and nano-positioning. A background in physics/engineering and experience in MATLAB are required.

More information available from: ali.afzalifar@aalto.fi

Project 4. Probing anti-stiction forces

Instructor: Dr. Maja Vuckovac

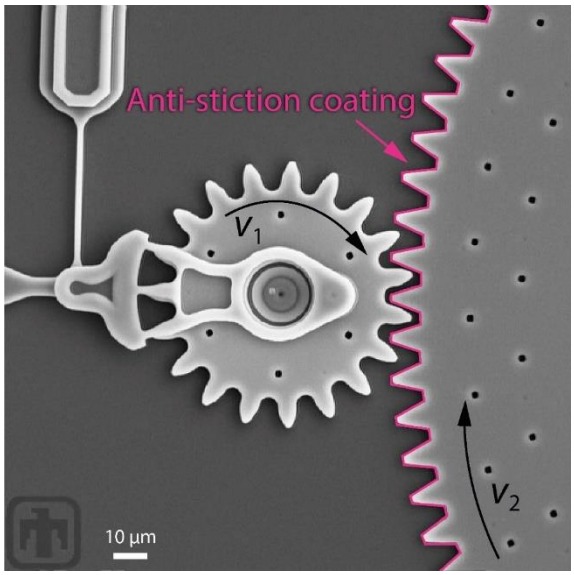


Figure 1. Gear reduction unit in MEMS devices. *Stiction prevents rotational motion. Anti-stiction coatings enhanced device efficiency and longevity by preventing stiction. Image is modified from https://www.sandia.gov/meso/mems-video-image-gallery/.*

Stiction refers to static friction and describes the force resisting motion between two surfaces in contact. It originates from the interface's intermolecular forces, particularly capillary, van der Waals, and electrostatic forces. It is a critical factor in various technological applications, affecting the reliability and performance of devices, especially in micro-electromechanical systems (MEMS) and nanoscale devices. Anti-stiction strategies aim to counteract static friction, involving surface treatments and lubrication. Unraveling the complexities of anti-stiction is essential for enhancing device functionality, longevity, and overall operational efficiency, yet it presents its own challenges in materials science and engineering. Thus, understanding surface interactions, adhesion forces, and material properties is crucial for designing effective mitigation approaches in diverse technological applications.

Surface interactions and adhesion forces are usually measured using atomic force microscopy (AFM), tribometers, and micro/nanoindentation techniques. However, challenges persist in achieving high sensitivity for small anti-stiction forces, capturing dynamic variations, addressing surface heterogeneity, integrating environmental factors, ensuring controlled contact areas, and resolving nonlinear behavior. Advancements are needed in instrumentation and experimental methodologies to overcome these challenges and enhance the precision of anti-stiction measurements, particularly in micro and nanoscale applications.

In this summer project, you will utilize the scanning droplet adhesion microscope to probe anti-stiction and map adhesive forces across the sample. The project aims to adopt the force sensor design to probe dry anti-stiction and intriguing wetting properties. You will perform hands-on experiments, analyze the data in MATLAB, and present results during group meetings. We welcome motivated students who are genuinely interested in working on surface dynamics. Experience with MATLAB is beneficial but not required. This project suits a BSc thesis, a special assignment, or an MSc thesis.

Please contact Maja Vuckovac (maja.vuckovac@aalto.fi) for more details!