

# Leonardo Da Vinci Award



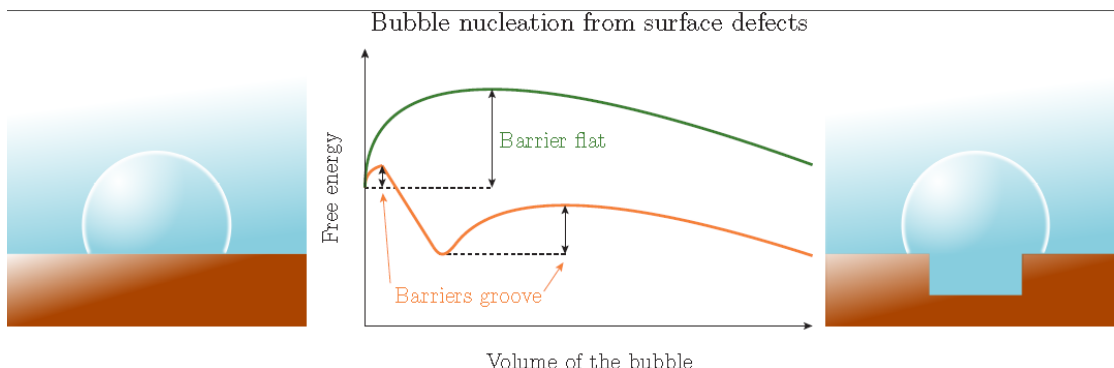
# Slip, Wetting, and Nucleation on Rough Surfaces

By Alberto Giacomello

Sapienza University of Rome, Rome, Italy

## Summary:

All real surfaces exhibit a certain degree of topographical and chemical heterogeneities: microscopic roughness, scratches, dirt, lubricants, etc. What is the influence of such microscopic details on the static and dynamic properties of a wetting fluid? This is the main topic of my presentation. In particular, I will consider surfaces that combine hydrophobicity and roughness to entrap gas pockets within surface asperities in the so-called Cassie state. This "superhydrophobic" state shows remarkable properties (self-cleaning, ultra-repellency, drag-reducing...) but is fragile, as it may collapse in the fully wet Wenzel state. By means of advanced molecular dynamics simulations and macroscopic models the stability of the superhydrophobic Cassie state will be analyzed across scales ranging from the nanometer to the millimeter. Other important consequences of the interplay of surface heterogeneities and wetting will be considered, namely, the catalyzed nucleation of gas bubbles from surface roughness and the emergence of slippage at the solid boundaries.



# Controlled Deformation, Rupture and De-wetting of Thin Liquid Films on Partially-Wetting Substrates

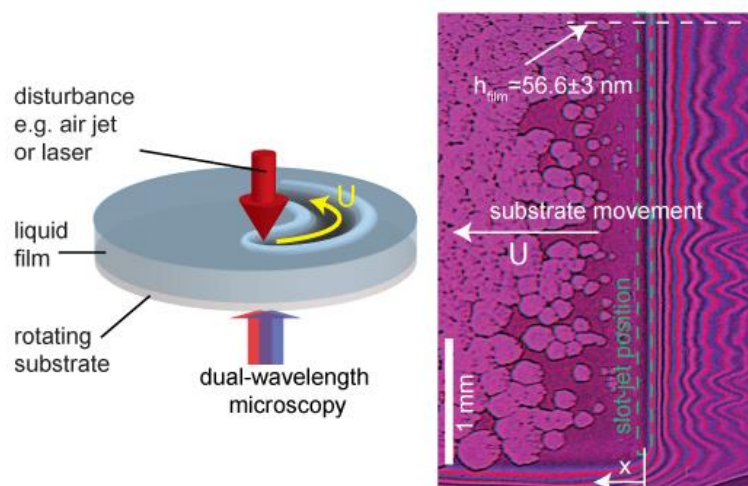
Christian Berendsen

Eindhoven University of Technology, Eindhoven, The Netherlands

## Summary:

In immersion lithography, light is focused through water to achieve high resolution projections for the production of semiconductor chips. At high production speeds, a thin film of water is deposited on the partially wet table silicon wafer. This film is unstable and breaks up, leaving undesired droplets behind.

We have studied the breakup process of thin liquid films using laboratory experiments and numerical simulations. In our search for effective ways to influence deformation, rupture and dewetting of liquid films, we have systematically investigated the effect of impinging air-jets, infrared laser heating and electrostatic surface charges on thin liquid films. In this presentation, I will focus on the main outcomes and potential applications of this work.



# Convection in Porous Media, and Implications for CO<sub>2</sub> Sequestration

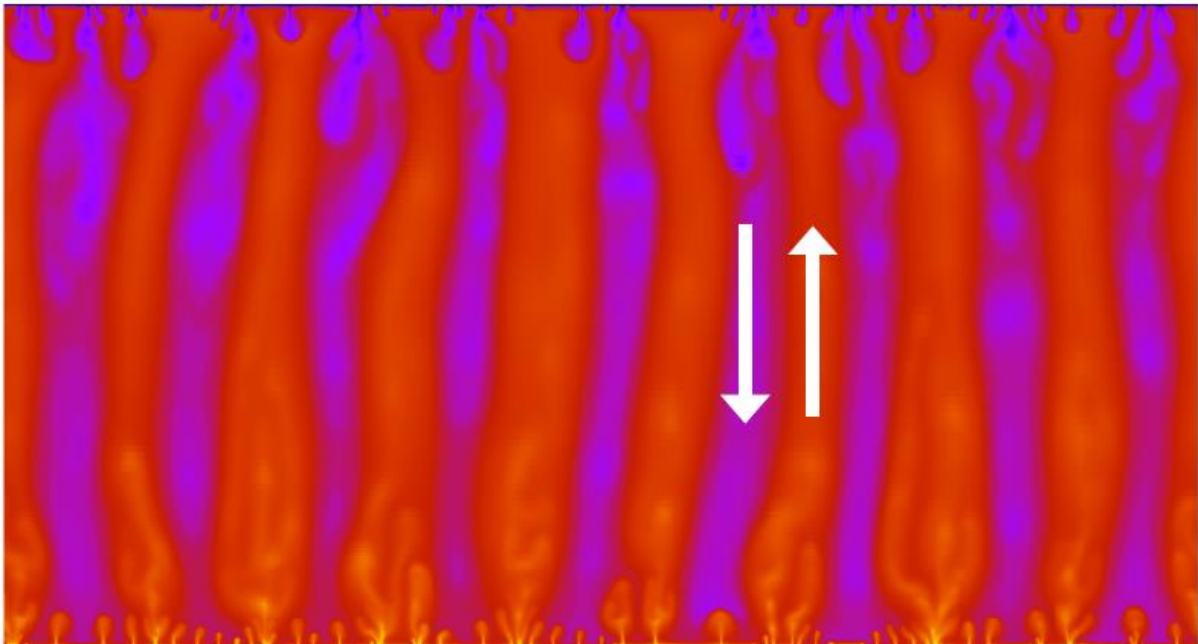
Duncan Hewitt

University of Cambridge, Cambridge, UK

## Summary:

The convective flow of fluid through a porous medium plays a central role in a wide range of geophysical and industrial processes. My work has been particularly motivated by its relevance to the long-term storage of CO<sub>2</sub> that has been sequestered in underground porous rock. I will present a detailed numerical and theoretical study of statistically steady vigorous convection in porous media. Using the results of high-resolution numerical simulations in two and three dimensions, I will discuss the relationship between the strength of convection, as described by the Rayleigh number  $Ra$ , and the transfer of buoyancy, as described by the Nusselt number  $Nu$ . I will examine the remarkable dynamical structure of high-Rayleigh-number porous convection, which is characterized by strikingly ordered vertical columnar exchange flow, and investigate the physical control of this structure. Finally, I will extend and utilize these results to consider the physically relevant context of convection from below one boundary only, and discuss the implications of my work for the long-term storage capacity of underground porous rock into which CO<sub>2</sub> has been injected.

COLD UPPER BOUNDARY



HOT LOWER BOUNDARY

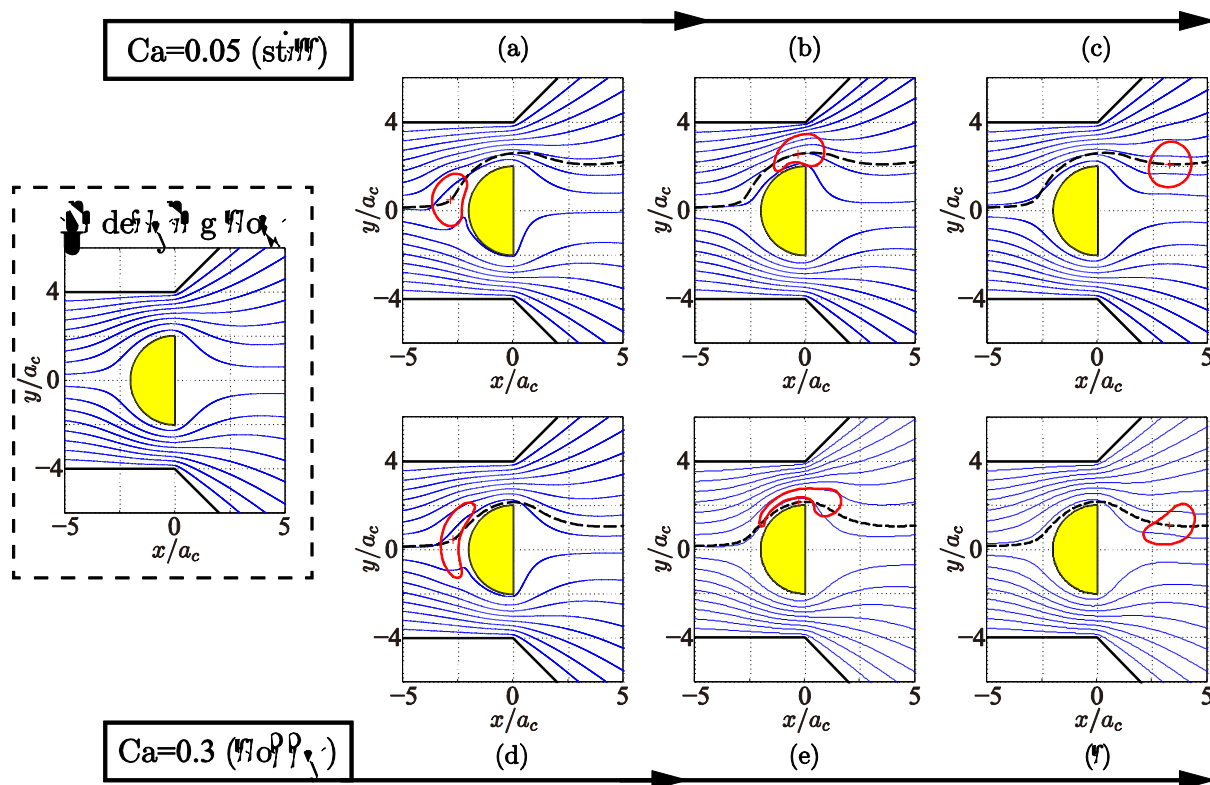
# Predicting the Motion of an individual Cell in Flow

Laila Zhu

Royal Institute of Technology, Stockholm, Sweden

## Summary:

We develop and utilize numerical tools to predict the motion and dynamics of biological cells in the flow. Self-propelling microorganisms and passively transported cells like red blood cells are investigated. We firstly present our study on the kinematic and energetics of ciliated cells swimming in the viscoelastic fluid, illustrating the interaction between different gaits and the resulting polymeric dynamics. We then simulate and analyse the locomotion of a swimming Paramecium inside a capillary tube, examining the influence of the strong confinement on its performance and stability of motion. Finally, we present a newly proposed micro-fluidic technique capable of sorting cells according to their deformability and demonstrate its effectiveness via high-fidelity simulations; the underlying physical picture is discussed.



# Modeling and Simulation of Multiphase Phenomena with Smoothed Particle Hydrodynamics

Stefan Adami

Technische Universitat Munchen, Garching, Germany

## Summary:

Smoothed Particle Hydrodynamics (SPH) is a meshless particle method that allows for modeling complex multiphase phenomena while ensuring exact mass and momentum conservation. In this work, the fundamental SPH method was improved to allow for stable "blackbox"-type simulations without numerical artifacts and an efficient multi-phase formulation for water-air interfaces with surface-tension effects and surface active agents ("surfactant") is presented. Using the LRZ supercomputer allowed to simulate the deformation of drops under the effect of surfactants and the experimental observation of so-called tip-streaming was reproduced numerically.

The figure shows a volume-rendered SPH simulation result of a drop in a shear flow.

