IITB-Monash Research Academy

An Indian-Australian research partnership

Project Title:	**Particles transport during evaporation of sessile droplets on a solid surface**
Project Number	**IMURA0465(a)**

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Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?

(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. **Advanced computational engineering, simulation and manufacture**
2. Infrastructure Engineering
3. Clean Energy
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research

The research problem

Particle deposition during the evaporation of a sessile droplet on a solid surface is a much studied problem in the last decade. This problem has technical relevance for depositing and organizing biological materials such as proteins and DNA; manufacturing of electrical conductive microwires, explosive crystalline layers and nanocrystals; inkjet printing. The physics during the droplet impact on a solid surface is characterized by complex and coupled transport phenomena: fluid dynamics in the presence of a severely deforming liquid-gas surface, wetting line motion and convective and conductive heat transfer. Previous studies have investigated the effect of Marangoni circulation [1], electrostatics forces [2], hydrophobicity [3] and ways to control the ring shape[4]. However, effects of thermal gradients, solvent volatility and increased concentration of particles on the deposits are poorly understood. The objective of this project is to develop a finite-element based solver to simulate the particle-laden droplet evaporation and validate it with in-house experiments. This numerical model will solve for fluid flow, heat transfer, mass-transport, wetting at three-phase contact line, colloidal particles concentration, Marangoni stresses at liquid-gas interface. The governing equations will be discretized by finite element method in Lagrangian coordinates, which accurately describes liquid-gas interface. The numerical predications will be compared with respective in-house, and published numerical and experimental data.

1. Bhardwaj R, Fang X, Somasundaran P and Attinger D, Self-assembly of colloidal particles from evaporating droplets: role of the pH and proposition of a phase diagram, Langmuir, Vol 26 (11), pp 7833-7842, 2010.
2. Bhardwaj R, Fang X and Attinger D, Pattern formation during the evaporation of a colloidal nanoliter drop: a numerical and experimental study, New Journal of Physics, Vol 11, pp. 075020, 2009
3. F. F. Shao, A. Neild, T. W. Ng, Hydrophobicity effect in the self assembly of particles in an evaporating droplet, Journal of Applied Physics 108, 034512 (2010).
4. F. F. Shao, A. Neild, T. Alan, Controlled particle self-assembly in an evaporating droplet, Colloids and Surfaces A: Physicochem. Eng. Aspects 398 (2012) 64 68.

Project aims

The aims of this project are the following:

- Develop a finite-element based matlab CFD solver to simulate the droplet impact and evaporation.
- Validate the solver with in-house experiments.

Expected outcomes

We expect the following outcomes from this project

- A state-of-the-art, CFD matlab solver for droplet impact and evaporation.
- Quality Ph.D. graduate with ability and skills to understand and model incompressible flows in complex geometries.

How will the project address the Goals of the above Themes?

The target of the project is to model incompressible flows and understand multiphase flows via advanced computational techniques. Thus, the project will address the goals of above theme (Advanced computational engineering, simulation and manufacture).

Capabilities and Degrees Required

The student for this project will require the following skills

- Sound background in fluid mechanics and numerical methods.
- Some experience with computer programming with matlab. If not, a willingness to learn is essential.
- Good written and communication skills.