Master Thesis subjects 2015-2016 in Chemical and Materials Engineering

Physical chemistry / Microgravity Research Center (MRC) - ULB

1. Measurement of diffusive properties in liquid systems in microchannels

Summary: Experimental investigation of diffusive properties in liquid systems remains a challenging topic. In most existing experimental technique, buoyancy driven convection disturbs the studied processes. Microchannels can be used to limit the influence of convection. The purpose of the work is to perform interferometric measurements in binary liquid systems in microchannels. The study will include:

- integration of the experimental set-up
- experimental study of the process
- data processing and analysis of the results

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2. Nano-fluid based heat pipes

Summary: Nano-fluids are being considered as promising liquids for heat pipes. The study will compare and model the performances increase in a set-up with visualisation.

- integration, control and measurements set-up
- thermal performances as function of heat pipe regime
- explanation of experimental results

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3. Performances of nano-fluid based heat control loops

Summary: Nano-fluids (nano-dispersions) have recently been considered for heat transfer applications. They can be used in critical equipment heat control fluid loops. The purpose of the work is to quantify the performances of these nano-fluids based heat control loops. The study should include:

- integration of the thermal regulation loop and of the control and measurements
- experimental study of the thermal performances as function of the nanofluid properties
- based on experiments and theory, output optimisation criteria

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4. Contribution to the study of Liquid-liquid jet mixing

Summary: Jet injection of fluid into fluid is a technique used for mixing. The process is highly dependent of the fluid couple considered. The purpose of the work is to quantify the mixing efficiency and contribute to the understanding of process with fast camera visualisation. The study will include:

- integration of the experimental set-up
- experimental study of the process and parametrisation of the experiments
analysis of the results and of the critical mechanisms

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5. Mixing – demixing by vibrations

Summary: Microfluidics has recently motivated both fundamental and applied researches. The challenge is to find an optimal process to manipulate small liquid quantities, down to the nanoliter scale where convection is negligible. One of the ways to progress in the understanding the underlying phenomena is to perform experiments in microgravity where convection is also absent. The work proposed in master thesis will focus on experiments on vibration in binary mixtures in order to control pattern and flow structures, mixing, observe onset of instability regimes that lead to creation frozen waves.

All laboratory and numerical findings are verified in series of parabolic flights, which prepared and performed by the whole team in Novespace, Bordeaux. This work is considered as a one of step in frame of preparation space experiment VIPIL which is planned on-board of the International Space Station.

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6. Particles accumulation in periodic flows

Summary: The student(s) working on the proposed project will participate in preparation of the upcoming Japanese European Research Experiment on Marangoni Instability space experiment JEREMI. The effort is dedicated to the study of an exciting phenomenon of appearance of coherent structures formed by a large number of small particles (PAS). One of the theories explains the phenomenon to the general mechanism of synchronization, which is encountered everywhere in nature, e.g., in biological and astronomical systems.

The work proposed in the frame of this master thesis will consist in performing experiments using the existing and functional experimental setup, and analyzing the obtained results. The student(s) will be thoroughly supervised by experienced scientists and all the necessary help and guidance will be constantly provided.

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7. Controlling liquid behaviour for improvement of growing crystal quality // Liquid bridge

Summary: Directional solidification/crystallization are widely used technological processes for growing crystals with specially designed properties or for deep purification of electronic materials. All processes occurring in a liquid phase are key players in getting desired properties/structure of obtained crystalline solid product. Typical technological process occurs at high temperature and often with non-transparent melts, a common approach to understand phenomena is to simulate it with low-temperature transparent analogue allowing easy observation.

The proposed work will focus on a novel controlling technique of convection and heat transfer in the crystal melt based on forced external gas flow around the liquid zone. The joint effect of improved heat exchange, evaporation and mechanical stresses should suppress or localize undesirable instabilities inside liquid zone.

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8. Investigation of thermodiffusion (Soret) effect

Summary: Thermal gradients have a strong impact on mass transport in liquid mixtures. In response to this gradient, concentration gradients appear in an initially uniform mixture. This effect is known as thermodiffusion (Soret) effect. At small temperature gradients, the effect is slow and play a visible role on
geological scales. It can be responsible for redistribution of species in underground oil reservoirs staying millions of years in geothermal gradient; it can affect redistribution of salinity in ocean, possibly giving impact on climate change. At large temperature gradients, the component separation occurs on small scale and can be used in nanotechnology. Measuring the amplitude of this effect is based on optical diagnostics of superior sensitivity and precision, namely interferometry. The objective of proposed work is to measure Soret coefficients in liquid mixtures, what is non-trivial engineering task.

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9. Optical interferometer realized with a 3D printer

Summary: Optical interferometry is used in numerous fields as in fluid physics, biomedicine and environment. This optical technique provides very accurate information on the samples under investigation. One of the limitations of interferometry is the flexibility of the instrumentation and there is a need to improve the usual manufacturing schemes. Recently, the 3D printers were developed and became in few years a unique way to manufacture and produce parts or complete objects that cannot be realized otherwise. In this Master Thesis, we propose the realization of an optical interferometer with the new emergent technology of the 3D printers. This work will involve the design, the realization and the test of the interferometer.

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10. Functional patterning of surface by multi-layer/drops deposition

Summary: Additive manufacturing – a technique for manufacturing complex 3D object “layer-by-layer” – was first introduced in the ’70, but it is only at the beginning of the XXI century that this technique became widely used in many industrial applications, thanks to the introduction of more advanced tools and processes such as stereo-lithography and laser sintering. In recent years, 3D-printing triggered a real technological revolution still on-going.

An intriguing possibility to achieve layered structures opportunely functionalized could consist in depositing and evaporating successive layers/drops of fluid dispersed with micro/nano particles. Playing on the dispersed phase concentration and modulating the environmental conditions (temperature, pressure, speed of deposition, and wettability of the substrates) it will be possible to create peculiar particle assemblies.

The proposed work will then focus on characterizing those assemblies and their properties respect to some external stimuli (e.g. light wavelength selection in the case of a photonic crystal structure)

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11. Production of Hydrogen from Microalgae for fuel cell applications

Summary: In the last decades, the search for new sources of energy created an increasing interest for a special class of eukaryotic cells: microalgae. This interest was more than justified by considering that microalgae are a tremendous source of lipids (in proportion to their mass) but also of other very valuable by-products such as vitamins and proteins. More recently, it has been proved that some strains of microalgae (e.g. clamydomonas reinarditii) are able to up-regulate the expression of the enzyme hydrogenase – allowing for hydrogen production, when their culture media is deprived of sulphur based constituents and in anaerobic conditions.

The work proposed in the frame of this master thesis will consists in quantifying the amount of hydrogen one or more microalgae cultures are able to release in a specific period of time as a function of the development evolution of the culture.

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12. Sensors on flexible substrates

**Summary:** Wearable electronics is attracting more and more interest in the last few years for the enormous potential in the field of smart devices. Flexible sensors that could be embedded in textile promise for the real-time monitoring of bio-activity and life-saving parameters as well as environmental status. One of the main challenges in the field is the adaptation of the electrodes on the flexible substrates while assuring for electrical conductivity and stable signal outputs.

In the frame of a NATO project, the student will test different combination of substrates and electrodes. In addition, he will measure the actual response of the embedded system respect to a given stimulus and assess the stability of the proposed configuration.

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