PhD THESIS PROPOSAL :

Nucleate boiling: heat transfer mapping and study of mechanisms at wall-fluid interfaces

Research unit : thesis co-directed by the University of Bourgogne Franche-Comté and the University of Aix-Marseille:

- FEMTO-ST institute, 15 B avenue des Montboucons, 25030 BESANCON cedex (University of Bourgogne Franche-Comté), FRANCE
- IUSTI laboratory, 5 rue Enrico Fermi, 13453 MARSEILLE Cedex 13 (University of Aix-Marseille), FRANCE

Keywords: nucleate boiling, heat transfer, microfabrication, sensors.

PhD supervision :

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Funding: Duration of 3 years, ANR funding (French National Research Agency)

Context :

This thesis is part of the TraThI project (Thermal Transfer at Interfaces) labelled by the ANR in 2021. It aims to study heat transfer at the transition between convective and nucleated boiling regimes, at micro and macro scales. This ANR is a partnership between the institutes IUSTI, FEMTO-ST and IMFT (in France) and LTT-UL (Slovenia). The objective of the project is to understand in detail the mechanisms at the wall-fluid interfaces in order to develop new strategies to improve the heat transfer between a fluid and a wall. The project anticipates the challenges to be met in the fields of energy technologies and industry of the future, where the flow densities are an order of magnitude higher than those accessible by current techniques.

Detailed presentation of the subject:

The thesis will be mainly experimental and will focus on performing nucleate boiling experiments (Tadrist et al., 2020). The objective of the thesis will be to study the mechanisms at the solid-liquid-vapor interfaces in order to propose new strategies capable of subtantially increasing the heat flux densities between a wall and a fluid. Solutions capable of continuously renewing the fluid layer (a few micrometers thick) adjacent to the wall would allow to substantially increase the heat transfer. The study of heat transfer in the presence of wall nucleation will allow to evaluate the heat fluxes transferred and to identify the mechanisms at the origin of the intensification of heat transfer in this regime.

Part of the thesis work will concern the structuring of the surfaces and the development of temperature and flow sensors. Indeed, in order to control the nucleation and quantify the heat exchanges, the nucleation surface will be controlled and instrumented by sensors thanks to microfabrication processes in clean room (Zribi et al., 2018, Mokadem et al. 2019). Several approaches for surface texturing will be considered (chemical etching, chemical vapor deposition...) some of which have already shown promising results (Zakšek et al., 2020). In addition, temperature microsensors (Lanzetta et al., 2011), associated with optical measurements (Carvalho et al., 2014), will allow mapping velocities and temperatures in the liquid (especially near the surface). The obtained measurements will allow the creation of a database. This will be used to develop a numerical code by a collaborator (post-doc) recruited in the framework of the TraThI project. A complementary experimental study (convective boiling) will be conducted by another PhD student with the other partners of the project (IMFT/LTT-UL). The person recruited on this thesis will thus have to work in close collaboration with the various partners of the TraThI project.

Objectives of valorization :
The expected results being completely original will be valorized, through oral communications (presentations of the results at national or international conferences) and publications in international journals with reading committee.
In terms of valorization, this work could lead to patents in the field of heat and mass transfer intensification, instrumentation and surface treatments.

Scientific and material conditions :
Financial support of the thesis : in the framework of the ANR TraThI (Thermal Transfer at Interfaces). For the microfabrication part in clean room, the Femto-st institute benefits from a microtechnology center (MIMENTO) which is part of the RENATECH network of large technology centers. The IUSTI laboratory and the Femto-st institute are equipped with experimental benches and characterization equipment. Collaborations/interactions with other research institutes (within the framework of ANR: IMFT in Toulouse, France and LTT-UL in Ljubljana, Slovenia).

Background and skills :
- Master II or Engineer level
- Scientific skills :
  - Very good in heat transfer ★★★★★
  - Good in liquid-vapor phase change (nucleation, boiling…) ★★★★☆
  - Good in sensors and signal processing ★★★★☆
  - Some skills/knowledge in numerical simulation (Fluent, COMSOL…) ★★★☆☆
  - Some Skills/knowledge in material science ★★★☆☆
  - Some skills/knowledge in microfabrication would be appreciated.★☆☆☆☆
- Other criteria :
  - Good level in English
  - Ability to show initiative and autonomy
  - Have a strong taste for experimentation
  - Be geographically mobile (thesis straddling Marseille and Besançon; ANR partners in Toulouse and Slovenia…)

Start of the thesis: The thesis may begin on **September 5, 2022** *(possibility of delaying the start until October 1st, 2022*)

Application deadline and required documents: 30/04/2022
When submitting the application by email, candidates must provide :
- a letter of motivation specifying their interest in the subject and research
- a complete curriculum vitae
- copies of grades obtained at level Master 1 and Master 2
- certificates/copies of diplomas
- a certificate of internship of master or engineer with if possible a letter of recommendation and the contact information of the supervisors of the internship.

Références :

Barthes et al. (2007) Europhysics Letters (EPL), 10.1209/0295-5075/77/14001
Carvalho et al. (2014) Mechanics & Industry, 10.1051/meca/2014021
Lanzetta et al. (2011) CRC Press, Taylor and Francis, 95-142, 10.1201/b10918
Mokadem et al. (2019) Proc. of 19th International Metrology Congress, Paris hal-02366775
Tadrist et al. (2020), International Journal of Heat and Mass Transfer, 10.1016/j.ijheatmasstransfer.2020.119388
Zakšek et al., (2020) Nanoscale and Microscale Thermophysical Engineering, 10.1080/15567265.2019.1689590
Zribi et al. (2018) European Physical Journal Applied Physics, 10.1051/epjap/2018170295