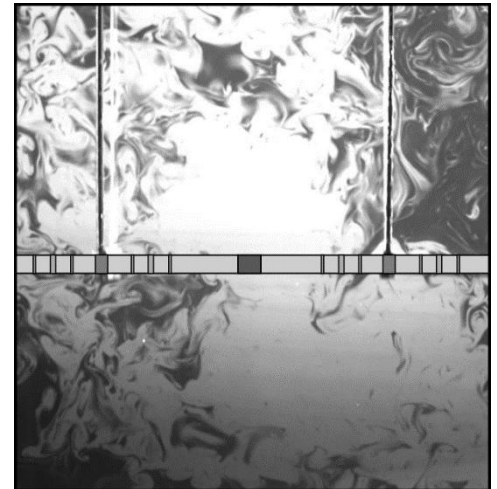


**Project:** In the context of today's urgent ecological and energy transitions, the development of technologies that combine the bio-sequestration of greenhouse gases with the production of bio-based products for industrial, chemical/pharmaceutical, or food applications holds significant promise for advancing the circular economy. Many of these bioprocesses, such as the production of high-value compounds using microorganisms (e.g., microalgae or fermentation systems), involve fluids with inherently complex and evolving rheological properties, often exhibiting non-Newtonian behaviour. The efficiency of these processes strongly depends on the ability to efficiently transport and mix the nutrients and other compounds required for microorganism growth and product formation. However, process intensification through enhanced heat and mass transfer and improved mixing remains particularly challenging. On the one hand, agitation is essential to ensure adequate transport and mixing, but excessive shear stresses can damage microorganisms, thereby affecting both productivity and product quality. On the other hand, mixing performance is strongly influenced by the complex and continuously evolving rheological properties of the culture medium. There is therefore a need to develop mixing strategies that provide efficient transport while limiting mechanical stress and remaining robust to changes in fluid rheology. Over the past several years, IMT Nord Europe has developed a number of research projects addressing these challenges, in collaboration with academic partners, with a particular focus on gentle stirring strategies for enhancing mixing in bioprocess-relevant complex fluids. The internship will contribute to these ongoing research activities through two complementary tasks:



1. **Formulation of rheological analogue model fluids** representative of microalgae culture media. These model fluids will be designed to reproduce the relevant rheological properties of biological media while remaining transparent and compatible with advanced optical flow-diagnostic techniques.
2. **Experimental investigation of flow and mixing dynamics using optical flow-visualisation techniques**, such as Particle Image Velocimetry (PIV) and Planar Laser-Induced Fluorescence (PLIF – see figure). Experiments will be performed in several canonical flow configurations, including Taylor–Couette flows, oscillating-grid flows, and channel flows, to characterise their hydrodynamics and mixing performance.

The internship will provide an opportunity to work at the interface of fluid mechanics, rheology, experimental flow diagnostics, and bioprocess engineering, contributing to the development of more efficient and sustainable bioprocessing technologies.

**Person specification:** We are looking for an enthusiastic and motivated Engineering/MSc/M2 student, with solid basis in **fluid mechanics, rheology and/or process engineering** willing to engage in **cutting edge fundamental research**. Strong analytical, organisation and communication skills, and proficiency in English language are required. Aptitude and/or appeal for **experimental work** is essential. Additional desirable skills (not mandatory) would be: basic programming skills (Matlab, Python), prior experience with optics or optical methods for fluid mechanics, image processing, ability to read and speak French. **Candidates interested in pursuing a Ph.D with the research team are particularly encouraged to apply.** Depending on the candidate's profile and research interests, opportunities for Ph.D. funding through existing projects or funding applications will be explored.

**Work environment:** The successful applicant will work in the research centre of **IMT Nord Europe** in Douai (<https://recherche.imt-nord-europe.fr>), **centre for energy and environment**, and be part of the **complex fluid flow lab**, that conducts research on complex fluids, complex flows, and their role in transfer and process intensification. The M2 internship will contribute to collaborative **research projects** involving Ph.D students and postdocs, **local, national and international collaborators** numerical modellers and bio-process specialists. The candidate will have the opportunity to contribute to scientific publications resulting from the project.

|                        |                                                                                                                                            |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| <b>How to apply:</b>   | Send detailed CV and most recent transcripts to <a href="mailto:tom.lacassagne@imt-nord-europe.fr">tom.lacassagne@imt-nord-europe.fr</a> . |
| <b>Expected start:</b> | February or March 2027                                                                                                                     |
| <b>Duration:</b>       | 6 months                                                                                                                                   |
| <b>Salary:</b>         | ≈680€/month                                                                                                                                |
| <b>Location:</b>       | Douai, Hauts de France, France                                                                                                             |



**Project:** A diversity of fields, including geophysics, bioprocessing, food processing, and healthcare, involve the flow of complex fluids, i.e., fluids containing mesoscopic suspended materials (macromolecules, particles, cells) and exhibiting non-Newtonian rheology. Understanding and controlling momentum, heat, and mass transfer in such media is crucial for apprehending environmental and biological systems and for designing energy-efficient processes with a limited carbon footprint. However, the additional rheological non-linearities arising from the interplay between the suspended material and the flowing fluid generate specific hydrodynamic regimes, making these systems particularly challenging to characterize [1]. In particular, experimental approaches capable of bridging the gap between rheological properties, flow stability and chaotic dynamics, and macroscale mixing and transport remain needed [2]. In this context, neuromorphic, or event-based, cameras offer a promising new approach to flow diagnostics. Inspired by the human visual system, these cameras do not acquire images at regular time intervals, but instead record changes in the scene as individual events, providing very high temporal resolution and ultra-low latency. Their ability to capture fast dynamics has recently led to their adoption in optical diagnostics of fluid flows, notably through the development of event-based velocimetry techniques [3]. More recently, their potential has also been demonstrated for scalar measurements [4], enabling the visualization of refractive-index gradients within a flow (figure). These capabilities open new opportunities for resolving the fast and multiscale dynamics of complex fluid flows and for developing experimental approaches capable of linking flow stability, hydrodynamics, and macroscale transport phenomena.

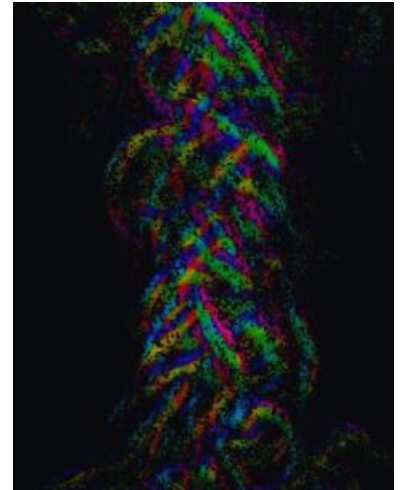


Figure 1: observation of a thermal plume with an event based camera, Shiba et al. 2024

The internship will address the following scientific question: **How can event-based imaging be used to resolve hydrodynamic instabilities in complex fluids and relate their dynamics to mixing efficiency?** To that end, its aim will be to develop original flow visualisation techniques and test them on the flow of model complex fluids in various configurations (such as Taylor-Couette, Oscillating Grids, Channel flows...).

**Person specification:** We are looking for an enthusiastic and motivated Engineering/MSc/M2 student, with solid basis in **fluid mechanics** willing to engage in **cutting edge fundamental research**. Strong analytical, organisation and communication skills, and proficiency in English language are required. Aptitude and/or appeal for **experimental work** is essential. Additional desirable skills (not mandatory) would be: basic programming skills (Matlab, Python), prior experience with optics or optical methods for fluid mechanics, rheology, image processing, ability to read and speak French. **Candidates interested in pursuing a Ph.D with the research team are particularly encouraged to apply.** Depending on the candidate's profile and research interests, opportunities for Ph.D. funding through existing projects or funding applications will be explored.

**Work environment:** The successful applicant will work in the research centre of **IMT Nord Europe** in Douai (<https://imt-nord-europe.fr/>), **centre for energy and environment**, and be part of the **complex fluid flow lab**, that conducts research on complex fluids, complex flows, and their role in transfer and process intensification. The M2 internship is part of an **ANR-funded research project** involving collaborations with Ph.D students and postdocs, **local** (Sébastien AMBELLOUIS – CERI SN), **national** and **international partners** numerical modellers and bio-process specialists. The candidate will have the opportunity to contribute to scientific publications resulting from the project.

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| <b>Location:</b>       | Douai, Hauts de France, France                                                                                                             |



- [1] T. Boulaferis, T. Lacassagne, N. Cagney, et S. Balabani, Philos. Trans. R. Soc. Math. Phys. Eng. Sci., vol. 381, no 2243, p. 20220131, 2023, doi: 10.1098/rsta.2022.0131.
- [2] C. Carré, T. Lacassagne, N. E. Hani, et S. A. Bahrani, Exp. Fluids, vol. 67, no 3, p. 30, 2026, doi: 10.1007/s00348-026-04187-1.
- [3] C. E. Willert et J. Klinner, Exp. Fluids, vol. 63, no 6, p. 101, 2022, doi: 10.1007/s00348-022-03441-6.
- [4] S. Shiba, F. Hamann, Y. Aoki, et G. Gallego, IEEE Trans. Pattern Anal. Mach. Intell., vol. 46, no 4, p. 2011-2026, 2024, doi: 10.1109/TPAMI.2023.3328188.