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Parcours Optics & Photonics (Europhotonics) - Year 2025 - 2026

☐ Initiation to research activities (Master 1) ☐ Apprenticeship (Master 2)
☐ Internship (Master 1) ☒ **Master Thesis (Master 2)**

Name of host organization: Institut Fresnel CNRS UMR7249
Mail address **:**Faculté des Sciences de Saint Jérôme, 52 avenue Escadrille Normandie Niemen, 13013 Marseille

Title: Optical sequencing of digital polymers for molecular data storage

Name of the supervisor(s): Jérôme Wenger
Email address : Jerome.wenger@fresnel.fr
Phone number : +33 7 86 39 18 49

Summary of the subject (maximum 1 page) :

Molecular data storage relies on the ability to write and read digital information encoded onto large molecules, and usually DNA is used. Recently, digital polymers have been introduced offering interesting perspectives for data storage due to a larger versatility and variety. However, sequencing of macromolecules, *i.e.* reading the digital information they contain, is a major challenge for molecular data storage. Nowadays, the main characterization techniques are based on mass spectrometry or electrical current detection. Despite their high sensitivity, these methods remain restricted to specific polymers and low level of parallelization.

We propose here a novel approach involving the development of fluorescently encoded synthetic polymers, combined with an optical sequencing technique that enables faster reading of their controlled sequence. Our aim is to set up an innovative platform based on the real-time optical sequencing of digital synthetic polymers (Figure 1). Departing from current mass spectrometry and electrical approaches, this project aims at exploring the possibilities offered by an optical readout, taking advantage of fluorescent-coded polymers and single photon counting detectors.

Adapted polymer chains will be synthesized by our IMP partner in Lyon, using fluorescent dyes that offer a high degree of freedom to encode several bits of information in intensity, color/spectrum and/or lifetime. We will develop an innovative platform for sequencing fluorescently-encoded synthetic polymers at the single molecule level. While optical detection is generally performed on diffraction-limited microscopes, recent advances in nanophotonics open new means to overcome the diffraction limit and concentrate light at a spatial scale well below the optical wavelength. However, such integration remains a burgeoning field, mostly driven by DNA sequencing applications for biosensing and diagnosis. The applications for molecular information storage remain largely unexplored. Our vision is to build a high throughout device with high sensitivity for real-time detection of the information encoded into synthetic polymers for information storage.

Additional information (optional):

* Keywords: Optical Fluorescence Microscopy, Nanophotonics, Fluorescently-encoded polymers, Time-resolved optical sequencing, Nanopores

* Required skills : optics & photonics, mostly experimental work

* Salary : grants will be allocated for internships > 8 weeks according to current regulation

* Begin/End dates (min 7 weeks for Internship, min 4 months for Master thesis): to be discussed

* Miscellaneous : can be continued by a PhD thesis

* About us: The Institut Fresnel is a research state laboratory based in Marseille / France, devoted to research and higher education with affiliation to both CNRS and Aix Marseille University. Institut Fresnel is seeking to recruit talented, enthusiastic young scientists who are highly motivated to boost their research career in the areas of nanosciences, biosensing, and nano/biotechnologies. Jerome Wenger's group has acquired a wide expertise in the nanoscale control of light fields in plasmonic nanostructures and its application to enhance fluorescence spectroscopy applications.

Web Links www.jeromewenger.com www.fresnel.fr

Gains of this Master thesis project:

1. Close supervision by an internationally recognized expert in the field of nanophotonics and single molecule fluorescence techniques.
2. Access to state-of-the-art equipment and technology, allowing to perform cutting-edge research and stay at the forefront of the field.
3. The opportunity to work on groundbreaking research projects that have the potential to make a significant impact in the field of molecular data storage.
4. Personal and professional development training, including leadership and communication skills to prepare for a successful career in academia or industry.
5. The opportunity to develop a diverse set of transferable skills and gain valuable experience that will be highly sought after by employers in academia and industry.

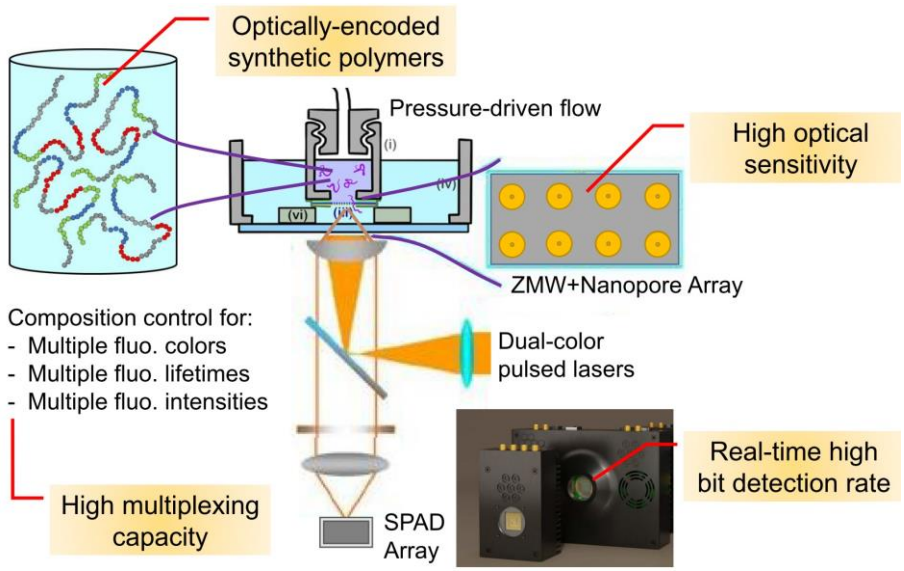

Figure 1. Optical sequencing of fluorescently-encoded polymers at the single-molecule level