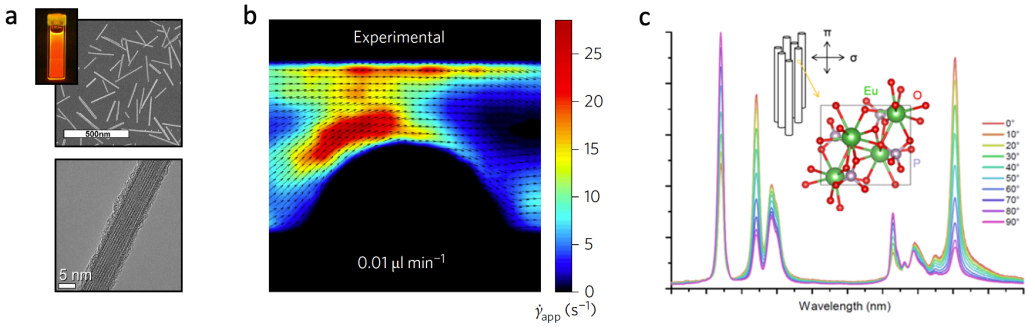
Master Internship / PhD

Internship Title	**Microfluidic Shearmetry using Optical Nanoprobes for Biomedical Applications**
Location	Nanocrystals for Optics & Electrochemistry (NOEC) team Laboratoire PMC – Ecole Polytechnique – Route de Saclay – 91120 Palaiseau
Contact	Prof. Jongwook Kim (jong-wook.kim@polytechnique.edu)
Website	https://www.jongwookkim.net/microfluidic-shearmetry https://pmc.polytechnique.fr/?lang=en
Starting date	March 2027

Flows of blood, cytosol, lymph, and mucus in living organisms are highly dynamic (i.e. nonstationary). Understanding the flow-driven cellular activities is crucial to develop innovative biomedical diagnoses, therapies, and devices. However, we have only shallow knowledge on how flow regulates such a variety of cell functions because current microfluidic analysis techniques cannot measure the rapidly varying flow profiles near cells (e.g. pulsatile blood flow in capillaries).



Figures. (a) Luminescent nanoprobes. (b) Tomographic shear-map. (c) Polarized emission spectra of nanorods.

We are developing a novel *3D microfluidic shearmetry* technique that enables to instantly measure the shear stress in a microscopic local region and tomographically map its 3D profile [1-4]. The technique is based on the tendency of nanorods dispersed in fluids to orient along the shear stress. We capture the swift and synchronized orientation of the small nanorods, from which we derive the locally applied shear stress. How to reveal the orientation of the nanorods? The nanorods are composed of lanthanide-doped crystals exhibiting peculiarly polarized luminescence that signals their own orientation [5]. What is the correlation between the rod-orientation and the shear stress? The *stress-optical law* predicts this relationship [6], which we exploit to empower our new microfluidic analysis platform to be highly accurate and reliable.

This internship project will investigate the influence of blood flow on the metamorphosis of capillary vessels, in collaboration with Prof. Barakat at LadHyX. Understanding this phenomenon may allow to deliberately control branching, merging, and propagation behavior of blood capillaries. The student would perform inter-disciplinary works including confocal micro-spectroscopy, microfluidic manipulations, and synthetic engineering of nanocrystal probes.

This internship can be continued as a PhD thesis with larger scope of research.

[1] J. Kim et al, *Nature Nanotechnology*, 12, 914 (2017) - https://doi.org/10.1038/nnano.2017.111
[2] Z. Wang et al, *ACS Nano*, 18, 44, 30650 (2024) - https://doi.org/10.1021/acsnano.4c09493
[3] Q. Zou et al, *Adv. Funct. Mater*. 35, 35, 2423439 (2025) - https://doi.org/10.1002/adfm.202423439
[4] L. Magermans et al, *Nature Communications* (2026) - https://doi.org/10.1038/s41467-026-78323-0
[5] E. Chaudan et al, *J. Am. Chem. Soc.* 140, 30, 9512 (2018) - https://doi.org/10.1021/jacs.8b03983
[6] Philippoff et al, *Rheol. Acta* 1, 371 (1961) - https://doi.org/10.1007/BF01989069