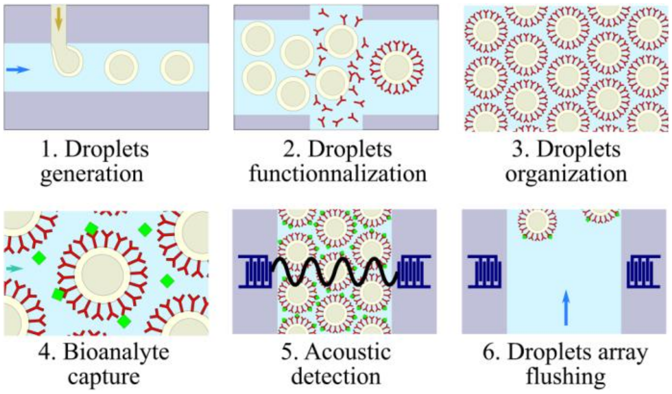
PhD thesis proposal

Acousto-fluidics in water emulsion and foam for detection of bio-analytes

Keywords: acoustic wave, biosensor, microfluidics, numerical simulation, microfabrication

1. Project background

Since a few year, we are working inside the Biomicrodevices team of the FEMTO-ST Institute (www.femto-st.fr) on a new paradigm of bio-analyte sensing. In short, the principle is based on the capture of bionalayte on the surface of functionalized droplets/bubbles followed by their acoustic probing for estimating the bioanalyte concentration in the liquid. The overall sensor principle of operation is shown in Fig. 1.



. Figure 1 : Principle of operation of droplet based acoustic bioanalyte sensor.

The sensor has potentially several advantages over existing techniques used for biomolecular interaction analysis: increased total capture (increased capture surface for the same sensor surface), increased capture efficiency (strong increase in diffusive transport) and simple regeneration (flushing micro-droplet).
We have been working on the project during the previous PhD of C. Azzopardi that ended in 2018 and that was focused on the microfluidic part (droplet generation, functionalization and capture) [Azzopardi 2019] without much consideration on the acoustic detection part. More recently, we have been developing with Dr. A. Jaloulli the fabrication technology to integrate the microfluidic circuit in glass with an acoustic wave sensor based on the propagation of a Lamb wave, and with Dr. A. Oseev the possibility to use thinned piezoelectric material for acoustic membrane fabrication.
The next step concerns acoustic detection in the emulsion/foam and it requires the experience of two research teams of the MN2S department (https://www.femto-st.fr/en/Research-departments/MN2S/Presentation).

2. PhD project

In his work the PhD student will focus on the bubble-droplet interaction with acoustic wave both by simulation and experimentally by designing, building and testing micro-devices. The work will take place in the Phononics team (M. Addouche) with strong expertise in acoustics and numerical simulation and the BMD team (F. Chollet) with expertise in MEMS, microfabrication and microfluidics. Strong collaboration with the other members of these two teams, that total about 30 members, is also expected. Moreover, the candidate will have access to the FEMTO-ST cleanroom, a key partner of the CNRS Renatech network of cleanroom (https://www.femto-st.fr/fr/Plateformes-technologiques/Mimento-presentation), with help from its experienced staff for all the microfabrication work.
The numerical simulation will be mostly based on commercial FEM software (COMSOL) while, the microfabrication process will try to reuse developed clean-room technology for shortening development time. The characterization of the demonstrators will use microfluidic benches available in the BMD team (microfluidic flow controller, LWD microscope, high speed camera, fluorescent microscopy…).

The project also needs droplet/bubble functionalization work that will be based on previously validated model [Azzopardi 2019], but that will be investigated further in parallel with Master student projects in collaboration with the BMD team and external collaboration (J. Fattaccioli at IPGG, Paris).

3. Scientific context

It appears that our system shares some features with the techniques based on functionalized solid magnetic nanoparticles for bioanalyte capture [Choi 2002]. In fact, these systems also allow simple regeneration of the functionalized interface by washing away the particles, but they do not form dense network and cannot impose 3D interaction with the particle surface, foregoing a major asset of our device. Moreover the use of solid particles prevent probing interface with acoustic wave, probably limiting the sensitivity of the approach.
Since Minnaert seminal work in the 1930s, different research groups are working on acoustic wave/diphasic fluid interaction either by considering single droplet [Marmottant 2005] or a regular network [Leroy 2009, 2016]. Still, there is no proposal yet to use this approach in integrated microfluidics circuit, nor as a biological sensor.
The possibility to use acoustic probing for biomolecular interaction analysis has been tried by Nanotemper Technologies in Germany in their Seismos system [Klumpers 2014] but using non-reusable flat functionalized surface in a relatively bulky system for analysis. Actually, to the best of our knowledge, there are no groups in the world trying to use acoustic interaction within a functionalized droplet network for biological sensing.

4. Candidate profile

The candidate should have a master or engineering degree in applied mechanics, physics or electronics engineering. He/she has to show sufficient knowledge in some (but not necessarily all :-) of the following disciplines: acoustics, waves in solid, fluid mechanics, chemical-physics, micro-/nano-fabrication, numerical simulation (COMSOL, ANSYS…).
Proficiency in English is important.

5. Application

The PhD position is for a full time research contract of 3 years (about 1900 euros/month gross salary), with a possibility to have complementary part time teaching appointment.

This research project, including the PhD salary, will be funded by the “BIAcoustic” project, a Bourgogne Franche-Comté Région research grant.

For applying, send a single pdf-file **BEFORE END OF MAY** including:

- Curriculum Vitae
- Short summary of the final year or master's thesis
- Suggestion of two referees with contact details
- Detailed explanation justifying your choice for this PhD project

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6. References

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