Processes and EngIneering in Mechanics and Materials Laboratory (PIMM)

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POST-DOCTORAL POSITION OPENING

"Design of versatile acoustically active surfaces using electro-active materials"

Laboratory and/or research group: PIMM / DYSCO Team

Supervisors: M. Rébillat (marc.rebillat@ensam.eu), M. Pruvost (mickael.pruvost@arkema.com) & N. Mechbal (nazih.mechbal@ensam.eu)

Funding: ARKEMA

Starting date: 2nd semester 2023 **Duration**: at least 12 months

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Context:

Active material, and more precisely piezoelectric materials are very appealing as they offer the possibility to design smart and multifunctional structures in particular for acoustical applications. The word *"smart"* is related here with the possibility of those structures to react dynamically to their environment and the word *"multi-functional"* to the fact that several functions can be simultaneously achieved by relying on this smartness ability. One can thus imagine structures able to monitor autonomously their health state (structural health monitoring [1]), to actively control their vibration level (active control [2]), or to provide a haptic or audio feedback to a user [3] … Ceramic piezoelectric materials (PZT) have been widely used in that area but suffers from several limitations that hinder their practical use: their geometries are constrained to simple shapes, they are fragile from a mechanical point of view, and they contain lead which is environmentally not acceptable. Newly developed active materials such as P(VDF-*co*-TrFE) (Poly(vinylidene fluoride-*co*-trifluoroethylene)) overcome these problems because they can be printed in any form, are not brittle and are lead-free. P(VDF-*co*-TrFE) copolymers thus offer numerous applications opportunities in the smart multifunctional structures context as they can be fully optimized to achieve a set of desired target functions [6] (see Figure 1).

The main challenges related with the design of versatile acoustically active surface made of P(VDF-*co*-TrFE) are [4,5]:

- their electromechanical properties and their interaction with their host structure are still not well understood and need to be experimentally characterized and numerically modeled
- algorithms for optimizing a whole P(VDF-*co*-TrFE) network satisfying a set of target acoustical functions does not exist and cost functions dedicated to the target functions need to be defined
- this concept of *"design for smart functions"* approach has never been experimentally demonstrated in a practical real-life scenario that is targeted here

Figure 1: [Left] Example of film network produced by partners based on Arkema's P(VDF-co-TrFE) copolymer and [right] illustration of a smart multifunctional structure based on P(VDF-co-TrFE) films (from https://piezotech.arkema.com/en/)

Objectives and research work:

In this context, this post-doctoral position is offered between the company Arkema which is producing P(VDF-*co*-TrFE) copolymers under the name Piezotech (https://piezotech.arkema.com) and the DYSCO team of the PIMM laboratory (https://pimm.artsetmetiers.fr/) which is working on smart and multifunctional structures design and possess an expertise in audio and acoustics.

The objectives of this post-doctoral position are thus:

1) to perform experiments allowing to quantify the electromechanical properties of P(VDF-*co*-TrFE) materials and to understand their ability to dynamically interact with their host structure either as actuator or sensors,
2) to develop and validate a numerical model allowing to predict the dynamical behavior a P(VDF-*co*-TrFE) patch bonded to a host structure in a frequency range up to several hundred of kHz covering acoustical applications and more.
3) to design an optimization algorithm along with the associated cost functions allowing to design a P(VDF-*co*-TrFE) network corresponding to a given set of target acoustical functions
4) to validate experimentally on an elementary example the concept of *"design for smart functions"* by satisfying to targets functions using an optimized P(VDF-*co*-TrFE) network

Candidate profile

You are expected to hold a PhD degree in **Acoustics, Structural Dynamics or Ultrasounds** with an experimental background and a signal processing or machine learning component. We expect a demonstrable **interest and experience regarding both experimental and numerical or theoretical activities.**

Interested candidates should apply to the following link:

https://emploi.cnrs.fr/Offres/CDD/UMR8006-MARREB-003/Default.aspx

Applications should include:

1) a **personal motivation letter** (max. 1 A4 page) describing why you apply and how the position fits into your career plans,
2) **a full CV** showing how your profile fits the requirements (max 4 pages),
3) an electronic copy of your **PhD's thesis**
4) **recommendation letter**s
5) a list of **referees** we can contact.

References:

[1] Mitra M. & Gopalakrishnan S. (2016). "Guided wave based structural health monitoring: A review." Smart Materials and Structures, 25(5). https://doi.org/10.1088/0964-1726/25/5/053001

[2] Alkhatib R. & Golnaraghi M. F. (2003)." Active structural vibration control: A review." Shock and Vibration Digest, 35(5), 367–383. https://doi.org/10.1177/05831024030355002

[3] Ganet F. et al. (2015). "Haptic feedback using an all-organic electroactive polymer composite." Sensors and Actuators B: Chemical. http://dx.doi.org/10.1016/j.snb.2015.06.071

[4] Philibert M. et al. (2022) "Lamb waves-based technologies for structural health monitoring of composite structures for aircraft applications." European Jour. of Materials. https://doi.org/10.1080/26889277.2022.2094839

[5] Li Y. et al. (2022) "Insight into excitation and acquisition mechanism and mode control of Lamb waves with piezopolymer coating-based array transducers: Analytical and experimental analysis." Mechanical Systems and Signal Processing. https://doi.org/10.1016/j.ymssp.2022.109330

[6] Han, J., Saravanapavanantham, M., Chua, M.R. et al. A versatile acoustically active surface based on piezoelectric microstructures. Microsyst Nanoeng 8, 55 (2022). https://doi.org/10.1038/s41378-022-00384-0