Theme 1-5: Mechatronics and Control - 2023

Title	Name of the PI	List the Names of the Co-Is	Department	Abstract	Starting Date	Ending Date	Funding	Amount of Funding
Multi-Modal MEMS Gas Sensors: Theoretical and Experimental Investigation	Mehdi Ghommem	Eihab Abdel-Rahman (University of Waterloo)	MCE	In this project, we propose to investigate the rich potential of the multi-modal motions of asymmetric arch microbeams to design gas sensors with higher sensitivity and signal-to-noise ratio. These sensors will be made of clamped-clamped microbeams coated with a detector material and actuated with an electrode extending over one-half of the beam span in order to maximize the actuation of asymmetry. The sensing approach will be based on exploiting the interactions between symmetric and asymmetric modes to achieve detection mechanisms with high sensitivity and extended operating range. Upon exposure to CO_2, the mass added via gas sorption to the detector material is expected to impact the dynamics of the microbeam. A preliminary numerical analysis showed promising detection mechanisms with superior performance in comparison to their conventional counterparts. The project will deal with the design, implementation, and performance assessment of a novel MEMS gas sensor. This sensor will be fabricated using the PiezoMUMPS process. It will comprise an arch microbeam actuated via an underneath electrode and coated with a detector material that has high affinity to CO_2 gas. It also includes a transverse sensing arm and side electrodes to enable differential capacitance measurements. A deposition system, equipped with a microfluidic pump, a digital microscope, and a micromanipulator, will be developed to achieve high precision placement of the detector material on the sensing microstructure. The characterization of the sensor and the experimental verification of the proposed detection mechanisms will be carried out using two measurement methods: optical and motion-induced current. The intellectual merit of the present project lies in the exploitation of the dynamics associated with asymmetric arch beams for gas sensing applications.	01/06/2023	31/05/2026	FRG	594550
A novel MEMS device for mass detection: development, experimental characterization, and performance analysis	Mehdi Ghommem	Vincent Walter and Najib Kacem (External collaborators)	MCE	In this project, we propose to explore the potential for use of an array of mechanically coupled microbeams for mass sensing applications. The goal is to exploit the mode localization phenomenon of coupled microstructures and the operation near bifurcations of their hysteretic nonlinear dynamic response to enable simultaneous and highly sensitive detection of tiny masses (in the order of few pico-grams). The plan is to design, fabricate, and conduct a comprehensive experimental and theoretical investigation of the performance of the proposed mass sensor. To facilitate the design phase of the MEMS device and identify novel detection mechanisms, we will develop and validate a decent multi-physics model with the capability to capture the associated dynamic features. The microfabrication, characterization, and initial performance analysis of the mass sensor will be performed at FEMTO-ST institute, France. Further testing will be conducted at AUS using an experimental sensing set-up based on motion-electrical current transduction technique. The sensor demonstration will be carried out following two measurement methods: optical using a laser-Doppler vibrometer and electrical using a lock-in amplifier. The experiments will focus on testing the feasibility of unconventional nonlinear mass detection mechanisms and tuning the coupling and electrostatic nonlinearities of the microsystem to enhance the sensitivity of the mass sensor. We believe that this project will significantly improve the research expertise at the American University of Sharjah (AUS) in the area of MEMS design through collaborations with world-renowned scholars, development of advanced experimental facilities, and exposure to top-notch MEMS research laboratories.	01/06/2021	31/05/2023	FRG	117500