Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
Family name	BASROUR
First name	SKANDAR
Email	Skandar.basrour@univ-grenoble-alpes.fr
Web reference	http://tima.univ-grenoble-alpes.fr/tima/en/timalaboratory/persopage_id879.html
Lab name	TIMA Laboratory (Techniques of Informatics and Microelectronics for integrated systems Architecture)
Lab web site	http://tima.univ-grenoble-alpes.fr/tima/en/index.html
Polytech name	Polytech GRENOBLE
University name	Université Grenoble Alpes (UGA)
Country	France

PhD information	
Title	Soft miniaturized piezoelectrets for energy harvesting, MEMS and robot applications
Main topics regards to CSC list (3 topics at maximum)	VI.7: Robot and integration of microelectromechanic

	IV.10: Biomaterials and polymer materials IV.11: Information, storage and sensor materials
Required skills in science and engineering	- Knowledge in material science : polymer manufacturing, electrical and mechanical properties of materials, modelling - Interest for manufacturing soft devices with polymers - Knowledge in softwares as Ansys, Comsol Multiphysics or Matlab.

Subject description (two pages maximum)

CONTEXT: Piezoelectric materials are attractive for energy harvesting, transducers and robot applications. Usual materials for such applications are ceramics, typically PZT or equivalent. However, their brightness is important, the efficiency of these materials is reduced at low frequency and complex geometries for device incorporating this material are impossible to obtain. Finally, the cost of such devices are still too high for very low-cost applications addressed by these systems.

PVDF polymers and its co-polymers could constitute an alternative. However the energy density available with these materials need to be improved and the cost of co-polymers (PVDF –TrFE) stay expensive.

In a previous work, we proposed a low-cost alternative by developing original micro-structured PDMS (polydimethysiloxane) piezoelectrics materials for micro-sensors applications [1-2]. This new concept is now demonstrated and we want now to improve it and extend potential novel applications with these devices particularly in microelectromechanical systems (MEMS) and robotic applications.

DESCRIPTION OF THE RESEACH WORK: The principle of our piezoelectrets is described in Ref [1-2]. The geometry of the structure must be improved in different ways. The

distribution of cavities and the number of PDMS layers can be optimized. For that, numerical simulations (Matlab, ANSYS) can help for the optimal choice. Another approach for the manufacturing of the layers can be investigated: cavities can be coated by a polymer electret. Moreover, the nature of electrodes deposited on the PDMS needs some exigence in terms of conductivity and strain: up to now commercial conductive pastes were used. First studies with silver nanowires are in progress and could constitute an interesting route. The reduction of dimensions for theses piezoelectrics structures is also envisaged in order to address new applications for miniaturization of transducers.

In term of electric analyses of these new structures, the measurements of energy density, dielectric properties and leakage current is necessary.

These new devices will then be validated in MEMS and robotics applications to replace the piezoelectric materials generally used. Particularly, for soft robots, dielectric elastomer actuators (DEAs) need a high voltage supply for their functioning [3]. The realization within the framework of this thesis of new piezoelectrics in generator mode would avoid the addition of a high-voltage power supply that strongly limits the development of applications to date.

WORKING ENVIRONMENT: This study will be done in TIMA laboratory. The PhD candidate will benefit of the environment of the FMNT (Micro-Nano-Technology Federation) and facilities of the Nano-microelectronics Interuniversity Center (CIME-Nanotech).

References:

[1] A. Kachroudi, S. Basrour, L. Rufer, A. Sylvestre, F. Jomni, 'Dielectric properties modelling of cellular structures with PDMS for micro-sensor applications', *Smart Mater. Struct.* 2015, **24**, 125013.

[2] A. Kachroudi, S. Basrour, L. Rufer, A. Sylvestre, F. Jomni, ' Micro-structured PDMS piezoelectric enhancement through charging conditions', *Smart Mater. Struct.* 2016, **25**, 105027.

[3] G-Y. Gu, J. Zhu, L-M. Zhu, X. Zhu, 'A survey on dielectric elastomer actuators for soft robots', *Bioinspir. Biomim.* 2017, **12**, 011003