Title of the thesis	FabriCAtion of solid state Micro-SupercapacitOrs for Internet of Things appLications
Acronym	CAMISOL
Reference number	013

Hosting institution	**Employer**
Université de Lille Website: https://www.univ-lille.fr/home/	CNRS Website: http://www.cnrs.fr/en
Hosting research unit 1	**Hosting research unit 2**
Name: Institute of Electronic, Microelectronic and Nanotechnology Acronym: IEMN Identification number: UMR 8520 Address: Cité Scientifique Avenue Henri Poincaré 59 652 Villeneuve d'Ascq Cedex, France Website: https://www.iemn.fr/	Name: Unité de Catalyse et Chimie du Solide Acronym: UCCS Identification number: UMR 8181 Address: Université de Lille Cité scientifique Bâtiment C7 59652 Villeneuve d'Ascq Cedex – France Website: http://uccs.univ-lille1.fr/index.php/fr/
Principal supervisor	**Co-supervisor**
Name: Christophe Surname: LETHIEN Email: Christophe.lethien@univ-lille.fr Phone: 03 20 19 78 97	Name: Pascal Surname: ROUSSEL Email: pascal.roussel@univ-lille.fr Phone: 03 74 95 13 75

Thesis information

Keywords	Internet of Things, micro-devices, thin films, sputtering, ALD, structural characterizations
Abstract	**Description of the PhD project:** The CAMISOL project between IEMN and UCCS labs from ULNE with the support of the University of California Los Angeles (UCLA) and Nantes University aims at developing better and safer miniaturized solid state electrochemical capacitors (i.e. micro-supercapacitors (MSC)) in order to get autonomous small, smart and connected sensors for Internet of Things applications (IoT). The interdisciplinary approach based on material science, micro / nanotechnologies, advanced *in situ / operando* characterization technique and electrochemistry will lead to new breakthroughs and the fabrication of new disruptive devices. **In the frame of the CAMISOL project, new asymmetric 3D MSC are proposed for powering the Internet of Things**. Bimetallic transition metal oxide and nitride films will be investigated as new pseudocapacitive electrodes. In the 1st part of this project, asymmetric MSC based on sputtered nitride / oxide electrodes are proposed to increase the cell voltage ($\Delta V \sim 1.5$ V) of symmetric planar MSC ($\Delta V < 1$ V) operating in aqueous electrolyte. Once the multicationic materials are fully understood and the proof of concept demonstrated, 3D MSC will be fabricated to improve the energy density of the device (EMSC = ½.C.ΔV2). To reach challenging values (EMSC > 0.1 mWh.cm-2) taking into account the optimized cell voltage achieved in the 1st part, the bimetallic oxide and nitride films will be developed by Atomic Layer Deposition facility in the 2nd part of this proposal. The deposition on high performance 3D scaffold based on hierarchical approach will allow enhancing the film capacitances due to the high specific area of the 3D template. Atomic Force Microscopy, X-Ray

	(micro)Diffraction and synchrotron X-Ray Absorption spectroscopy analyses at Soleil (ROCK beamline) will be coupled to study *in situ / operando* evolution of the mechanical and (micro)-structural properties of thin films upon electrochemical cycling. Those analyses will be used to investigate the charge storage process and to identify the failure mechanisms of the proposed pseudocapacitive electrode materials and will be performed in collaboration with Nantes University taking into account the strong background of the Thierry Brousse's group in the field of oxide-based pseudocapacitive electrodes. Finally, the last part of this proposal deals with the fabrication of solid state asymmetric MSC in collaboration with Bruce Dunn at UCLA which is a key player in the field of solid-state electrochemical energy storage miniaturized devices. **Labs involved from Lille University:** IEMN UMR CNRS 8520 (Christophe Lethien - Hub 3 ULNE, member of the RS2E and Store-Ex labex) & UCCS UMR CNRS 8181 (Pascal Roussel - Hub 2 ULNE) **Secondments:** Bruce Dunn's Lab from UCLA (US) & Thierry Brousse's group from IMN Nantes
Expected profile of the candidate	**Applicant profile:** The PhD candidate should have a master degree with a strong background in the field of material science and electrochemical energy storage devices. An additional background in the field of microfabrication technique will be an asset. The applicant will report its results at ECS, MRS, E-MRS, ICAC, ISEECAP, ISE and PowerMEMS congresses.
Application procedure	The application procedure is detailed on the European programme PEARL website www.pearl-phd-lille.eu. The funding is managed by the I-SITE ULNE foundation which is a partnership foundation between the University of Lille, Engineering schools, research organisms, the Institut Pasteur de Lille and the University hospital. The application file will have to be submitted before April 15, 2020 (10h Paris Time) and emailed to the following address : international@isite-ulne.fr.
Net salary and Lump Sum	A net salary of about €1,600 + €530 per month to cover mobility, travel and family costs.