



UNIVERSITÀ DI PISA  
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE  
Dottorato di Ricerca in Ingegneria dell'Informazione

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Doctoral Course

**“Electrochemical Energy Storage for Flexible Microelectronics. Principle and applications”**

Thierry Djenizian

*Head of Flexible Electronics Department  
Center of Microelectronics in Provence*

**Short Abstract:** With the spectacular rise of wearable technologies, R&D on microbatteries is rapidly emerging on the world market. For example, smart electronic textiles require new features and battery designs that traditional battery technologies simply cannot provide. This has opened the door to innovation and added a new dimension to the global competition between battery suppliers. The potential sector that can be impacted includes Internet of Things (IoT), healthcare (skin patches, medical sensors, medical diagnostic devices), smart cards, active and battery-assisted passive RFID, etc... To date, the fabrication of thin-films and/or flexible microbatteries is still in its infancy because it requires the marriage of complementary scientific knowledge and expertise besides several technological challenges to overcome.

This course is dedicated to the principle of electrochemical energy storage for flexible microelectronics. It will be presented recent progress achieved in the field of Li-ion microbatteries. The principles will be explained in terms of basic electrochemistry and thermodynamics. The relationship between properties at the atomic level with the performance of the power sources will be highlighted. Particularly, an insight into the use of nanostructured materials to improve the storage capacity, rate capability, and cyclability will be given.

**Course Contents in brief:**

**I. Basics of electrochemistry**

- Redox reactions
- Thermodynamics of redox reaction
- Kinetics of redox reaction (activation and diffusion processes)
- The Electrochemical interfaces (The Helmholtz Model, the Gouy-Chapmann Model, and the Stern Model)
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**II. Electrochemical analysis techniques for batteries**

- Potentiodynamic and potentiostatic experiments
- Current and potential transients

- Cyclic voltammetry
- Charge and discharge profiles
- Electrochemical impedance spectroscopy

### **III. Lithium-ion microbatteries**

- Principle and applications
- The negative electrodes for microbatteries (C, oxydes, Si, ...)
- The positive electrodes for microbatteries (spinels, ...)
- The different electrolytes for microbatteries
- Towards the next generation of microbatteries

### **IV. Microfabrication processes for designing microbatteries**

- Optical lithography
- Electron- and ion-beam lithography
- Thin-film deposition of battery components (top down and bottom-up)
- Recent examples dedicated to the fabrication of energy storage microsystems
- Flexible microbatteries

**Total # of hours: 20**

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## **CV of the Coordinator**



Prof. Thierry Djenizian is the head of the flexible electronics department at the Ecole Nationale Supérieure des Mines de Saint-Etienne (Campus Georges Charpak). In 2002, he received his PhD degree in Materials Chemistry for microelectronics from the Swiss Federal Institute of Technology in Lausanne and the Friedrich Alexander University of Erlangen-Nuremberg. His research activities are mainly focussed on the nanostructuring of materials by electrochemical techniques for applications in energy storage and conversion at the micrometer scale. He is the author of over 80 publications in international journals and 5 book chapters (H-index 23). He is one Conference Chair of Porous Semiconductors Science and Technology international conferences.

## **Room and Schedule**

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

**Monday 10/04**

9:00 – 12:00

14:00 – 16:00

**Tuesday 11/04**

9:00 – 12:00

14:00 – 16:00

**Wednesday 12/04**

9:00 – 12:00

14:00 – 16:00

**Thursday 13/04**

9:00 – 12:00

14:00 – 16:00