Postdoctoral Position for 24 months in lithium-ion batteries

Place of postdoc: Institut de Recherche de Chimie Paris, CNRS – Chimie ParisTech (UMR 8247), ENSCP (France),
11 rue Pierre et Marie Curie, Paris, France

Field of research: Physico-chemistry of surfaces; Electrochemistry; Electrode processes; Lithium-ion batteries

Title: **"Reactivity of high capacity negative electrode materials used in lithium-ion batteries."**

Duration: 24 months

Starting date: 2016

Responsible persons: Jolanta Swiatowska, Vincent Maurice, Philippe Marcus

Description of Postdoctoral Research

Lithium-ion batteries (LIBs) are the dominant power sources for portable applications such as cell phones, digital cameras, laptops etc., because of their high energy density. They are also the prime candidate of power sources for the next generation of electric vehicles (EVs) and hybrid electric vehicles (HEVs). However, the applications of lithium ion battery in EVs and HEVs are limited mostly due to the lack of suitable materials and the difficulty in mastering of electrode processes.

One of the most promising negative electrode material is silicon due to its ability to insert large amounts of lithium, delivering a very high theoretical specific capacity of 3579 mAh/g, which is almost 10 times higher than graphite electrode (372 mAh/g). Nevertheless, a high volume variation (280 % for $Li_{15}Si_4$) during lithiation leading to a morphological damage of electrode materials and a huge capacity loss (of about 30%) observed during the first charge are the major drawbacks for application of Si as anode material. These damages can be considerably decreased or avoided by using nanosized materials, (such as Si nanowires), by application of different types of electrolytes and electrolyte additives influencing better properties of the surface layer (Solid Electrolyte Interface - SEI layer), or modifications of the chemical composition of the Si electrode material. The improvement of the electrochemical performance of the Si electrode material depends also on the surface chemistry related to formation of the SEI layer occurring during the first lithiation at potential ower than 1V vs Li/Li^+. The aim of this work will be then to understand the electrode processes occurring at the electrode/electrolyte interface (including the SEI layer) and in the bulk of electrode material.The composition of the SEI layer depends on the nature of the solvent/salt system. Due to wide development of new mixtures of electrolytes, additives, application and development ionic liquids it is necessary to understand the behavior of these new electrolytes vs the high capacity Si negative electrode.

Besides the traditional electrochemical methods, various experimental techniques can be applied to understand the electrode processes, such as X-ray photoelectron spectroscopy (XPS), and Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) or Atomic Force Microscopy (AFM). XPS allows identification of the elements present in the sample and their chemical state (oxidation state) by simple measurement of their binding energy. Quantitative analyses can also be done to determine surface composition and film thickness. ToF-SIMS will be used as a technique complementary to the XPS. A big advantage of the ToF-SIMS technique is a good depth resolution and an excellent sensitivity to Li.

Experience of laboratory in the field:
The postdoctoral position, for a period of 24 months, will be held in the in the Group of Physical Chemistry of Surfaces (PCS) in the Institut de Recherche de Chimie Paris, CNRS – Chimie ParisTech. The PCS Group has already rich experience in the study of interfacial reactions in lithium-ion batteries (see below a list of selected publications) in a frame several projects of collaboration with university (national and international) and industrial partners (Renault).

Profile of Postdoctoral Candidate:
Prior experience in electrochemistry and physical chemistry is required. The experience in lithium batteries and surface analytical techniques (for example XPS, TOF-SIMS) will be highly appreciated. The post-doc will be awarded to the successful applicant according to the local conditions and salary scales proposed by FFCSA. For information please e-mail the contact shown below.

List of selected publications:

1. C. Pereira-Nabais, J. Światowska, A. Chagnes, A. Gohier, S. Zanna, A. Seyeux, P. Tran-Van, C.-S. Cojocaru, M. Cassir, P. Marcus, Insight on the Solid Electrolyte Interphase (SEI) onto Si nanowires in lithium-ion battery: chemical and morphological modifications upon cycling, Journal of Physical Chemistry C 118 (6) (2014) 2919–2928.
2. E. Nanini-Maury, J. Światowska, A. Chagnes, S. Zanna, P. Tran-Van, P. Marcus, M. Cassir, Role of sebaconitrile as a cosolvent in the formulation of high-potential electrolytes for lithium-ion batteries, Electrochimica Acta 115 (2014) 223–233.
3. F. Liao, J. Światowska, V. Maurice, A. Seyeux, L. H. Klein, S. Zanna, P. Marcus, Ageing mechanisms of conversion-type electrode material studied on iron sulfide thin films, Electrochimica Acta 120 (2014) 359–368.
4. B. Tian, J. Światowska, V. Maurice, S. Zanna, A. Seyeux, L. H. Klein, P. Marcus, Combined surface and electrochemical study of the lithiation/delithiation mechanism of iron oxide thin film anode for lithium-ion batteries, Journal of Physical Chemistry C 117 (42) (2013) 21651–21661.
5. C. Pereira-Nabais, J. Światowska, A. Chagnes, F. Ozanam, A. Gohier, P. Tran-Van, C.–S. Cojocaru, M. Cassir, P. Marcus, Interphase chemistry of Si electrodes used as anodes in Li-ion batteries, Applied Surface Science 266 (2013) 5-16.
6. J.-T. Li, V. Maurice, J. Swiatowska-Mrowiecka, A. Seyeux , S. Zanna, L. Klein, S.-G. Sun, P. Marcus, XPS, Time-of-Flight-SIMS and Polarization Modulation IRRAS study of Cr2O3 thin film materials as anode for lithium ion battery, Electrochimica Acta 54 (2009) 3700-3707.
7. J. Światowska-Mrowiecka, V. Maurice, L. Klein, P. Marcus, Nanostructural modifications of V2O5 thin films during Li intercalation studied by in-situ AFM, Electrochemistry Communications, 2007, 9, 2448–2455.

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