Jolanta Światowska, J Fundam Renewable Energy App 2016, 6:7(Suppl)
http://dx.doi.org/10.4172/2090-4541.C1.023

International Conference on
Battery and Fuel Cell Technology
December 08-09, 2016 Dubai, UAE

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Understanding the surface reactions as a necessity for development of new electrode materials for Li-ion batteries

Understanding the electrode processes occurring at the electrode/electrolyte interface and in the bulk electrode material is necessary for development of high energy density batteries (lithium-ion, sodium-ion or sulfur batteries) for portable and transport applications. The main electrode processes in Li-ion batteries (LIB) are insertion/extraction reactions that induce changes in the positive and negative electrode materials. These reactions are accompanied by decomposition of electrolyte that leads to formation of passive layer. The passive layer formed on the negative electrode material, widely known as a solid electrolyte interphase (SEI) layer, strongly influences the battery performance and cycle life. Much thinner passive layer named as a solid permeable interphase (SPI) layer, can be formed on the positive electrode material. The mechanism of electrode passivation is even more complicated if the electrode material is not stable during the process of lithiation/delithiation and cycling and undergoes the volume changes expansion/shrinkage. The strong electrode modifications occur in the case of new, high capacity alloying or conversion-type electrode materials, such as Si-based or transition metal oxide/sulfide-base materials, respectively. To have a better insight into these different reactions induced by electrochemical processes the advanced surface-sensitive techniques: X–ray photoelectron spectroscopy (XPS) and time-of-flight secondary ion mass spectrometry (ToF-SIMS) are particularly suitable for characterization of electrode materials. Apart the chemical composition of the surface SEI layer, a dynamic increase/decrease of SEI upon lithiation/delithiation, and the irreversible chemical and volume modifications of electrode materials upon cycling evidenced by ToF-SIMS ion depth profiles will be discussed. Using ToF-SIMS ion depth concentration profiles the ionic transport properties of different electrode materials can be estimated. The ionic transport of Li can be limited by Li trapping in the bulk of electrode material, at the interfaces, formation and growth of the SEI layer.

Biography

Jolanta Swiatowska is a Research Associate (CR, HDR) at CNRS (Centre National de la Recherche Scientifique) in the Institut de Recherche de Chimie Paris, Chimie Paris Tech, France. She obtained her PhD degree in 2003 from AGH University of Science and Technology in Poland. Her research areas lie in physical chemistry of surfaces, surface treatments, corrosion mechanisms/protection, thin films, electrochemistry, and conversion and energy storage with emphasis on batteries (lithium-ion batteries). In her research she combines the *in situ* electrochemical techniques with advanced surface analytical methods such as X-ray photoelectron spectroscopy, time-of-flight secondary ion mass spectrometry and atomic force microscopy. She has published more than 60 papers in scientific journals, books and conference proceedings and is the co-author of over 100 international and national conference presentations. She is also working as an expert for the European Commission, French National Research Agency (ANR) and Research Foundation Flanders (FWO).

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