Graphene as a thinnest electrode in electrochemical systems

L.V.Yashina [1,*]
[1]*Lomonosov Moscow State Unoversity leninskie Gory 1/3/ 119991 Moscow*
**Yashina@inorg.chem.msu.ri*

The operation of all electrochemical energy-related systems, such as supercapacitors, batteries, fuel cells, etc. depends largely on the processes occurring at electrochemical interfaces at which charge separation and chemical reactions occur. Many od such systems uses electrode composed by sp^2-carbon materials such as carbon black, carbon nanotubes, reduced graphene oxide etc. Evolution of structure and composition at the interface between electrodes and electrolytes affects all the device's functional parameters including power and long-term performance stability.

Graphene is a unique material modelling behaviour a great variety of carbon materials used in electrochemistry. Currently transferred graphene was applied as an electrode for operando studies by X-ray photoemission and absorption. Being the thinnest imaginable electrode graphene possesses a high electronic conductivity, good mechanical properties, and a reasonable transparency to photoelectrons excited by soft X-rays [1]. A fair degree of success has been achieved in fabricating cells with single or few-atomic layer graphene membranes that act as a "window" for photoelectrons. However, such a cell, was only used to acquire the photoemission spectra from a liquid beneath the membrane [2]. First observations of electrochemical phenomena using such kind of membranes have been reported [3]. Utilizing graphene as both window for XPS in UHV with soft X-rays and working electrode remains an attractive idea, though the problems of radiolysis of the electrolyte, bubble formation under the graphene among others, make it a challenge. Fortunately, significant progress in the preparation and transfer of the large-scale high quality graphene sheets leaves room for hope that this approach will be further developed. Another possibility is to use all solid electrochemical cell used in [4,5] to evaluate graphene reactivity towards electrochemical products and inretmediates.

[1] A. Kolmakov, M. K. Abyaneh, D. A. Dikin, L. J. Cote, J. Huang, M. Amati, L. Gregoratti, S. Günther, M. Kiskinova, *Nat. Nanotechnol*. 2011, 6, 651– 657.
[2] J. Kraus, R. Reichelt, S. Günther, L. Gregoratti, M. Amati, M. Kiskinova, A. Yulaev, I. Vlassiouk, A. Kolmakov, *Nanoscale* 2014, 6, 14394 – 14403.
[3] Juan J. Velasco-Velez,Verena Pfeifer, Michael Hävecker, Robert S. Weatherup, Rosa Arrigo, Cheng-Hao Chuang, Eugen Stotz, Gisela Weinberg, Miquel Salmeron, Robert Schlogl, and Axel Knop-Gericke *Angew. Chem*. Int. Ed. 2015, 54, 1 – 6
[4] Itkis D. M., Semenenko D. A., Kataev E.Yu., Belova A. I., Neudachina V. S., Sirotina A.P., Hävecker M., Teschner D., Knop-Gericke A., Dudin P., Barinov A., Goodilin E. A., Shao-Horn Y., Yashina L.V. *Nano Lett* 13 (10), 2013, pp 4697–4701
[5] Kataev E.Yu., Itkis D.M., Fedorov A., Senkovskiy B., Usachov D., Verbitskiy N., Grueneis A., Barinov, A., Tsukanova D. Yu., Volykhov A.A., Mironovich K., Krivchenko V., Rybin M., Obraztsova E., Laubschat C., Vyalikh D., Yashina L.V. *ACS Nano*, 9 (2015) 320–326