Nanoscale resolved solid-state electrochemistry: the scanning probe microscopy approach

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Progress in secondary batteries and fuel cells is driven by advances in development of more effective materials for mobile ion storage and conduction. The crucial part of this process is a thorough understanding of material functional behavior at the micro- and nanoscale. Variety of structural methods is now available in commercial equipment to resolve and study material transformation due to intercalation-deintercalation process. In the same time there is still a lack of functional methods allowing to probe local potential, ion mobility together with mechanical properties and electronic conductivity.

Tendency to conduct nanoscale resolved studies of battery materials functionality forces rapid development of scanning probe microscopy (SPM) methods. In this contribution we consider recent advantages in this specific area of investigations. Both conventional current-based methods, such as scanning electrochemical microscopy and conductive atomic force microscopy, and strain-based SPM methods as electrochemical strain microscopy and Kelvin probe force microscopy are discussed on the basis of their application and limitations. The particular focus of the talk will be on electrochemical strain microscopy (ESM) as a method with simplest realization possible to de bone in different experimental configurations and possessing high spatial resolution. The realization of the method is based on Vegard displacement of the surface under the action of charge carrier's concentration gradient stimulating by the biased SPM tip. ESM allows to probe quantitatively ionic mobility in the different electrochemical systems [1]. The recent development of ESM experimental approach and supporting theoretical basis will be reported on the basis on our recent publications [1,2].

The work was financially supported by Russian Science Foundation (Grant 17-72-10144). The equipment of Ural Center for Shared Use "Modern Nanotechnology" Ural Federal University was used.

1. D.O. Alikin, K.N. Romanyuk, B.N. Slautin, et al., *Nanoscale* **10**, 2503 (2018).
2. D.O. Alikin, A.V. Ievlev, S.Yu. Luchkin et al. *Appl. Phys. Lett.* **108**, 113106 (2016).

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