Dissertation abstract

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„Modified transparent conductive layers as new electrode materials.”

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Modern technologies are currently mostly based on semiconductor materials. They form the basis of integrated circuits, miniaturized electronic circuits, which are the main source of income for the global electronics market.

The aim of this doctoral dissertation was to characterize new semiconductor electrode materials based on transparent oxide layers used in optoelectronics. A number of electrode modifications have been made, leading to new surfaces that differ in properties from the original material. Electrochemical techniques – cyclic voltammetry and electrochemical impedance spectroscopy as well as physicochemical – ellipsometry, photoelectron spectroscopy in the X-ray range and contact angle measurements were used as the research tool. A number of carbon materials that differ in both physical and chemical structure, as well as the type of substrate, were also tested for comparative purposes. Such a broad analysis allowed the selection of FTO electrodes as optimal matrices for creating new electrode materials.

The results presented in this dissertation prove the wide possibilities of surface modification of FTO electrodes. In-depth analysis of their electrochemical parameters has made it possible to highlight the differences in the electron transfer process for model redox systems relative to the unmodified FTO electrode. Based on the performed measurements, it has been shown that the use of silanes gives the possibility of effective modification of transparent conductive layers. This was indicated by both the results of impedance and voltammetric measurements. The selection of appropriate silane derivatives gives the ability to control the properties of the electrode surface.

The introduction of reactive surface amino groups $-NH_2$ and isocyanate $-NCO$, using various deposition techniques, chemical and plasma, gives the possibility of further modification of the surface properties of electrode materials. This allows to regulate the interaction of the surface of the electrode material with a potential analyte in order to recognize it, control oxidation and reduction processes, or study electron transfer processes in complex chemical and biochemical systems. Functionalization of the pre-modified silane surface of the FTO electrode with electroactive compounds clearly indicated the direct impact of surface development on the properties of the obtained layers, as well as their dependence on the pH of the solution.

The research results presented in this dissertation significantly broaden the existing knowledge about electrode materials. In addition, they allow their classification in relation to electrochemical properties, and also define their usefulness in sensory applications.