Nowadays, the development of high power and energy density energy accumulation complexes integrated into solar cell (photovoltaic), wind energy and concentrated solar power systems is extremely important for the wider exploitation of sustainable renewable energy sources. Mainly two types of electrochemical energy storage devices are available: supercapacitors (SC) and batteries. Supercapacitor, as energy storage device with high power density and long cycle life but moderate energy density has been considered to be a promising high power energy source in combination with battery for hybrid electrical vehicles, combined solar cells and wind power systems etc., thus, for development of combined energy recuperation complexes. Taking into account the strong pulsation of energy generating properties of the wind turbine and photovoltaic systems, the quick accumulation and regeneration of current pulses is inevitable for modern renewable energy complexes. Overcoming of this problem can be achieved by means of supercapacitors with double layer ideal capacitive or pseudocapacitive energy storage mechanism. It should be noted that a key to success in this endeavor is to ensure the combination of optimal porous structure of the electrode/electrolyte interface with appropriate electronic structure and electrochemical stability of the interface between metallic contact and semiconductive carbon electrode that provides unblocking of Helmholtz layer capacitance by capacitance of spatial charge region in surface layers of the carbon electrode. Therefore the SCs with optimised power and energy density are important energy storage systems, which can be used in various areas of modern technology, starting from the pulse energy generation systems for transportation and finishing with the consumer goods.

For the long-lasting exploitation and optimal specific energy — specific power regime, in addition to the optimised microporous structure of carbon material, the long-lasting electrochemical time stability of electrode material, electrical contacts and electrolyte (solvant and salt) is extremely important [1-3].

This paper reports the results of investigations of the electrochemical behaviour and surface chemical composition of the supercapacitor electrodes, based on Al and Ti current collectors and deposited Al- and Ti-layers on TiC-CDC and 1.5 M (C2H5)3CH3NBF4 in acetonitrile containing micropores for adsorption of partially desolvated ions and a small quantity of mesopores for quick mass transfer of ions into the micropores. However, it was assumed that at higher cell voltages \( U \geq 3.2 \, \text{V} \), more detailed studies discussing the electrochemical behaviour of Al and Ti layers, deposited onto TiC-CDC carbon electrodes, as current collectors, are inevitable. FIB-SEM, XPS and TOF-SIMS have been used for the chemical analysis of supercapacitor electrodes before and after electrochemical tests. Cyclic voltammetry, constant current charge/discharge (CC/CD) and electrochemical impedance spectroscopy methods have been used for obtaining the electrochemical characteristics for the supercapacitors during long-lasting constant current charge/discharge cycles. The region of ideal polarizability of supercapacitor, gravimetric and volumetric capacitances (practically independent of CC/CD cycles number) were calculated before and after CC/CD cycling, respectively. The results of CC/CD data for TiC-CDC are in a good agreement with CV data, and demonstrate high round trip efficiency (98 - 99 %) at \( U \leq 3.4 \, \text{V} \) for 1.5 M \((\text{C}_2\text{H}_5)_3\text{CH}_3\text{NBF}_4\) acetonitrile based supercapacitor, practically independent of cycle number analysed. The faradic reactions became noticeable only at cell voltages higher than 3.4 V and in agreement with FIB-SEM, XPS and TOF-SIMS data the contamination of carbon electrode surfaces with reaction intermediates (\( \text{F}_2, \text{CH}_-, \text{CHO}, \text{CN}_-, \) organic radicals etc.) takes place during CC/CD cycles.

The dependence of the normalized real and imaginary parts of the complex power on frequency shows that the characteristic time constant somewhat increases during the long-lasting CC/CD cyclation. For Al-deposited supercapacitors the gravimetric energy (34 - 35 W h kg\(^{-1}\)) and volumetric energy (25 - 26 W h dm\(^3\)) calculated before and after CC/CD cycling at cell voltage \( U = 3.4 \, \text{V} \) were independent of cycle number analysed. However, initial gravimetric power is practically 1.4 times higher (195 kW kg\(^{-1}\)) than that calculated after 40000 charge/discharge cycles (144 kW kg\(^{-1}\)) which is probably caused by the changes in the chemical composition of materials mentioned above. Thus, for more stable power densities less wide voltage region \( U \leq 3.4 \, \text{V} \) or more stable materials have to be used. Electrochemical stability of Ti current collector based SCs were somewhat lower if \( U \geq 3.4 \, \text{V} \) has been applied.

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References