291b Electrochemical Capacitors of Ruo2 Nanophase Grown on Linbo3(100) and Sapphire(0001) Substrates

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The electrochemical properties of RuO2/LNO and RuO2/SA electrodes made of RuO2 rods and plates of nanometer size on LiNbO3(100) and sapphire(0001) substrates are investigated. Both of rods and plates are grown vertically using chemical vapor deposition in a cold-wall reactor. The nanorods are of height 1300 nm and diameter 50-110 nm. The nanoplates are of height 1000 nm, width 60-450 nm, and thickness 30-50 nm. The alignment of rods and plates results from the epitaxial growth. The epitaxial relation between RuO2 nanorods and LiNbO3(100) is described as RuO2(001)//LiNbO3(100) and RuO2[100]//LiNbO3[010]. The epitaxial relation between RuO2 plates and sapphire(0001) is described as RuO2(100)//sapphire(0001) and RuO2[001] parallel to one of the three possible sapphire [-1010] directions. The RuO2/LNO electrode has a higher electrolyte/solid surface area, compared with the RuO2/SA electrode. When immersed in H2SO4 acid, voltammograms of both electrodes exhibit chemisorption and pseudocapacitive characteristics of the RuO2 single crystal. The chemisorption features decrease after repeated cyclic voltammetry (CV) sweeps, and the voltammograms become more mirror-like. The specific capacitance of RuO2/LNO electrode measured in CV is 285 Fg-1, that of RuO2/SA 179 Fg-1, measured between 0.3 and 0.9 V (vs Ag/AgCl). These values are reconfirmed in charging-discharging measurements. The measured capacitance decreases with the sweep rate, and the decreasing trend of RuO2/LNO is higher than that of RuO2/SA. Reduction of accessible charge at high sweep rates results from higher internal resistance of the RuO2/LNO electrode which is distributed because of its porous nature. The impedance spectrum of RuO2/LNO electrode confirms its higher internal resistance. It also indicates the electrode is a nearly ideal capacitor below a knee frequency 200 Hz. The energy density and power density of the two capacitors are discussed using the Ragone plot.