An Electrochemical Impedance Spectroscopy Study of Mesoporous Silicon in Aqueous Electrolyte Solution

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The datasets presented here belong to an electrochemical impedance spectroscopy (EIS) investigation of porous silicon immersed in a perchloric acid electrolyte solution with a concentration of 1 mol/l. A thin film of porous silicon, with a thickness of 630nm, is fabricated on top of a bulk silicon wafer. The wafer has a (100) orientation, a resistivity of 0.01 to 0.02 Ω cm and a thickness of 100 ± 10 µm. Porous silicon is fabricated in an electrochemical etching procedure by applying a constant current with a density of 12.5 mA cm^{-2} between the wafer (working electrode) and a platinum counter electrode in a 2:3 volumetric mixture of hydrofluoric acid (48%, Merck Emsure) and ethanol (absolute, Merck Emsure). To obtain an electrochemically stable porous silicon material, the porous silicon's inner surface area is electrochemically oxidized by an applied potential of 1.2V for 24 hours.

The dataset contains the file "pdot-pSi_1MHClO4_CV_0-1-2V_100mVs_x5.txt". It contains five cycles of a cyclo voltammetry measurement of the oxidized porous silicon sample with applied voltages in the range of 0 to 1.2 V with a scan rate of 100 mV/s. A plot of the current versus the applied potential shows typical features of a capacitive charging of the electrical double layer at the interface of the porous silicon electrode and the electrolyte solution. Only negligible Faradaic currents, towards the upper vertex point, are visible.

The dataset contains a folder named "porous silicon". It has the data for an electrochemical impedance spectroscopy study of the porous silicon electrode. The impedance is recorded and averaged at 12 frequency steps per decade from 100 kHz down to 0.2 Hz. The applied potential has an alternating sinusoidal amplitude of 10 mV around a static potential. The respective applied static potential can be found in the name of the datafile, e.g. "pdot-pSi_1MHClO4_EIS_0-1MHz-200mHz_1pt_x12_0-01Vampl_**0-2V**" (applied static potential in bold, here 0.2 V). The EIS measurements are resolving the EDL charging of the porous silicon electrode since in a Nyquist plot a half-circle in the high-frequency range (100 to 1 kHz) and an ensuing vertical increase in the mid-frequency range (1000 to 1 Hz) is resolved. The low-frequency range (< 1 Hz) is not of interest for the EDL charging.

The other folder in the dataset, titled "bulk silicon", contains datafiles of EIS measurements of a bulk silicon electrode. The bulk silicon has been oxidized in the same manner as the porous silicon electrode. The EIS measurements are conducted in the same type of electrolyte solution and a similar frequency range (from 100 kHz to 0.5 Hz). The datafiles are labelled in the same style as the porous silicon EIS files. The EIS study performed on bulk silicon can be directly compared to the porous silicon electrode type and enables the investigation of the effect of the pores on the EDL charging process and the characteristics of the interface. In particular, the determined capacitances c can be plotted versus the applied static potential E in the form of a Mott-Schottky plot (c^{-2} vs E). This enables the determination of doping type, doping density and flatband potential of both electrodes and their direct comparison. Most importantly, it can be determined that the flatband potential is significantly higher for the porous silicon electrode (1.4 ± 0.1 V in comparison to 1.9 ± 0.2 V).