Integration of Optimized Carbon Aerogels in Supercapacitors

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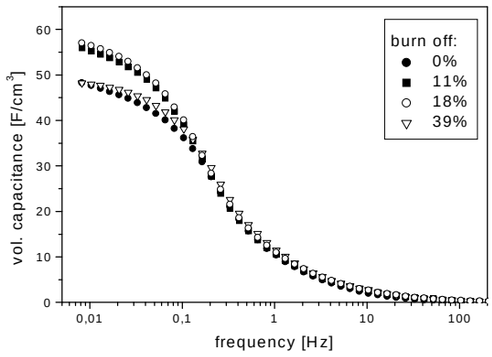
Introduction

Carbon aerogels are highly porous materials. They were prepared via pyrolysis of resorcinol-formaldehyde aerogels. Carbon aerogels exhibit a monolithic structure with accessible micropores. In applying thermal activation methods the accessible surface area of carbon aerogels can be increased from 700 m^2/g up to 2500 m^2/g [1]. Such carbon aerogels are promising materials for supercapacitor electrodes.

Modification of Carbon Aerogels

In order to optimize the accessible surface area carbon aerogels were activated in controlled CO_2-atmosphere.
After activation the electrodes were vacuum impregnated with 1 m H_2SO_4 and investigated via impedance spectroscopy in a three electrode arrangement.
Graph 1 shows the volumetric capacitance of differently activated structures. The data reveal an optimized volumetric capacitance at a burn off between 10 and 20 % (surface areas between 900 and 1200 m^2/g).

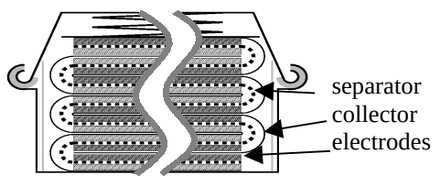


***Graph 1**: Volumetric capacitance of an aerogel structure after different burn off rates. Physical data: density: 0.45-0,30 g/cm³ , resistance at 8,25 mHz: 0,5 - 0,4 Ω cm² ,electrode thickness: 1,3 mm.*

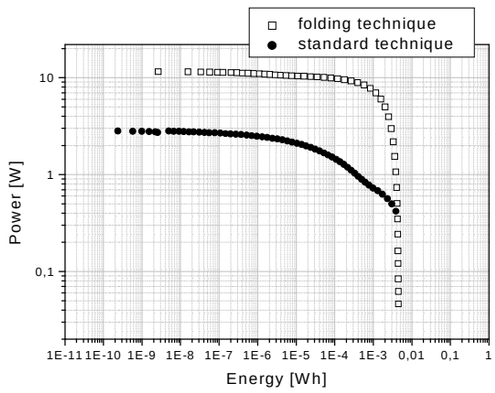
At higher activation rates the specific surface area is further increased. Despite the increase in volumetric surface area the volumetric capacitance of highly activated structure decreases. This can be explained by the reduced ionic accessibility of micropores located within the carbon microcrystallites, which are created at higher activation rates [1]. These results are based on a comparison of data obtained via nitrogen sorption and model analysis of the impedance data. The model respects different pore geometries and enables a detailed understanding of the charging mechanism in microporous carbon electrodes [2].

Integration of Carbon Aerogels in Button Cell Casings

In order to integrate carbon aerogels in button cell casings an innovative folding technique was applied.
The applied electrode arrangement is scetched in graph 2. In the cell fibre reinforced aerogels with a thickness of 180 µm were used as electrodes. The reinforced electrodes resist the high pressure in the cell and show almost no degradation of resistance and capacitance in long term cycling tests. Graph 3 shows the Ragone plot of the button cell scetched in figure 2. The values were evaluated according to a transformation of the impedance data assuming an operating voltage of 1.2 V [3]. In addition the performance of a button cell supercapacitor prepared via the standard electrode arrangement is shown. The latter stack consists of two electrodes with a thickness of 2 mm facing each other.
The data reveal an improved performance (time constant) of the folded system. The folding technique provides up to 5 times higher power densities compared to the standard arrangement.



***Graph 2**: Integration of fibre reinforced aerogels via folding technique in a button cell casing (cell vol.: 2.1 cm³). 4 molar KOH served as electrolyte.*



***Graph 3**: Ragone plot for button cells prepared via standard and folding technique (non-activated electrodes). External electrode area: 2,8 cm² (standard), 24 cm² (folding technique). Total capacitance: 23 F (standard), 12 F (folding technique).*

References:

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[3] T. Christen, M.W. Carlen and C. Ohler, 9th International Seminar on Double Layer Capacitors and Similar Energy Storage Devices, Deerfield Beach, Florida (1999).