SILICON NANOFIBERS USED AS ANODE MATERIALS FOR LITHIUM ION BATTERIES

Jie Shan[1,2], **Paul Kiekens** [2],
[1] *State Key Laboratory of Coal Conversion, Institute of Coal Chemistry, Chinese Academy of Sciences, PR China*
[2] *Department of Materials, Textiles and Chemical Engineering, Ghent University, Belgium*
shanjie@sxicc.ac.cn

EXTENDED ABSTRACT

Key Words: silicon anode, silicon nanofibers, electrospinning, magnesiothermic reduction

1. INTRODUCTION

Lithium-ion batteries (LIBs) are attracting increasing research attention as energy storage devices due to their high energy density and long cycle life For anode materials, silicon has been proposed to be one of the most promising candidates because of its highest theoretical capacity of ~4200 mAh g^{-1} for $Li_{4.4}Si$, low electrochemical potential (< 0.5 V vs Li^+/Li), low cost, and abundant in nature as well as mature mass production.[1-3]

2. EXPERIMENTAL SECTION

In this research, we use tetraethyl orthosilicate (TEOS), ethanol, distilled water, HCl at molar ratios of 1:2:2:0.01 and do as follows (1) TEOS mixed with ethanol (2) HCl solution was added to TEOS/ethanol under vigorous stirring (3) Heated at 80 ºC until the volume decreased to approximately 3/8 of the initial volume and the desired viscosity was reached. Finally, the solution was cooled down to room temperature, resulting in a viscous sol.[4] (4) Electrospinning at a needle with an inner diameter of 1.024 mm under the voltage of 22.5 kV with flow=1mL/h (Fig.1). (5) Coated in 2mg/mL dopamine solution overnight. Then we got the carbon-coated silica nanofiber and after that 1 g of the nanofiber and 1 g of the Mg powder were mixed and placed in a tube furnace filled with Ar. The furnace was then heated to 650 °C at a rate of 2 °C min^{-1} and was maintained at this temperature for 7 h. After that the MgO formed during the reduction process was removed by etching with HCl for 6 h, and the etched sample was washed several times with water and dried in vacuum at 60 °C overnight the result was showed in Fig.2, the obtained product was totally reduced to Si. The electrochemical measurements were carried out in CR2032 coin cells with Li foil as the counter electrode and 1M LiPF6 in 1:1 ethylene carbonate (EC) and dimethyl carbonate (DMC) as the electrolyte. The discharge and charge measurements were conducted on a Land CT2001A battery tester.

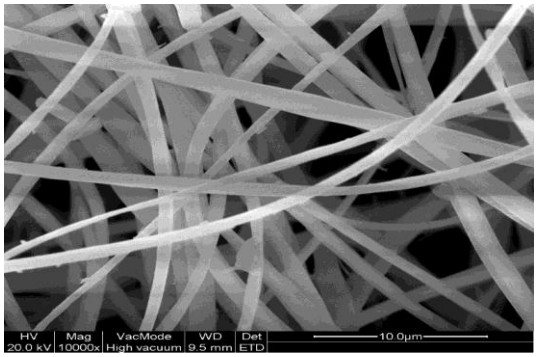

Figure 1. SEM images of electrospun silica nanofiber

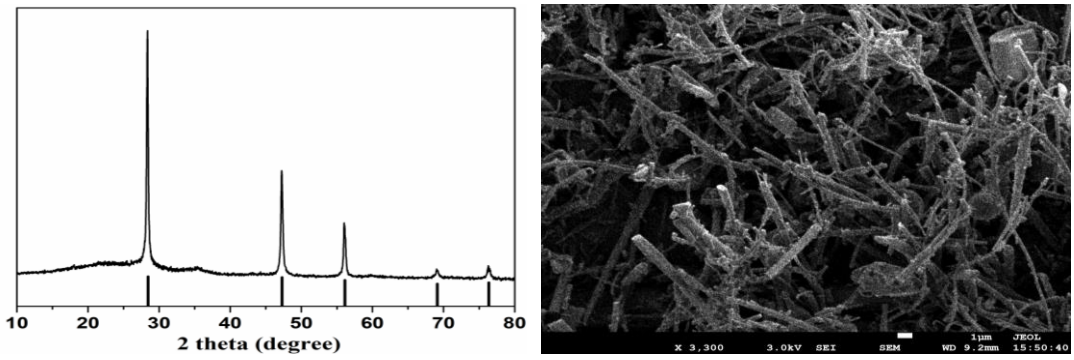

Figure 2. XRD pattern (Si PDF#27-1402) and SEM images of silicon nanofiber after reduction

3 RESULTS AND DISCUSSIONS

We successfully prepared silicon nanofibers using a simple technique involving electrospinning and the magnesiothermic reduction of silica. These SiNFs exhibited highly desirable electrochemical characteristics for use as an anode material for LIBs. The cells fabricated using these SiNFs showed a reversible capacity as high as 1000 mAh g^{-1} at a current density of 100 mAg^{-1}. The nanofibers coated with dopamine permit the fibers to not only accommodate large changes in volume during battery operation but also allow Li^+ ion greater access [5]. Moreover, given the scalable and facile nature of the synthesis procedure, these SiNFs can be exploited commercially as an anode material for LIBs.

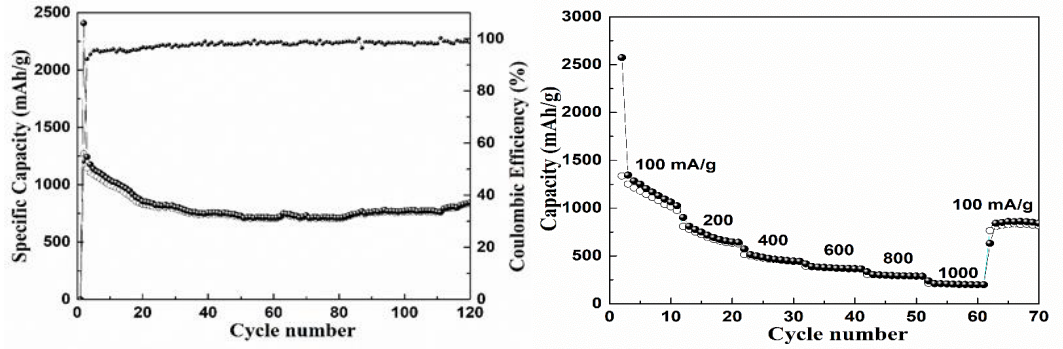

Figure 3. Cycling performance at 100 mAg^{-1} and rate capability of as-prepared SiNF

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