Synthesizing 3D graphene foam with direct etching for energy storage applications

Sakineh Chabi[1], Zhuxian Yang[1], Chuang Peng[1], Yongde Xia[1], Yanqiu Zhu*[1]

[1]College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter, Devon, UK
[2]Department of Chemical and Environmental Engineering, University of Nottingham Ningbo Campus, Ningbo, 315100 China
*y.zhu@exeter.ac.uk

Abstract

In this study, a general strategy for the synthesis of 3D graphene foams using chemical vapor deposition method and Nickel template was developed using a direct etching process. Large scale,4 cm^2, flexible graphene foams, without using PMMA or further acetone dissolving process, were obtained. The as-prepared graphene foam has a very high surface area (approaching theoretically maximum values and is higher than all reported values), and also shows a very low density of *ca*. 3 mg/ cm^3 which is believed to be originated from the robust interconnected 3D structures. All these features make it an excellent scaffold for 3D electrode in energy storage applications.
In a traditional architecture of energy storage devices, there is always a compromise between energy density and power density mainly due to the limitations of two dimension (2D) structure of the electrodes [1]. It is hoped that a 3D graphene-based structure could offer both high energy and power densities by providing short pathways for electron and ions.-1

The structural, morphological and performance of the resulting graphene foams were characterized and assessed by using SEM (Fig1), Raman spectroscopy (Fig2) EDX, TEM, cyclic voltammetry (CV) tests, OCP-time and A.C Impedance techniques.

After the complete removal of the nickel template, which was confirmed by EDX analysis and TGA test, the Raman spectroscopy study shows that the as-prepared samples are not made of a single layer graphene but consisted of a few layers of graphene sheets. The almost symmetric characteristics of the 2D (~2700 cm^{-1}) peak presented in Fig 2 confirm the graphene features of the samples [2]. In a graphite spectrum, a hump at the left side of 2D peak is normally visible [2].
The stability and cycleability of graphene foams were investigated by electrochemistry tests in a three electrode cell. The graphene foams were used directly as the working electrode, without using binder or other carbon additive. Binders such as PVDE are insulator and affect negatively the efficiency of the electrodes [3]. The tests revealed an excellent capacity retention and mechanical stability, even after 20000 cycles no capacity fading was observed. This capacity retention is attributed mainly to the strong interconnected 3D architecture, the hierarchical porous structure and large surface areas of the foam.

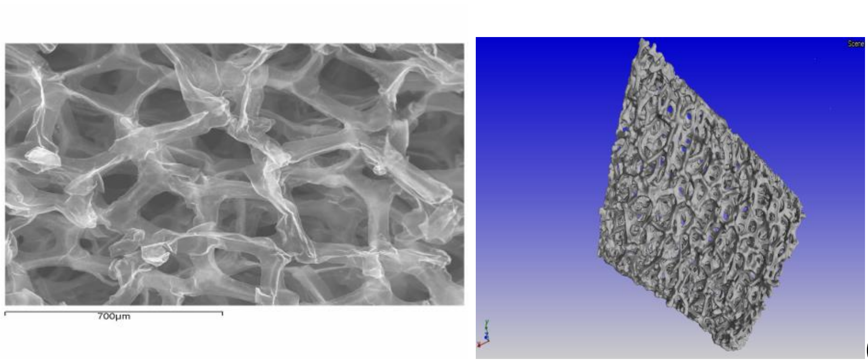
References

[1] J. W. Long , B. Dunn , D. R. Rolison , H. S. White , Chem. Rev. **104** (2004) 4463.

[2] Yu, Qingkai, et al. Applied Physics Letters **93** (2008) 113103.

[3]. J. Jiang , Y. Li , J. Liu , X. Huang , C. Yuan , X. W. Lou , Adv. Mater, **24** (2012) 5166

Figures



(b)

(a)

Figure 1: a,b SEM images of graphene foams.

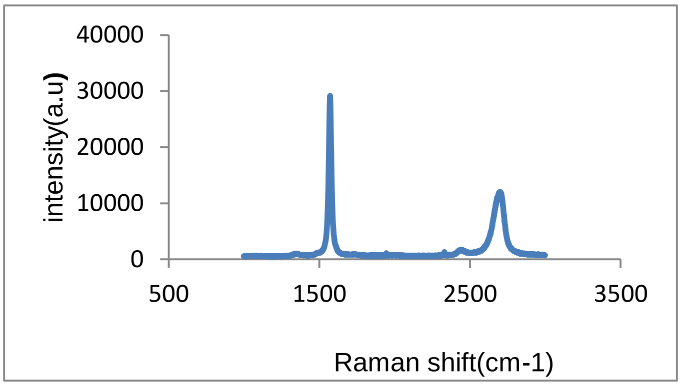


Figure 2 Raman spectroscopy of graphene foam.

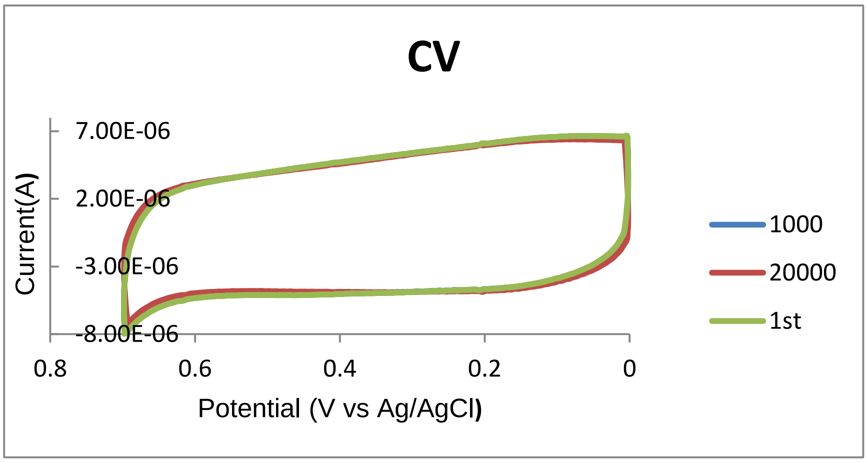


Figure 3 cyclic voltammetry of graphene foam in KCl solution.