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Short communication

Enhanced performance of multilayer graphene platelet film via three dimensional configuration with efficient exposure of graphitic edge planes

Ziyang Wang, Hongwei Ni *, Rongsheng Chen, Weiting Zhan, Chao Zhang, Rui Lei, Bowei Zhang

The State Key Laboratory of Refractories and Metallurgy, Wuhan University of Science and Technology, Wuhan 430081, China
Key Laboratory for Ferrous Metallurgy and Resource Utilization of Ministry of Education, Wuhan University of Science and Technology, Wuhan 430081, China

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ABSTRACT

Herein, we report a scalable strategy to fabricate a film of 3D multilayer graphene platelets by the carbonization of a polydopamine coating on a template of an aligned nanopore array formed by the electrochemical anodization on a stainless steel surface. The 3D graphene platelets possess a large number of exposed edge planes on the open ends as well as inner walls of the nanopores. The simultaneous voltammetric determination of uric acid (UA) and ascorbic acid (AA) has been demonstrated at the 3D multilayer graphene platelet film, with linear ranges of 50–2000 μM for AA and 5–500 μM for UA. Amperometric detection of dopamine illustrates a linear response in the range of 1–272 μM and a detection limit of 0.02 μM (S/N = 3).

1. Introduction

Development of high performance electrochemical sensors has become one of the most promising applications of graphene [1–3]. The apparent anisotropy in edge and basal plane is the fundamental issue to understand chemical and electrochemical behaviors of graphene based electrochemical sensors. The heterogeneous charge transfer rate constants, k^0, at graphene edge-planes are estimated to be ~10^7 times higher than those at basal-planes [4,5]. Therefore, there has been an exploration of interest to develop carbon nanomaterials with a large number of exposed edge planes for high performance electrochemical sensors [6–9]. Due to the inherent 2D structure of graphene sheets, the density of exposed edge planes is relatively low, which limits the electrochemical activity of graphene based electrodes. Moreover, a critical issue encountered in practical applications of graphene sheets is the irreversible aggregation or restacking of graphene into graphite, thus compromising the inherent structures and properties of graphene bulk materials [10,11]. Great efforts have been recently made to prepare 3D graphene architectures by various approaches such as by lithography [12], laser shock-induced shaping [13], chemical vapor deposition [14,15] and solvothermal reactions [16,17]. However, these techniques involve sophisticated instruments or lack the precisely controlled architecture and morphology required for the fabrication of 3D graphene structures. It is imperative to develop facile strategies to fabricate 3D graphene by scalable approaches with controllable architecture and morphology.

Recently, polydopamine (PDA) coatings have become an extremely attractive approach for single-step surface functionalization over a wide range of inorganic and organic materials [18–20]. The thickness of PDA coatings can be precisely controlled by adjusting the deposition conditions with a resolution of approximately 1 nm [21,22]. The resulting coating can serve as a versatile carbon precursor to produce uniform carbon films that resemble multilayer graphene [23–25]. We have described a scalable approach to obtain aligned nanopore arrays formed on a stainless steel surface by electrochemical anodization [26,27]. Herein, we report a facile strategy to fabricate scalable 3D multilayer graphene platelet films from PDA coatings on the template of aligned nanopore arrays on a stainless steel surface. The as-prepared 3D multilayer graphene platelet film has a large number of exposed edge planes and high specific surface area that can be easily accessed by molecules in the solution and thus has immense potential in biosensing applications, for example, simultaneous determination of uric acid (UA) and ascorbic acid (AA) under biological conditions.

* Corresponding author at: The State Key Laboratory of Refractories and Metallurgy, Wuhan University of Science and Technology, Wuhan 430081, China. Tel.: +86 27 68862856; fax: +86 27 68862811.
E-mail address: nihongwei@wust.edu.cn (H. Ni).

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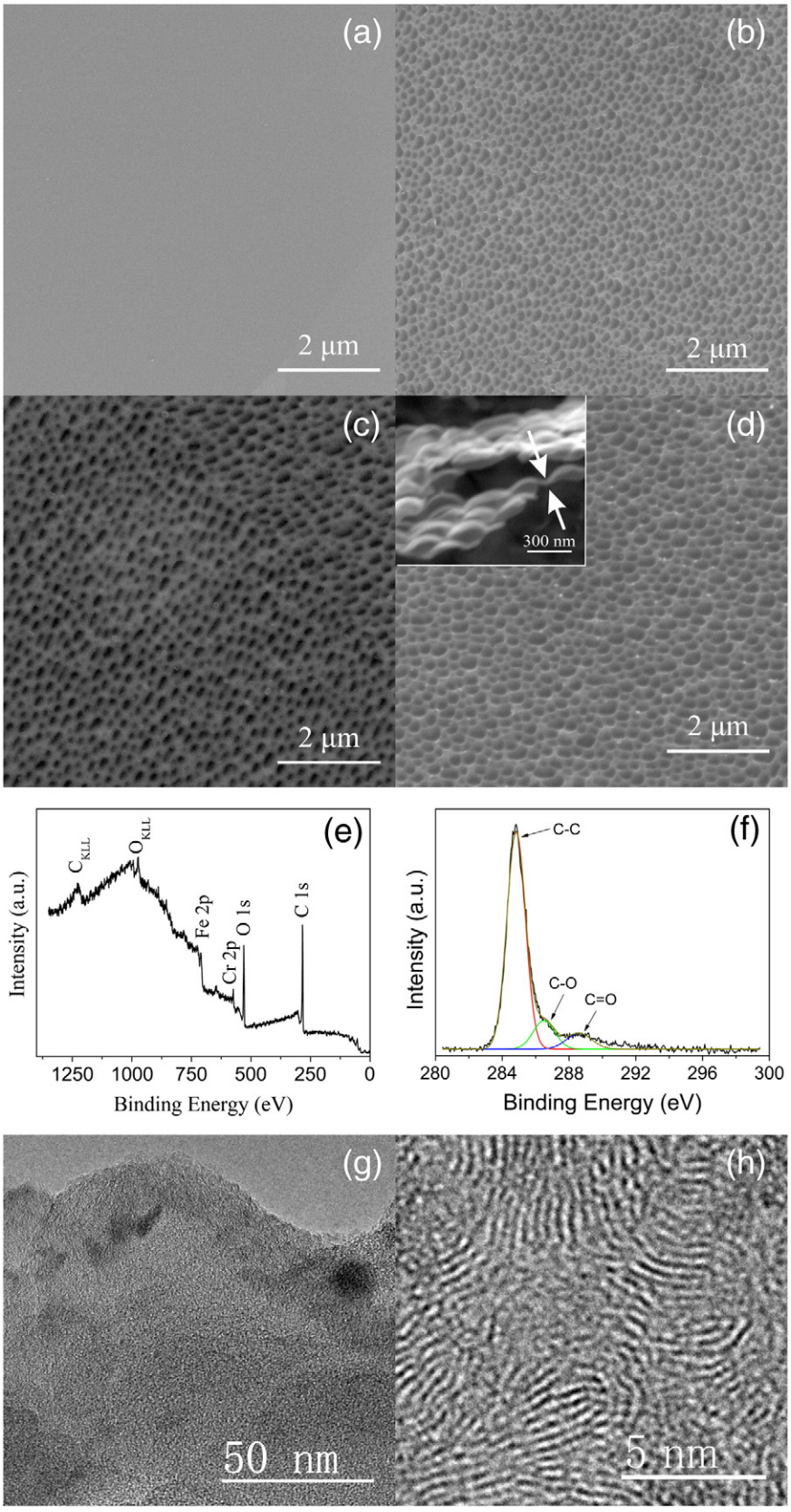

Fig. 1. SEM images of (a) electropolished stainless steel foil, (b) anodized foil, (c) PDA coated foil and (d) carbonized PDA film, XPS survey scan (e) and high resolution spectra for C 1s (f) of the carbonized PDA film, and TEM (g) and HR-TEM (h) images of the carbonized PDA film. The inset in (d) is the side view image of carbonized PDA film that peeled off the substrate.