SCIENTIFIC REPORTS

OPEN

Hierarchical Aerographite 3D flexible networks hybridized by InP micro/nanostructures for strain sensor applications

Received: 7 June 2018
Accepted: 29 August 2018
Published online: 17 September 2018

Irina Plesco[1], Julian Strobel[2], Fabian Schütt[2], Cameliu Himcinschi[3], Nabiha Ben Sedrine[4], Teresa Monteiro[4], Maria Rosário Correia[4], Leonid Gorceac[5], Boris Cinic[5], Veaceslav Ursaki[1], Janik Marx[6], Bodo Fiedler[6], Yogendra Kumar Mishra[2], Lorenz Kienle[2], Rainer Adelung[2] & Ion Tiginyanu[1]

In the present work, we report on development of three-dimensional flexible architectures consisting of an extremely porous three-dimensional Aerographite (AG) backbone decorated by InP micro/nanocrystallites grown by a single step hydride vapor phase epitaxy process. The systematic investigation of the hybrid materials by scanning electron microscopy demonstrates a rather uniform spatial distribution of InP crystallites without agglomeration on the surface of Aerographite microtubular structures. X-ray diffraction, transmission electron microscopy and Raman scattering analysis demonstrate that InP crystallites grown on bare Aerographite are of zincblende structure, while a preliminary functionalization of the Aerographite backbone with Au nanodots promotes the formation of crystalline In_2O_3 nanowires as well as gold-indium oxide core-shell nanostructures. The electromechanical properties of the hybrid AG-InP composite material are shown to be better than those of previously reported bare AG and AG-GaN networks. Robustness, elastic behavior and excellent translation of the mechanical deformation to variations in electrical conductivity highlight the prospects of AG-InP applications in tactile/strain sensors and other device structures related to flexible electronics.

Over the last few years, increasing attention has been paid to the development of flexible nanocomposite hybrid materials based on carbon aerogels decorated by semiconductor nanoparticles as next-generation nanomaterials for electronic, photonic and sensor applications. Carbon foams such as graphene aerogels (GA)[1] and Aerographite (AG)[2] represent promising scaffolds for the deposition of various solid-state nanoparticles, resulting in the formation of hybrid nanocomposite materials with flexible three-dimensional (3D) architectures. Recently 3D architectures of GaN and ZnO micro/nanocrystallites deposited on AG scaffolds have been proposed for micro- and nano-optoelectronic applications[3,4], in particular for the development of flexible broadband photodetectors covering the spectral range from ultraviolet to infrared[4]. Linking nanoparticles to highly porous 3D skeleton of GA or AG via chemical bonds might be very important for biomedical applications since it avoids nanoparticle agglomeration occurring in liquids[3]. When nanoparticles of electrostrictive semiconductors are deposited on GA/AG templates in the form of continuous nanocrystalline films, the resulting nanocomposites

[1]National Center for Materials Study and Testing, Technical University of Moldova, Stefan cel Mare av. 168, MD-2004, Chisinau, Republic of Moldova. [2]Institute for Materials Science, Kiel University, Kaiserstr. 2, D-24143, Kiel, Germany. [3]Institute of Theoretical Physics, TU Bergakademie Freiberg, Leipziger Str. 23, D-09596, Freiberg, Germany. [4]Department of Physics and I3N, Institute for Nanostructures, Nanomodelling and Nanofabrication, University of Aveiro, P-3810-193, Aveiro, Portugal. [5]Department of Physics and Engineering, State University of Moldova, Alexei Mateevici str. 60, MD-2009, Chisinau, Republic of Moldova. [6]Institute of Polymers and Composites, Hamburg University of Technology, Denickestr. 15, D-21073, Hamburg, Germany. Correspondence and requests for materials should be addressed to L.K. (email: lk@tf.uni-kiel.de) or R.A. (email: ra@tf.uni-kiel.de) or I.T. (email: tiginyanu@asm.md)