SCIENTIFIC REPORTS

OPEN

SUBJECT AREAS:
ORGANIC-INORGANIC NANOSTRUCTURES
MECHANICAL AND STRUCTURAL PROPERTIES AND DEVICES
SELF-ASSEMBLY

Received
15 September 2014

Accepted
6 February 2015

Published
6 March 2015

Correspondence and requests for materials should be addressed to Y.K.M. (ykm@tf.uni-kiel.de); R.A. (ra@tf.uni-kiel.de) or I.T. (tiginyanu@asm.md)

Three-dimensional Aerographite-GaN hybrid networks: Single step fabrication of porous and mechanically flexible materials for multifunctional applications

Arnim Schuchardt[1], Tudor Braniste[2,3,4], Yogendra K. Mishra[1], Mao Deng[1], Matthias Mecklenburg[5], Marion A. Stevens-Kalceff[6], Simion Raevschi[2,3,4], Karl Schulte[5], Lorenz Kienle[1], Rainer Adelung[1] & Ion Tiginyanu[2,3,4]

[1]Institute for Materials Science, Christian Albrechts University of Kiel, Kaiserstr. 2, D-24143 Kiel, Germany, [2]National Center for Materials Study and Testing, Technical University of Moldova, Chisinau, Republic of Moldova, [3]Department of Physics and Engineering, State University of Moldova, Chisinau, Republic of Moldova, [4]Institute of Electronic Engineering and Nanotechnologies, Academy of Sciences of Moldova, Chisinau, Republic of Moldova, [5]Institute of Polymers and Composites, Hamburg University of Technology, Denickestr, 15, D-21073 Hamburg, Germany, [6]School of Physics, University of New South Wales, NSW 2052 Sydney, Australia.

Three dimensional (3D) elastic hybrid networks built from interconnected nano- and microstructure building units, in the form of semiconducting-carbonaceous materials, are potential candidates for advanced technological applications. However, fabrication of these 3D hybrid networks by simple and versatile methods is a challenging task due to the involvement of complex and multiple synthesis processes. In this paper, we demonstrate the growth of Aerographite-GaN 3D hybrid networks using ultralight and extremely porous carbon based Aerographite material as templates by a single step hydride vapor phase epitaxy process. The GaN nano- and microstructures grow on the surface of Aerographite tubes and follow the network architecture of the Aerographite template without agglomeration. The synthesized 3D networks are integrated with the properties from both, i.e., nanoscale GaN structures and Aerographite in the form of flexible and semiconducting composites which could be exploited as next generation materials for electronic, photonic, and sensors applications.

Nanoscale structures from different semiconductors have played an important role in the development of modern technological devices because of their exceptional physical and chemical properties[1–4]. Particularly nano- and microstructures based on GaN are extremely promising candidates for the next generation nanoelectronic, nanopiezotronic, and photonic devices[3,5–7], light emitting diodes and lasers[8–10], chemical and bio-sensors[11]. Recently reported phenomena like water splitting have also opened opportunities for their utilization for renewable energy resources[1,7–8,12–14]. Important features like direct and wide bandgap (~3.4 eV at room temperature), high mechanical stability, and large electrical/thermal conductivity promote GaN nano- and microstructures for numerous other challenging applications[15–17]. Being technologically a very important material, various synthesis techniques have been utilized for versatile growth of different GaN nano- and microstructures[18–22]. However, almost all of these structures are based on one or two dimensional epitaxially grown architecture, e.g., nanorods, nanowires, nanotubes etc. and their arrays on particular substrates[2,10,23–25]. In the case of epitaxial growth, the requirement of single crystalline substrates with fitting lattice parameters limits the choice and size of substrates and hence the production of large quantities of GaN nano- and microstructures. Although there exist several techniques which enable the growth of various GaN nano- and microstructures, their appropriate integration with externally associated devices is a highly challenging task when it comes to real applications[26]. Multistep processes, for example synthesis followed integration, have been applied to fabricated nanostructures based devices but this approach is very time consuming and equally expensive. In order to overcome these issues, either direct growth of semiconductors on the desired substrates/chips[27–28] or the fabrication of large 3D interconnected networks made from these nano- and microstructures building blocks must be realized by appropriate techniques[29–31]. Such three dimensionally interconnected network structures exhibit all