Nano Energy 57 (2019) 903–910

Contents lists available at ScienceDirect

Nano Energy

journal homepage: www.elsevier.com/locate/nanoen

Full paper

High humidity- and contamination-resistant triboelectric nanogenerator with superhydrophobic interface

Qitao Zhou[a], Kyunghun Lee[a], Kyeong Nam Kim[b], Jun Gyu Park[a], Jing Pan[c], Juyeol Bae[a], Jeong Min Baik[b,*], Taesung Kim[a,d,**]

[a] Department of Mechanical Engineering, Ulsan National Institute of Science and Technology (UNIST), 50 UNIST-gil, Ulsan 44919, Republic of Korea
[b] School of Materials Science and Engineering, KIST-UNIST Ulsan Center for Convergent Materials, Ulsan National Institute of Science and Technology, Ulsan 44919, Republic of Korea
[c] School of Chemistry and Chemical Engineering, Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology (HUST), 1037 Luoyu Road, Wuhan 430074, PR China
[d] Department of Biomedical Engineering, Ulsan National Institute of Science and Technology (UNIST), 50 UNIST-gil, Ulsan 44919, Republic of Korea

ARTICLE INFO

Keywords:
Particle lithography
Superhydrophobicity
Self-cleaning property
Triboelectric nanogenerator

ABSTRACT

Triboelectric nanogenerators (TENGs) have been widely used in the recent years to harvest and convert mechanical energy to electrical energy. With the improved performance of TENGs, their stability and robustness in harsh environments have attracted increasing attention as a next challenge. We present herein a superhydrophobic interlayer-integrated TENG that exhibits high performance against humidity and environmental contamination. We used particle lithography to prepare a superhydrophobic interlayer with a three-dimensional (3D), hierarchical, porous pattern, resulting in a high static water contact angle of 161°. This 3D, hierarchical superhydrophobic interlayer played a key role in improving the TENG output performance. In addition, the TENG not only retained up to 86% of its initial electrical output at a high relative humidity of 80%, but also recovered much faster than a TENG with a regular flat interface under the same wet conditions. Finally, we found that the TENG was very robust against external contamination, maintaining approximately 88% of the initial output after five cycles of particulate contamination and washing in water, indicating that the TENGs with a superhydrophobic, 3D, hierarchical interlayer could be used for powering Internet-of-things devices that are exposed to harsh environments, such as highly humid ones with dense particulate matters.

1. Introduction

Harvesting energy from renewable and clean energy sources, for example heat, light, and vibration in the surrounding environment of our daily life, is the primary approach to address the growing global energy issues and realize self-powered systems. Among different energy harvest devices, triboelectric nanogenerators (TENGs) have been developed for mechanical to electrical energy conversion. Thus, TENGs are effective for harvesting vibrations or mechanical energy in our ambient environment to drive low-power consumption systems/devices [1–8]. The output performance and energy conversion efficiency of TENGs have drastically improved over the past few years because of the advances in the development of micro- and nanoscale fabrication technology. For example, polyethylene terephthalate (PET) [9] or polyvinyl chloride (PVC) [10] with rough surfaces were achieved by inductive-coupled plasma etching and porous polydimethylsiloxane (PDMS) interlayers were fabricated with the assistance of cube sugar [11] or polystyrene (PS) particles [12] as templets. In addition, molecular surface functionalization [13] and mechanical device design [14,15] have been developed to improve the performance of TENGs. Recently, stable and robust TENGs have been produced, and have attracted increasing attention. For example, a self-healing TENG has been achieved by using a shape-memory polymer, showing that the performance can recover from the morphological damages caused by a high

Abbreviations: FE-SEM, field-emission scanning electron microscope; IoT, Internet of Things; ITO/PET, indium–tin oxide/polyethylene terephthalate; PDMS, polydimethylsiloxane; PS, polystyrene; PTFE, poly-tetrafluoroethylene; SCA, static contact angle; TENG, triboelectric nanogenerator; UV, ultraviolet

* Correspondence to: School of Materials Science and Engineering, KIST-UNIST-Ulsan Center for Convergent Materials, Ulsan National Institute of Science and Technology (UNIST), Ulsan 689-798, Republic of Korea.
** Corresponding author at: Department of Mechanical Engineering, Ulsan National Institute of Science and Technology (UNIST), 50 UNIST-gil, Ulsan 44919, Republic of Korea.
E-mail addresses: jbaik@unist.ac.kr (J.M. Baik), tskim@unist.ac.kr (T. Kim).

https://doi.org/10.1016/j.nanoen.2018.12.091
Received 19 November 2018; Received in revised form 21 December 2018; Accepted 30 December 2018
Available online 04 January 2019
2211-2855/