Nanotechnology 28 (2017) 055402 (8pp) doi:10.1088/1361-6528/28/5/055402

High voltage generation from lead-free magnetoelectric coaxial nanotube arrays and their applications in nano energy harvesters

C S Chitra Lekha[1], Ajith S Kumar[1], S Vivek[1], U P Mohammed Rasi[1], K Venkata Saravanan[2], K Nandakumar[3] and Swapna S Nair[1]

[1] Department of Physics, Central University of Kerala, Kasaragod, Kerala-671314, India
[2] Department of Physics, Central University of Tamil Nadu, Thiruvarur, Tamil Nadu-610101, India
[3] School of Pure and Applied Physics, Mahatma Gandhi University, Kottayam, Kerala-686560, India

E-mail: swapna.s.nair@gmail.com

Received 23 July 2016, revised 26 October 2016
Accepted for publication 2 November 2016
Published 23 December 2016

Abstract

Harvesting energy from surrounding vibrations and developing self-powered portable devices for wireless and mobile electronics have recently become popular. Here the authors demonstrate the synthesis of piezoelectric energy harvesters based on nanotube arrays by a wet chemical route, which requires no sophisticated instruments. The energy harvester gives an output voltage of 400 mV. Harvesting energy from a sinusoidal magnetic field is another interesting phenomenon for which the authors fabricated a magnetoelectric energy harvester based on piezoelectric–magnetostrictive coaxial nanotube arrays. Piezoelectric $K_{0.5}Na_{0.5}NbO_3$ (KNN) is fabricated as the shell and magnetostrictive $CoFe_2O_4$ (CFO) as the core of the composite coaxial nanotubes. The delivered voltages are as high as 300 mV at 500 Hz and at a weak ac magnetic field of 100 Oe. Further tailoring of the thickness of the piezoelectric and magnetic layers can enhance the output voltage by several orders. Easy, single-step wet chemical synthesis enhances the industrial upscaling potential of these nanotubes as energy harvesters. In view of the excellent properties reported here, the lead-free piezoelectric component (KNN) in this nanocomposite should be explored for eco-friendly piezoelectric as well as magnetoelectric power generators in nanoelectromechanical systems (NEMS).

S Online supplementary data available from stacks.iop.org/NANO/28/055402/mmedia

Keywords: magnetoelectric multiferroics, piezoelectrics, energy harvesters, sol-gel method

(Some figures may appear in colour only in the online journal)

1. Introduction

Energy harvesting technologies have been attracting the attention of researchers over the last decade, for their potential applications in low power-consumption electronic devices at the sub-micron scale [1, 2]. Since the mechanical vibrations in the surroundings are abundant sources of renewable energy, research into harvesting this energy is making headway. Piezoelectric energy harvesters [3] can effectively convert mechanical vibrations into electrical energy, which make them promising in the areas of wireless sensors and low power electronics. The ease of integration of material structures into devices makes these piezoelectric energy harvesters viable for integrated devices. One-dimensional (1D) nanostructures, especially free standing vertical nanowires and nanotubes, emerged as the major component of many nanoelectromechanical systems (NEMS) [4] owing to their high electromechanical responses to weak random disturbances in their

