Journal of ELECTRONIC MATERIALS, Vol. 42, No. 5, 2013
DOI: 10.1007/s11664-012-2421-y

Formation of Nanodimensional 3C-SiC Structures from Rice Husks

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We have demonstrated that large quantities of β-SiC nanostructures can be obtained from rice husk agricultural waste by using controlled conditions in a thermogravimetric setup. This simple and inexpensive method of producing these structures on a large scale is critical for applications in nanoelectronics, nanosensors, and biotechnology. The temperature and atmosphere are two critical elements in forming either α-cristobalite (SiO_2) or β-SiC. Using different characterization methods (x-ray diffraction, scanning electron microscopy, transmission electron microscopy, and Raman spectroscopy), we have shown that pyrolysis of rice husks in argon atmosphere at 1375°C results in simultaneous formation of carbon nanotubes, β-SiC nanowires/nanorods, and β-SiC powder.

Key words: β-SiC, nanorods, rice husk, nanotubes

INTRODUCTION

Rice consumption is increasing globally, and consequently a large quantity of rice husks is generated during the production of edible rice. India alone is estimated to generate over 20 million tons of rice husks per year.[1] These husks are considered to be agricultural waste and are typically disposed of via incineration, which creates air pollution in the form of ash and fine silica particles that are toxic.[2] There is no current technology to eliminate the silica particles, thus incineration is not a safe method of disposal of rice husk biomass. However, the presence of carbon and silica provides an opportunity to inexpensively produce silicon carbide (SiC). It was reported by Cutler that the byproducts of a careful burnout procedure contained fine SiC particles along with SiC whiskers that were microns thick.[3,4] However, Cutler's process, along with others that have been subsequently developed, is at least a two-step process involving removal of volatiles at a lower temperature and a high-temperature reaction step. Several methods have been used to work around this restriction, such as acid treatments[5] and the use of an argon plasma reactor,[2] to reduce this to a one-step process. These processes, however, are expensive and usually produce whiskers of large diameter, which are more useful for the abrasive industry. On the other hand, SiC nanowires and nanorods have attracted a lot of interest because of their novel physical properties resulting from quantum confinement. The electrical and optical properties of low-dimensional nanostructures can be tailored for potential applications in nanoelectronics, nanosensors, and biotechnology. However, in all of these applications, large quantities of SiC nanostructures are needed and must be produced using an inexpensive and simple method. Therefore, currently, a large quantity of rice husks is available to produce SiC for the electronics industry, but there is no inexpensive way of producing it. This paper discusses a simple method of converting rice husks to SiC nanorods and nanowires to produce sufficient quality and quantity of nanostructures to characterize optical and electrical properties. This method is easily scalable to produce nanostructures on a manufacturing scale.

EXPERIMENTAL PROCEDURES

Rice husk was obtained from Orissa, India. The husk was milled into fine powder using a SPEX jar

(Received July 31, 2012; accepted December 27, 2012; published online February 9, 2013)