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Erbia-Tio2 nanofibers using electrospinning technique for Thermophotovoltaic Applications

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Abstract - Electrospinning has been recognized as a feasible process for fabrication of continuous fibers with diameters ranging from several micrometers down to a few nanometers. This paper presents an overview of current progress in functional polymeric nanofibers prepared by electrospinning. TiO_2 nanofibers were prepared by the process as mentioned above and characterized with X-Ray diffraction, Scanning electron microscopy and Raman Spectroscopy. The well-defined crystalline structure was obtained after calcined at 500 °C for 3 h and it was used to pyrolyse the PVP. Erbium (III) oxide particles were also added into the solution before the electrospinning process and selectively modified the near-infrared optical properties of the titania nanofibers as verified by both absorption and emission spectra.

The average diameter of these nanofibers was in the range from 40 to 400 nm depending on titania precursor. Temperature-dependent near-infrared emission spectra demonstrate that the erbia-containing nanofibers emit selectively in the range 6000–7000 cm^{-1}. Because of the large surface to volume ratios and optical emission in narrow-band range, these nanofibers can be used for selective emission in thermophotovoltaic applications.

Keywords: Titanium oxide, electrospinning, nanofibers, Thermophotovoltaic;

1.INTRODUCTION

Thermophotovoltaic (TPV) effects provide the basis for a promising energy conversion technology for the production of electricity from the infrared (IR) light radiated by a heated emitter. An idealized TPV system is comprised of a source of thermal energy which heats the emitter and an IR photovoltaic (PV) cell which absorbs the light and produces electricity. This technology is ideally suited for power generation in space and is a viable candidate for cogeneration schemes in other situations. Emitters should be isothermal and produce light that can be efficiently absorbed by the PV cells.

A prototypical selective emitter is a trivalent rare earth ion, such as erbium 3+ which emits light in the wavelength range from 1 to 1.5 microns. TPV devices are presently in an emerging state of development. Nanofibers provide routes to better designs and manufacturing methods.

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A photovoltaic cell made of InGaAs is the most efficient converter of light to electricity in this wavelength range.

It is advantageous to utilize the erbium ion emission since all available photovoltaics are inefficient at the longer wavelengths where the black body radiation is a maximum.

Waste heat, in the form of hot gas, heats a selective emitter, which radiates with greater than black body intensity at particular wavelengths. The emitted radiation in this intense band is converted to electrical energy by an efficient photodiode.

In this paper, Erbia modified Titania nanofiber was fabricated by electrospinning followed by the calcination process. Erbium is the candidate selective emitter for GaSb cells. Titania is transparent in the near-IR regions where erbia emits, and is also thermally stable at the temperatures of interest here. The goal of this work is to demonstrate the synthesis and characterization of high-temperature nanofiber materials with optical properties tailored for TPV applications. Scanning electron microscopy (SEM), X-ray diffraction (XRD), and the IR-Emission Spectroscopy of the titania nanofibers are presented. The selective near-IR emission of heated erbia-doped titania nanofibers and Their TPV applications are discussed.

2. EXPERIMENTS

MATERIALS

Poly(vinylpyrrolidone) (PVP; Mw = 13,00,000 g/mol), Anhydrous ethanol (AR) and tetrabutyl titanate (TBT) were purchased from Vijaya Scientific Company, Thuraipakkam, Chennai, Ltd. All the materials were used as received, without further purification.

PREPARATION of Er DOPED TiO_2 NANOFIBERS

The nanofibers were prepared by electrospinning a solution containing XXXXX of tetrabutyl titanate, XXXX of acetic acid, XXX g of poly(vinyl pyrolidone) (PVP, Mw $\approx$ 1.3×10^6), and XXX ml of ethanol. After stirring for 3 h, 0.0142 g Er III oxide particles were added into the above solution under vigorous stirring to form a transparent solution for electrospinning.

The electrospinning setup consisted of a syringe and needle, a ground electrode and a high voltage supply. The applied voltages were set at 20 kV with a tip-to-collector distance of 15 cm. After electrospinning, the composite nanofibers were then calcined in air at 773 K for 3 h to obtain 0.5 mol% Er:TiO2 films. The pure TiO2 nanofibers were prepared according to the above procedure without adding Er III oxide particles.

3. Results and Discussion

XRD Patterns

Figure 1 shows that the XRD patterns of the as-prepared samples calcined at 500 ^oC for 3 hours in air atmosphere. The peaks shown in the XRD patterns correspond to the (101), (103), (004), (112), (200), (105), (211), (204), (116), (220) and (215) planes of TiO2 tetragonal anatase phase. These patterns can be well indexed to tetragonal anatase (JCPDS No. 89-4921), space group: I41/amd(141)). No peaks of brookite or rutile phase were detected, which indicate the high purity of the as-prepared samples.

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According to the calculation results, the average crystall ite sizes of the samples were 12.86, 14.56,18.85,24.215 nm, respectively.

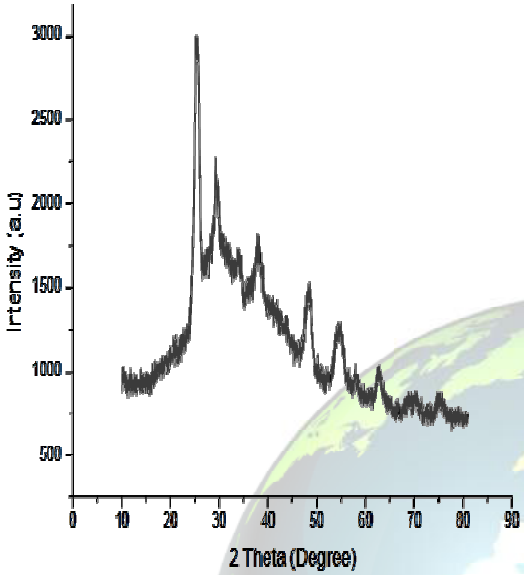

Figure 1. XRD patterns of the Er doped titania nanofiber calcined at 500 °C

SEM IMAGES

Figure a shows that the nanofibers have the diameter in the range from 40-400 nm and figure b shows that the encapsulation of erbia particles which should lead to excellent thermal equilibration, also desirable for selective emitter development.

Figure: SEM images 2(a) Er doped TiO_2 nanofiber calcined at 500 °C with various dimensions 2(b) shows that larger erbia particles are encapsulated within Titania nanofibers.

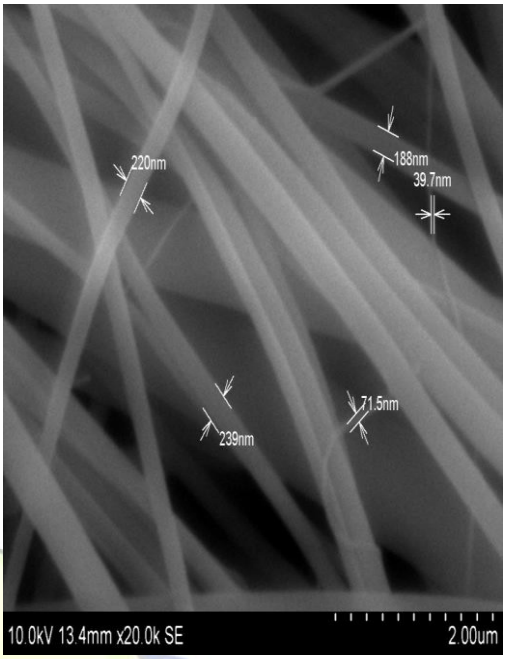

Figure 2(a) Er doped TiO_2 nanofiber calcined at 500 °C with various dimensions.

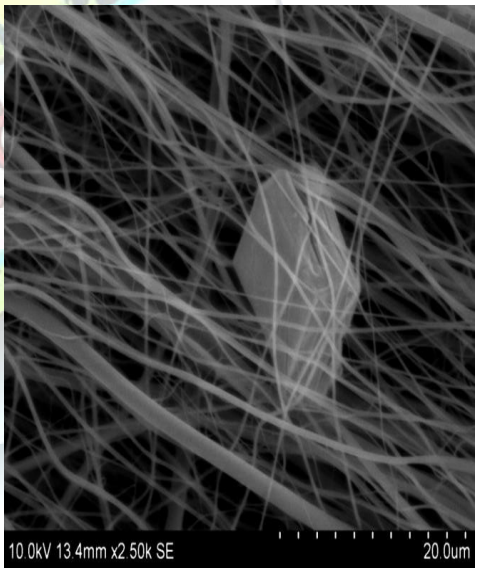

Fig 2 (b) Larger erbia particles are encapsulated within Titania nanofibers.

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RAMAN SPECTRUM

The following diagram represents the Raman spectrum of the erbium doped titania nanofiber. It has the peak around 1500 and 600 cm^{-1}. The response below 500 cm-1 will be more sensitive to the photo voltaic application. The Erbia doped titania nanofiber has the peak below 500 which is more suitable to the photo voltaic application.

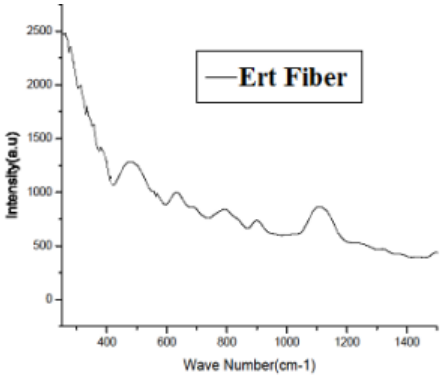

Figure 3 Raman spectrum of ERT Nanofiber

4. CONCLUSION

In this work, erbia doped titania nanofibers were synthesized by electrospinning and after annealing, the nanofibers were characterized by SEM, XRD and Raman spectroscopy. We demonstrated that we can control the diameters of the nanofibers by adjusting the pre-cursor solution, and that we can alter their crystal structure by annealing to different temperatures. The Erbia doped titania nanofiber has the peak below 500 which is more suitable to the photo voltaic application. The large surface to volume ratio, good thermal stability, and narrow-band emission properties of these nanofibers make them candidate selective emitter materials for thermophotovoltaic applications. The data presented here indicate that nanofiber electrospinning provides a new approach to enabling TPV systems that use selective emitter materials.

REFERENCES

1. Asmatulu, R. "Nanomaterials fabrication and characterization–class notes," Wichita State,2004.
2. Callister, W.D. "Materials Science and Engineering An Introduction–7th Edition," Wiley, 2007.
3. Charles P. Poole, Jr., Charles P. Poole and Frank J. Owens "Introduction to Nanotechnology," Wiley, 2003.
4. David Brandon and Wayne D Kaplan "Micro structural Characterization of Materials," John,2006.
5. Giuseppe Pezzottib, Gualtiero Gusmanoa Ilaria Cacciotti, Alessandra Biancoa" Synthesis, thermal behavior and luminescence properties of rare earth-doped titania nanofibers" Chemical Engineering Journal 166 (2011) 751–764.
6. Guozhong Cao "Nanostructures and Nanomaterials, Synthesis, Properties and Applications," 2004.
7. http://www.wikipedia.electrospinning/
8. http://www.eduprograms.david.pdf//
9. http://www.google.com//.
10. V. Tomera, R. Teye-Mensaha, J.C. Tokasha, N. Stojilovica,b,W. Kataphinanc, E.A. Evansd, G.G. Chased, R.D. Ramsiera,D.J. Smithb, D.H. Renekerc "Selective emitters for thermophotovoltaics: erbia-modified electrospun titania nanofibers" Energy Materials & Solar Cells 85 (2005) 477–488.