Al/CuFeS2/ITO BEHAVES LIKE SWITCH DEVICE WITH NEGATIVE DIFFERENTIAL RESISTANCE

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Abstract

Semiconducting $CuFeS_2$ nanoparticle has been synthesized by hydrothermal technique. Its special physical and electronic properties through the nanostructures make it a promising material for versatile device application. Here a thin film device of configuration Al/$CuFeS_2$/ITO has been fabricated, which behaves like a resonant tunneling device. The device shows a negative differential resistance at room temperature. The characteristic of this portable device discloses its probable applicability in solid-state switch.

Keywords: *$CuFeS_2$; Nanomaterial; Synthesis; Characterization; Resonance tunneling; Negative resistance.*

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1. INTRODUCTION

Currently the nonlinear current-voltage characteristic of Metal-semiconductor junctions explores the field of electronics as well as creates a great interest to several researchers and scientists.For almost all semiconductors based electronic devices, the reliable and well-controlled contacts are needed. Metal–semiconductor junctions serve the purpose in the form of barrier diodes [1]. The structural property of such metal-semiconductor junction plays a vital role in the device performance [2] and is the most widely used in semiconductor electronic devices, such as field effect transistors, solar cells and photodetectors etc. [3, 4]. Moreover another interesting sandwich structure metal/semiconductor/metal junctions reveal overriding current-voltage characteristics with the new concept of negative differential resistance. Standard applications of the kind of effect include use in ultra-fast pulse forming, radiation detection and signal generation system. In semiconductor device one of the responsible mechanisms for the negative resistance effect is resonant tunneling. This differential resistive behavior in conventional semiconductor based resonant tunnel diode has been tuned by modifying the materials, dopant concentration and the physical configuration of the device. Several reports have examined the relationship between negative differential resistance and electro activity in organic and inorganic systems. However, control of parameters governing negative differential resistance behavior in inorganic semiconductor material is just beginning to be explored experimentally and theoretically.

It is extremely important to study the interface properties for better understanding of the electrical properties of the metal-semiconductor junction that mainly control the performance of the junction diode [4–6]. In general, the physical properties of the metal/semiconductor interface depend on the surface preparation methods, which ultimately affect the performance, electrical properties, stability and reliability of the metal-semiconductor based devices [7, 8]. A resonant tunnel diode consists of a quantum well separated from two electrical contacts by two tunnel barriers. In resonant tunneling, the tunnel barriers control the probability of electrons moving from one electrode to the other through the quantum well. In conventional semiconductor based resonant tunnel diode, NDR behavior has been tuned by modifying the materials. However, control of parameters governing NDR behavior in inorganic semiconductor material is just beginning to be explored experimentally. Here for the first time we obtained the resonant tunneling of charge carrier and NDR behavior for the sandwich structured ITO/$CuFeS_2$/Al. In this article the electrical behavior of the sandwich structureITO/$CuFeS_2$/Alhave been illustrated aptly. In this art of work a new kind of $CuFeS_2$nanomaterial have been derived by hydrothermal technique. The underneath mechanism for the occurrence of such phenomena is illustrated on the focus of resonant tunneling, quantitatively.

2. EXPERIMENTAL SECTION

2.1. Materials and Synthesis

In typical synthesis of $CuFeS_2$ nanomaterial, a mixture of 10 ml of 0.1M $FeCl_3$ and 10 ml of 0.1M $CuCl_2$ was taken into a glass beaker. By continuing stirring technique solution of 0.1N Na_2S solution was added drop wise with this mixture till a dark brown precipitate (ppt) was obtained. Few drops of PVP [poly(vinyl-pyrrolidone)] were added as surfactant with the above mixture and stirred during precipitation (ppt). All the chemical reactions were carried out in open atmosphere. After collecting the ppt, it was transferred to a linear Teflon autoclave and was heated through overnight at temperature 140^0C. The baked ppt was collected and washed with ethanol and distilled water repeatedly and sequentially by centrifuge technique. The powder form of the synthesized material was collected and used for characterization by heating at 100^0C inside a vacuum oven.