Research Paper

Synthesis of CTAB Assisted Nanocrystalline $BiFeO_3$ as Acetone Sensor

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Abstract

The eect of CTAB addition on acetone sensing properties of $BiFeO_3$ (BFO) multiferroic semiconductor are investigated in this report. The material was synthe-sized by simple glycine combustion method. The sintered sample was studied by X-ray diraction analysis (XRD), Scanning Electron Microscope (SEM) and element com-position of material was determined by using EDAX. The experimental results indicate that the sensor based on the sample BFO/CTAB shows excellent gas sensing properties towards acetone gas at lower operating tem-perature. The response of the BFO/CTAB sample is 90 for acetone gas; while to other test gases the response is lower than 50. With increasing concentration of acetone, the resistance of the sensor based on sample BFO/CTAB increases. The response and recovery times of the sample towards acetone gas are 20 sec and 45 sec.

Keywords: $BiFeO_3$, Glycine combustion method, Gas Sensor .

1 Introduction

In recent years, a rhombohedrally distorted perovskite type BFO have been investigated for the multiferroic properties. Due to the interesting physical properties of BFO, it acts as a potential candidate for future techno-logical applications [1, 2, 3]. For the formation of BFO nanoparticles we adopted the time consuming glycine combustion technique. Here, we discuss the eect of sur-factant cetyltrimethylammonium bromide (CTAB) on the structural, morphological and gas sensing properties of BFO.

2 Experimental Details

For the facile synthesis of BFO nanoparticles $Fe(NO_3)_3$ $9H_2O$, Bi $(NO_3)_3$ $5H_2O$ and glycine were used as starting materials. Then a cationic surfactant cetyltrimethylammonium bromide (CTAB) was added to the solution with molar ratio of surfactant/Bismuth: 0.1. This mixture was dissolved in 100ml distilled water with vigorous magnetic stirring for 30min. at 70 C constant temperature. While another solution without surfactant was also prepared. The precursor solution was kept on the heater, which undergoes a ameless combustion and the uy foam of our nal product was obtained. The grinded calcined powder was used for the pellet forma-tion. The nal pellet samples are sintered at 550 C and silver contacts are drawn from it for the measurement of gas sensing properties.

3 Results and Discussion

X-ray diraction (XRD) pattern revealed that pure BFO samples have rhombohedral structure with some sec-ondary phases like $Bi_2Fe_4O_9$ [1], where as the CTAB as-sisted BFO samples show hexagonal phase without sec-ondary phases as shown in Figure 1. The XRD patterns show the diraction peaks corresponding to rhombohedral structure and hexagonal phase which match well with the JCPDS card No. 71-2494 [2].

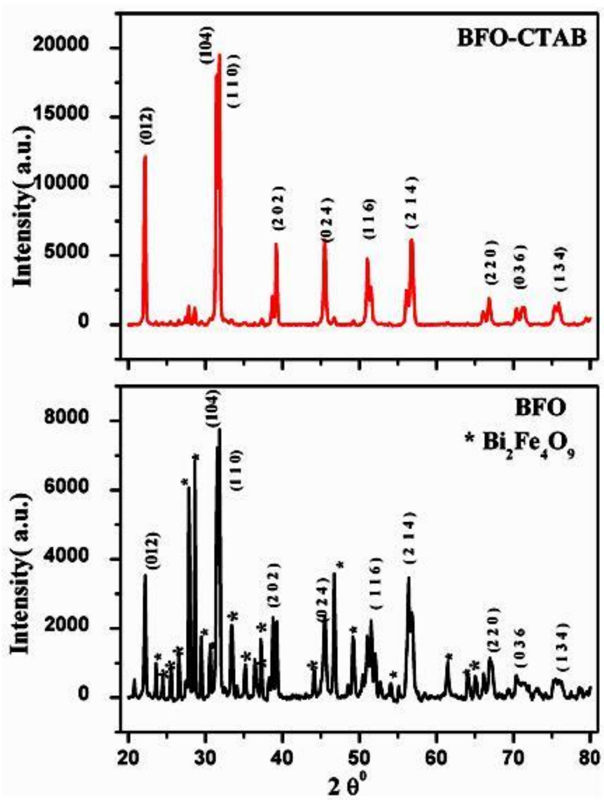

Figure 1: XRD pattern of BFO and BFO-CTAB sintered at 550 C.

Scanning electron microscope (SEM) images shows the agglomeration of small particles having irregular shape, size and porous structure, which forms the non uniform grains. A change in porosity provides more surface area for gas adsorption and hence, it exhibits enhanced gas sensing properties.

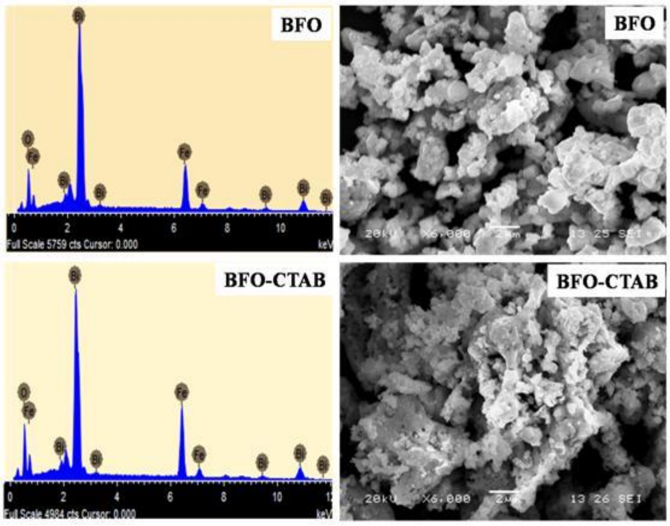

Figure 2: EDAX and SEM images.

Electron diraction spectrum (EDAX) spectrum shows the conrmation of elemental composition which is shown in Figure 2. The reducing gases were tested on the CTAB assisted BFO sample for gas sensing properties (Figure 3). The response of reducing gas is determined by [3]:

$$S(\%) = [\frac{R_g \quad R_a}{R_a}] \; 100$$

Where, R_a is resistance of sensor in air and R_g resis-tance after the exposure of test gas.

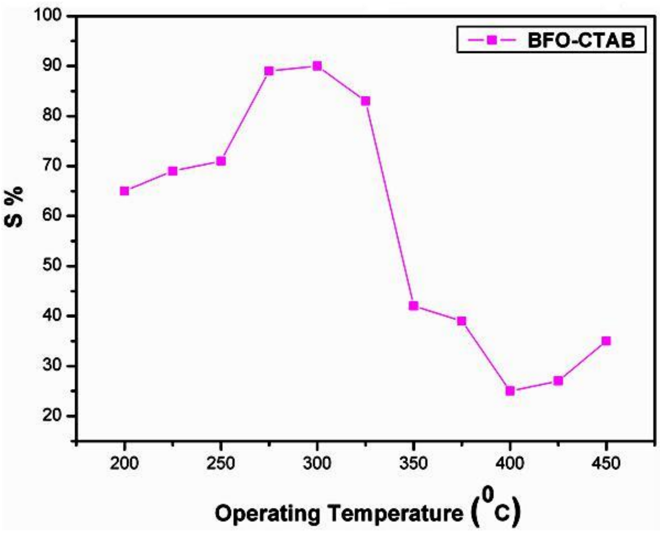

Figure 3: Gas sensing properties of BFO-CTAB sample Sintered at 550 C.

The CTAB assisted BFO sample shows selective highest response (90%) for acetone gas at optimal operating temperature 300 C as shown in Figure 4. The sensitivity of the sensor with increasing gas concentration is also plotted on the graph as shown in Figure 5.The response and recovery time observed in CTAB assisted BFO sensor is shown in Figure 6.

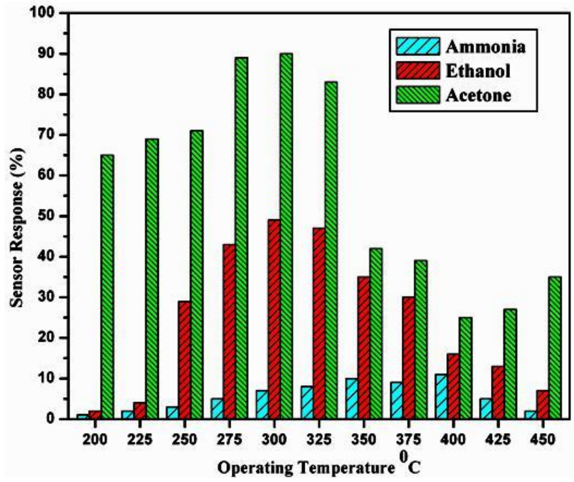

Figure 4: Selectivity of the BFO-CTAB sensor Sintered at 550 C.

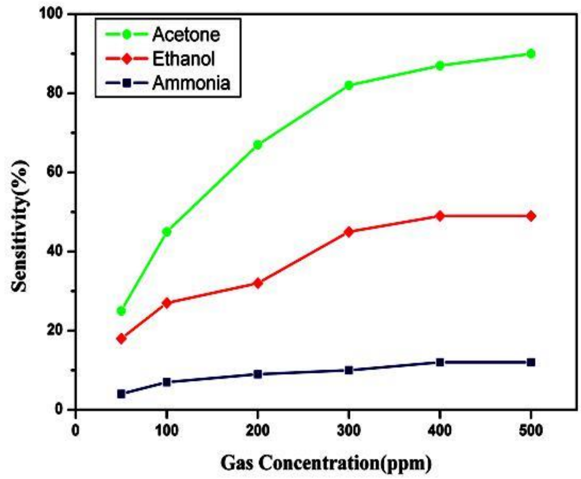

Figure 5: Sensitivity vs Gas concentration.

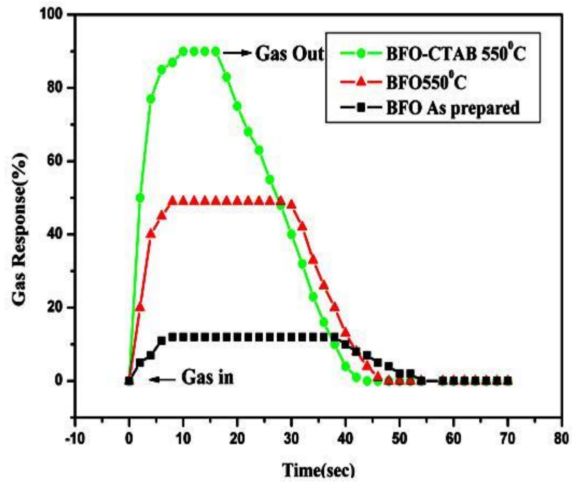

Figure 6: Transient response of the BFO-CTAB sensor.

4 Conclusion

The CTAB assisted BFO nanoparticles were successfully synthesized by glycine combustion method. XRD con-rms the formation of hexagonal structure single phase BFO. EDAX technique identies the chemical composi-tion of Bi, Fe and O. The CTAB assisted BFO sensor showed highest response towards acetone gas at optimal operating temperature which was mainly attributed to its porous structure.

References

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