Electrical aspect of nickel and zinc oxide composite: Effect of magnetic field

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Abstract

The composite of Nickel Oxide (NiO) with varying concentration of ZnO are chemically synthesized following thermal process. DC bulk and surface current voltage characteristics (CVC) were measured. DC Surface CVC was also measured under static magnetic field. It is observed that the bulk and surface conductivity of the prepared composite changes with applied magnetic field as well as percentage variation of ZnO.

1. Introduction

In recent year, considerable attention has been centred on study of the electrical properties with and without magnetic field of various transition metal oxides. Such studies are of primary importance for characterization of a material and are also useful for studying the electrical transport mechanism, details of band structure, magnetoresistance etc.

Transition metal oxides often exhibit novel phenomena of great fundamental and tecnological importance. NiO is a transition metal oxide has several applications, such as solar thermal absorber, electrodes for battery and photoelectron-catalysts [1]. Due to large band-gap energy of (≈4.00eV), and high thermal stability, make it a favourable material for electronic device applications [2]. On the other hand ZnO is one of the versatile and important material because of its typical properties such as transparency in the visible range, high electrochemical stability, direct band gap (3.37eV), absence of toxicity, abundance in nature etc. [3].

Pure NiO at room temperature is an antiferromagnetic material. It was possible to manipulate its magnetic properties as well as bulk and surface conductivity due to addition of ZnO in it. The objective of this work is to investigate bulk and surface electrical conductivity of pure and ZnO mixed NiO compound. The study also includes the effect of external magnetic field on the said electrical conduction. The details of materials, electrical and magnetic aspect of the developed composites are summarized in the following section.

2. Sample

The nickel acetate hydrate, analytical grade (Alpha Aesar) was heated (about 300 C) for 15h to produce NiO powder. A composite of Nickel Oxide (NiO) with varying concentration of ZnO prepared from thermal dissociation of nickel acetate hydrate and zinc acetate hydrate mixing. Final products were allowed to adequate sintering about 350 C for 10h. In this work we used five different composites with different percentage of nickel and zinc acetate hydrate. We denote these samples with decreasing concentration of ZnO as S1 (50%), S2 (40%), S3 (30%), S4 (20%) and S5 (10%). Anhydrous NiO and composites were taken in form of pellets prepared by mechanical pressing at pressure 12ton/cm^2.

3. Experiment

DC electrical measurement technique was applied to measure both bulk and surface CVC of developed specimens at room temperature with voltage step 100mV between 0 to 5V. We also measure dc surface CVC under magnetic field in a direction perpendicular to the current direction at room temperature with voltage step 100mV between 0 to 2V. Both recorded using PC interfaced Keithley 2400 series source meter.

4. Results and Discussions

Fig. 1 shows dc bulk CVC of NiO and composite specimens. It is clear from Fig. 1 that conductivity decreases with increasing ZnO content in the composite. Conductivity of the composite falls below that of NiO when concentration of ZnO in composite reaches at a certain level. However for composite of NiO and manganese oxide, conductivity increase due to decrease of the concentration of manganese oxide but could not exceed that of the corresponding value of pure NiO [4].

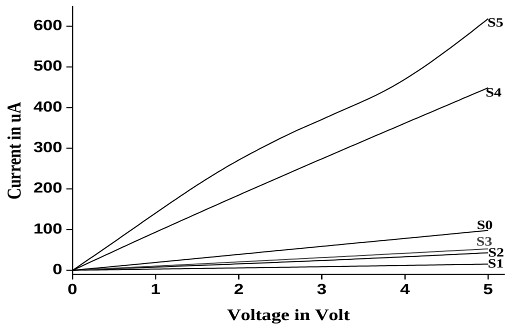

Figure 1.DC bulk CVC for NiO and composites.

It is also observed that dc CVC of NiO and composites except S5 (10%) are ohmic in nature. But for S5 the observed nonlinearity is probably due to low ZnO concentration and high degree of lattice distortion under external electric field.

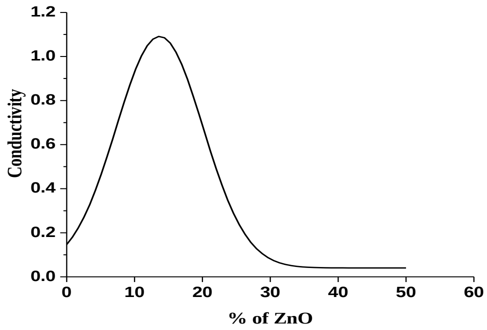

Figure 2. Variation of dc conductivity in the unit of 10-5 S/cm with % of ZnO.

The variation of dc bulk conductivity of the developed composites with percentage variation of ZnO in the composite is shown Fig. 2.

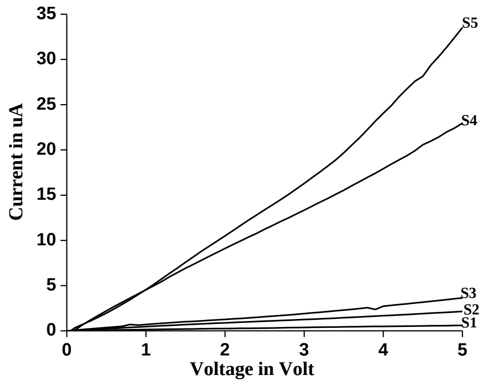

Figure 3. DC surfaceCVC of the composites.

Increasing the ZnO content increase the electrical conductivity of the composite and attains a maximum value at concentration (~13.5%). Further increasing the concentration of ZnO, decreases the conductivity of the composite and saturates after the concentration (~30%). So conductivity can be manipulated with variation of ZnO concentration in the composite.

The dc surface CVC of the composites is shown in Fig. 3. This figure shows that surface conductivity increase with decreasing the ZnO content.

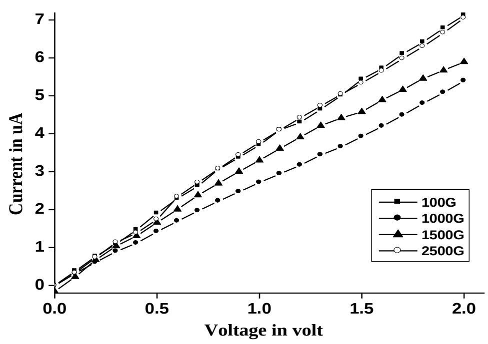

Figure 4. DC surface CVC for composite S4 under mention magnetic field.

Figure 4 shows that dc surface CVC of composite S4 under magnetic field. It reflects the fact that dc CVC of the composite changes due to application of magnetic field. It was also observed that there exists a limiting value of magnetic field at which CVC gets back the same value as that with low field. So composite may used as a manipulative magnetic semiconductor.

5. Conclusion

The electrical conductivity of oxide composite of NiO and ZnO shows an increasing trend with increase in ZnO concentration upto a limiting value. Both bulk and surface conductivity follows the same trend. The surface conduction of the developed composite is greatly affected by external magnetic field. It may be concluded that ZnO is capable to manipulate magnetism in NiO.

10. References

[1] S.V. Han, D.H. Lee, V.J. Chang, S.O. Ryu, T.J. Lee, C.H. Chang. Journal of the Electrochemical Society, 153(6), 382 (2006)

[2] K.S.R. Krish, M. Liberati, V.M. Grazioli, S. Turchini, P. Luches, S. Vateri, C. Carbone, J. of Magnetism and magnetic Materials, 310, 8 (2007)

[3] V.R. Shinde, C.D. Lokhande, R.S. Mane, H. Sung-Hwan, Applied Surface Science, 245, 407 (2005).

[4] Moumita Barman, Somnath Paul and A. Sarkar, AIP Conf. proc., 587-588, 1536(2013)