Journal of ELECTRONIC MATERIALS, Vol. 42, No. 4, 2013
DOI: 10.1007/s11664-012-2465-z

Development of Electronic and Electrical Materials from Indian Ilmenite

R. N. P. CHOUDHURY,[1,4] BISWAJIT PATI,[1] PIYUSH R. DAS,[1,5] R. R. DASH,[2] and ANKITA PAUL[3]

1.—Department of Physics, Institute of Technical Education and Research, Bhubaneswar, Odisha, India. 2.—R & D Section, Gandhi Institute of Engineering and Technology, Gunupur, Odisha, India. 3.—Department of Physics, National Institute of Technology, Rourkela, India. 4.—e-mail: crnpfl@gmail.com. 5.—e-mail: prdas63@gmail.com

Some new complex electronic materials have been prepared by mixing bismuth oxide (Bi_2O_3) and ilmenite in different proportions by weight, using a mixed-oxide technique. Room-temperature x-ray diffraction analysis confirms the formation of a new compound with trigonal (rhombohedral) crystal structure with some secondary phases. Studies of dielectric parameters (ε_r and tan δ) of these compounds as a function of temperature at different frequencies show that they are almost temperature independent in the low-temperature range. They possess high dielectric constant and relatively small tangent loss even in the high-temperature range. Detailed studies of impedance and related parameters show that the electrical properties of these materials are strongly dependent on temperature, showing good correlation with their microstructures. The bulk resistance, evaluated from complex impedance spectra, is found to decrease with increasing temperature. Thus, these materials show negative temperature coefficient of resistance (NTCR)-type behavior similar to that of semiconductors. The same has also been observed from their *I–V* characteristics. Complex electric modulus analysis indicates the possibility of a hopping conduction mechanism in these systems with nonexponential-type conductivity relaxation. The nature of the variation of the direct-current (dc) conductivity with temperature confirms the Arrhenius behavior of these materials. The alternating-current (ac) conductivity spectra show a typical signature of an ionic conducting system, and are found to obey Jonscher's universal power law.

Key words: Ilmenite, impedance analysis, bulk resistance, electric modulus analysis

INTRODUCTION

Ilmenite, a weakly magnetic iron–titanium oxide mineral of iron-black or steel-gray color, is an economically important and interesting mineral. It forms as a primary mineral in mafic igneous rocks and is concentrated into layers by a process called "magmatic segregation." It also occurs in pegmatites and some metamorphic rocks as well as in sedimentary rocks that are formed due to weathering and erosion. Iron titanium oxide ($FeTiO_3$) crystallizes in the trigonal system. Its crystal structure is an ordered derivative of the corundum structure, with the basic difference that in corundum all cations are identical whereas in ilmenite Fe^{2+} and Ti^{4+} ions occupy alternating layers perpendicular to the trigonal *c*-axis.[1,2] Ilmenite most often contains appreciable quantities of magnesium and manganese, and thus the full chemical formula can be written as $(Fe,Mg,Mn)TiO_3$. Therefore, ilmenite forms a solid solution with geikielite ($MgTiO_3$) and pyrophanite

(Received November 15, 2012; accepted December 28, 2012; published online February 21, 2013)