Synthesis and characterisation of cubic Bi3Zn2Ta3O14 and its related divalent-doped pyrochlore materials

ABSTRACT

Bi 3 Zn 2 Ta 3 O 14 , 'P', was crystallised in a cubic unit cell with lattice parameter of a=10.5437 (9) Å. The material had permittivity, ε', of around 58 and dielectric loss, tan δ, of 2.3 × 10 -3 at 30 o C, 1 MHz; temperature coefficient of capacitance (TCC) of -156 ppm/ o C in the range of 30 o C to 300 o C at 1 MHz. Chemical doping was carried out at either A (Bi 1.5 Zn 0.5-x M x) (Zn 0.5 Ta 1.5)O 7 , or B site (Bi 1.5 Zn 0.5)(Zn 0.5-x M x Ta 1.5)O 7 in search of better performance materials. Various divalent cations such as Cd 2+ , Ca 2+ , Mg 2+ , Ni 2+ , Pb 2+ , and Cu 2+ were used as dopants. Solid solutions formed were: Bi 3 Zn 2-x Cd x Ta 3 O 14 ($0 \leq x \leq 0.5$), Bi 3 Zn 2-x Mg x Ta 3 O 14 ($0 \leq x \leq 0.2$), Bi 3 Zn 2-x Ni x Ta 3 O 14 ($0 \leq x \leq 0.4$), Bi 3 Zn 2-x Pb x Ta 3 O 14 ($0 \leq x \leq 0.3$), Bi 3 Zn 2-x Ca x Ta 3 O 14 ($0 \leq x \leq 0.3$) and Bi 3 Zn 2-x Cu x Ta 3 O 14 ($0 \leq x \leq 0.1$). Electrical properties of the materials were investigated using impedance spectroscopy. Conductivities of the solid solutions were higher than that of the parent material Bi 3 Zn 2 Ta 3 O 14 . These doped materials exhibited similar behaviour as Bi 3 Zn 2 Ta 3 O 14 , showing a high degree of dispersion of permittivity at low frequencies (<1 kHz) and at temperatures above 500 o C. Between 100 kHz and 1000 kHz, non-frequency dependence was observed in the range of 100 – 300 o C. An increase in dielectric loss below 10 kHz was observed. Dielectric loss decreased with frequencies when temperature was above 500 o C. Dielectric loss of all divalent cation doped materials was higher than that of the parent material; maximum permittivity value of 68 was recorded at x = 0.3 in Bi 3 Zn 2-x Ca x Ta 3 O 14. TCC obtained in this study had negative values; no obvious correlation between TCC and composition of the doped materials can be deduced.

Keyword: Dielectric loss; Permittivity; Pyrochlore; Temperature coefficient of capacitance.