Effect of Calcination Condition on Phase Formation Characteristic of Magnesium Niobate Powders Synthesized by the Solid-State Reaction

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ABSTRACT

Magnesium niobate ($MgNb_2O_6$) powders were prepared and characterized by TG-DTA, XRD, SEM and EDX techniques. The effect of calcination temperature, dwell time and heating/cooling rates on phase formation characteristic of the powders were examined. The calcination temperature and dwell time were found to have a pronounced effect on the phase formation of the calcined magnesium niobate powders. It was also found that the minor phases of unreacted MgO and Nb_2O_5 precursor tended to form together with the columbite $MgNb_2O_6$ phase, depending on calcination conditions. Furthermore, it was observed that optimisation of calcination conditions could lead to a single-phase $MgNb_2O_6$ in an orthorhombic phase.

Key words: Magnesium niobate, Powder synthesis, Phase formation, Calcination

INTRODUCTION

Magnesium niobate ($MgNb_2O_6$; MN) is one of the binary niobate compounds which exhibits excellent dielectric properties at microwave frequencies (Ogawa et al., 2003; Zhang et al., 2003). It has very low loss and high dielectric constant and is promising candidate for application in microwave devices. This compound with a columbite crystal structure is also a suitable reference material for investigating the defect induced in $LiNbO_3$ substrates for waveguide fabrication (Hu et al., 1991; Zaldo et al., 1995; Simoes et al., 2002). Moreover, recently, it is well known as the key precursor for the successful preparation of single-phase relaxor perovskite $Pb(Mg_{1/3}Nb_{2/3})O_3$ (PMN), which is becoming increasingly important for transducer, electrostrictor and actuator applications (Saha et al., 1994; Joy and Sreedhar, 1997; Haertling, 1999; Uchino, 2000).

It is known that various compositions are possible in the Mg-Nb-O system (Norin et al., 1972). To date, four possible magnesium-niobium oxides have been identified: $MgNb_2O_6$, $Mg_4Nb_2O_9$, $Mg_5Nb_4O_{15}$ and $Mg_{2/3}Nb_{11(1/3)}O_{29}$ (Norin et al., 1972; Pagola et al., 1997). You et al., (1994) reported that MgNb2O6 and Mg4Nb2O9 are the only stable phases that exist at room temperature. It is known that synthesis of $MgNb_2O_6$ phase by the conventional method, i.e. by reacting individual oxides, generally results in varying amounts of the corundum $Mg_4Nb_2O_9$ phase alongside the columbite phase (Saha et al., 1994; Sreedhar and Mitra, 1997; Yu et al., 2001). Thus, a number of chemical routes using expensive precursors, for example,