Preparation and Characterization of Nickel Niobate ($NiNb_2O_6$) Nanopowders

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ABSTRACT

Single-phase columbite powders of nickel niobate ($NiNb_2O_6$, NN) were prepared by the solid-state reaction via a vibro-milling technique, being well known as a significant time-saving method to obtain single-phase nanopowders at low temperature. The powders were characterized by thermogravimetric and differential thermal analysis (TG-DTA), X-ray diffraction (XRD) and scanning electron microscopy (SEM) techniques. The calcination temperature was found to have a pronounced effect on the phase formation of the calcined nickel niobate powders. It was also found that minor phases of unreacted NiO and Nb_2O_5 precursor tended to form together with the columbite $NiNb_2O_6$ phase, depending on calcination conditions. Furthermore, it was observed that the pure columbite phase of $NiNb_2O_6$ nanopowders were successfully obtained from a calcination condition of 800°C for 4 h with heating/cooling rates of 20°C/min.

Key words: Nickel niobate ($NiNb_2O_6$), Nanopowders, Phase formation, Calcination

INTRODUCTION

Lead nickel niobate ($Pb(Ni_{1/3}Nb_{2/3})O_3$ or PNN) is one of the relaxor ferroelectrics which exhibits high dielectric permittivity (~ 4000) over a wide range of the transition temperature (~ -120°C at 1kHz) (Alberta and Bhalla, 2002). PNN is becoming increasingly important for multilayer ceramic capacitor, electrostrictor and actuator applications (Moulson and Herbert, 2003). However, it is very difficult to synthesize the high-purity PNN compound via a conventional solid-state reaction process which normally uses oxide-substance as starting materials, due mainly to the poor reactivity of nickel oxide (NiO) (Xiang et al., 2005). As a result, it is required to use another technique to obtain single-phase PNN at a high purity level. One of the promising techniques is to use a columbite precursor method which is known to provide the minimal level of impurity. Consequently, within this columbite precursor method, it is required to prepare the high-purity columbite-structure material for this precursor method, i.e., nickel niobate ($NiNb_2O_6$, NN) for the PNN. It is known that the nickel niobate ($NiNb_2O_6$) is a good precursor for the successful preparation of single-phase perovskite lead nickel niobate, $Pb(Ni_{1/3}Nb_{2/3})O_3$ (Lu and Hwang, 1996). However, as being aware in literatures (Lu and Hwang, 1996; Bove et al., 2001; Alberta and Bhalla, 2002), high-purity $NiNb_2O_6$ powders, especially at an ultrafine level ($NiNb_2O_6$ nanopowders) which is an important condition to obtain highly-efficient material processing, is far from being available in bulk quantities and is also very expensive. Thus, in this study, an approach to synthesize single-phase $NiNb_2O_6$ nanopowders with a mixed oxide synthetic route is developed via a columbite method assisted.