Comparison of Ionic Diffusion in Sol-Gel derived Micron and Nano LiTaO₃

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Abstract. LiTaO₃ is an important optical material. It may also be possible to use this material as a solid electrolyte for lithium-ion batteries which may be applicable in thin film solid-state batteries. Generally, ceramics have a wide range of impedances. Many ceramics have mixed charged species consisting of electronic as well as ionic charge carriers. This work investigates the conductivity of LiTaO₃ materials using ac impedance spectroscopy technique measured as a function of temperature.

Introduction

Lithium tantalate, LiTaO₃ is a material used in electro-optical applications [1-3], sensors [2], transducers [2], ferroelectric [1], pyroelectric [2] and piezoelectric devices [1, 2]. Li⁺ ion solid electrolytes have attracted attention in recent years [4]. This material may also be used as a solid electrolyte in lithium-ion batteries. Solid electrolytes are very important for specialized batteries used in medical applications. This is because, the requirements for no spillage and material stability is very stringent.

The conductivity of a solid electrolyte is very important for it to be considered a viable electrolyte material. The conductivity can be experimentally determined using ac impedance spectroscopy and interpreting the resultant Nyquist plots. Impedance spectroscopy is now considered a very powerful and useful tool for conductivity studies of materials [5]. This is because other values such as activation energy and ionic mobility can be determined from ac impedance results.

In our literature search, no work has been done on the bulk conductivity of pure normal (micron sized) and nano (100 nm or less) LiTaO₃ powders. The conductivity value of LiTaO₃ has to be determined if it is to be considered as a solid electrolyte in lithium batteries. This work investigates the conductivity of LiTaO₃ powders using the technique commonly used for the study of solid electrolytes in Li based samples.

Experimental method

The synthesis of LiTaO₃ was done using the sol-gel method. Li acetate and tantalum oxide was stirred in ethanol for 2 hours. A gelling agent was added to complex the mixture and later slow dried. The precursor material was annealed at 700°C for 24 hours. The material was then grinded until fine.