Preparation and Study of $\text{La}_{9.33}(\text{SiO}_4)_6\text{O}_2$ Solid Electrolyte Materials Doped with Ba and Zn

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ABSTRACT

In this paper, apatite-type lanthanum silicate (hereinafter referred to as ATLS) electrolytes were doped with Ba and Zn at La and Si levels by gel sol method at a lower temperature. The doped $\text{La}_{9.33}\text{Ba}_x\text{Si}_5\text{ZnO}_{25-x}$ electrolytes were characterized by XRD, SEM analysis. The addition of Ba and Zn into the lattice of ATLS did not destroy the apatite crystal structure of the substance itself. SEM test showed that $\text{La}_{9.33}\text{Ba}_x\text{Si}_5\text{ZnO}_{25-x}$ electrolyte had the best sintering effect when Ba doping amount $x=0.3$.\(^1\)

INTRODUCTION

The development of human society and the progress of science and technology cannot be separated from the support of energy. The chemical energy of the Fuel cell materials can be directly converted into electricity\(^1, 2\). Fuel cell can efficient use of the hydrogen power, it is a new kind of clean, efficient and sustainable energy. Fuel cell has attracted wide attention and research. Solid electrolyte is a Solid Oxide Fuel cell of the key components, it plays an isolation the important role of reaction gas and oxygen ions \(^3, 4\). The size of its conductivity performance directly affects the performance of the Fuel cell. Apatite lanthanum silicate is a kind of temperature under the working conditions with excellent electric conductivity of the electrolyte materials. Some research has shown that by in La or Si a mixed with a certain amount of alkaline earth metals, transition and rare earth elements and controls the synthesis conditions can be fast and effectively improve the ATLS electrolyte

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electrical performance. Apatite type oxide has great potential applications in solid oxide fuel cell electrolyte, it makes the solid oxide fuel cells work under the low temperature is possible.[5,6]

In this experiment, Ba and Zn doped La$_{9.33}$Ba$_x$Si$_5$ZnO$_{25-x}$ solid electrolyte was successfully prepared by sol-gel method. The morphology, physical phase and electrical properties of the synthesized samples were characterized and analyzed.

EXPERIMENTAL

The right amount of a certain amount of La$_2$O$_3$ and BaO and ZnO were mixed in ethanol. The mixture of nitric acid solution was heating in mixing water bath under 35~50℃ until the precipitation disappear in the mixture. Adding the ammonia adjust experimental process solution pH value to 5~6. Finally adding suitable amount of urea in the mixed solution and silicon source (TEOS). Place after clarifying the solution water bath must be under 60~90℃ until the formation of gel. Put the gel in oven dry and dry gel formation. The fully dried precursor was put into electric furnace under the 600~800℃. The calcined products were fully ground with an agate mortar, and the solid electrolyte powder was obtained after calcining for a certain period of time under 800-1000℃. The power was pressed into a sheet for testing.

RESULTS AND DISCUSSION

As shown in figure 1, the Ba and Zn doping La$_{9.33}$BaxSi$_5$ZnO$_{25-x}$ electrolyte powder’s XRD spectrum is obtained from test. According to the spectrum, it shows that when the Ba doping amount $x$ are 0.1, 0.2, 0.3, 0.4, the La$_{9.33}$BaxSi$_5$ZnO$_{25-x}$ electrolyte powder XRD spectrum diffraction peak shape and position are same to the basically. The diffraction peak is sharp, it showed that the crystallinity of powder overall performance is good, and the characteristic peaks are similar to LSO standard diffraction peaks. We can know that the doping does not change the crystal apatite structure of LSO, and it did not also generate the La$_2$SiO$_5$and La$_2$Si$_2$O$_7$ impurities. La$_{9.33}$BaxSi$_5$ZnO$_{25-x}$ electrolyte powder with high purity and no impurity was produced. By comparing the XRD spectra of the four different doping amounts, it can be seen that the diffraction peaks tend to move to a low Angle with the increase of doping amount. The reason may be that the addition of Ba and Zn increases the cell volume, which also indicates that effective doping was carried out in the experiment.

As shown in figure 2, the four kinds of doping amount La$_{9.33}$BaxSi$_5$ZnO$_{25-x}$ sintered body images can be observed from the map under the sintering temperature of 1300℃. The Ba doping amount on the different surface morphology of sintered body can produce different effects. Through the comparison of the four SEM graphs, it can be found that when the doping amount $x$ is 0.3, the grain boundary is
obvious. The arrangement is the most compact. The porosity is the lowest, and the sintered body has a high density. Under the condition of the same sintering temperature, the La$_{9.33}$Ba$_x$Si$_5$ZnO$_{25-x}$ solid electrolyte with Ba dopant $x$ of 0.3 had the best sintering effect.

Figure 1. XRD patterns of La$_{9.33}$Ba$_x$Si$_5$ZnO$_{25-x}$ powders ($x=0.1$, $x=0.2$, $x=0.3$, $x=0.4$).

Figure 2. SEM images of La$_{9.33}$Ba$_x$Si$_5$ZnO$_{25-x}$ sintered body (1300°C).
CONCLUSIONS

Ba and Zn doped La$_{9.33}$Ba$_x$Si$_5$ZnO$_{25}$-x solid electrolyte with high purity and no impurity was successfully prepared by sol-gel method. According to the test results, ionic doping did not change the p63/m apatite crystal structure of LSO solid electrolyte material. La$_{9.33}$Ba$_x$Si$_5$ZnO$_{25}$-x electrolyte had the best sintering effect when the doping amount was x=0.3.

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