Chapter 6

Conclusions

The development of next generation Solid Oxide Fuel Cells SOFCs has been focusing on reducing the operating temperature to an intermediate temperature range at 600-700°C. Because of the high degradation rates and materials costs incurred at 1000°C, it is economically more favorable to operate SOFCs at lower temperatures. The need for low-cost materials which are durable at high temperatures and low temperature operation are the main technical and economical challenges.

This work represents the manufacturing and characterizations of a number of electrolytes for SOFCs consisting of both single material electrolytes, i.e., YSZ, TZP, GDC and mixtures of TZP/YSZ and GDC/YSZ composite electrolytes. To investigate the suitability of the materials used as electrolytes for SOFCs, the electrical properties, microstructure, phases, and mechanical properties of YSZ, TZP and GDC as well as TZP/YSZ and GDC/YSZ composites were characterized. The microstructure of an electrolyte was significantly related to the sintering temperature and time. In addition, the electrical property of an electrolyte is greatly influenced by the microstructure especially grain size and amount of grain boundaries.

6.1 Single material electrolytes

- The sintering temperature and time affected the grain sizes of all single material electrolytes, i.e. YSZ, TZP and GDC. The grain size increase with increasing sintering temperature and time.
- The grain growth with increasing sintering temperature and time results in increasing of density.
- The sintering temperature and time affect the bending strength. The bending strength of TZP and YSZ tends to decrease with increasing sintering temperature and time. Conversely, the increase in sintering temperature and time decrease the mechanical strength of GDC. The TZP electrolytes showed the highest bending strength among three single materials used in this study.

- All the single material electrolytes do not represent the change of phase with increasing sintering temperature and time.
- The ionic conductivity of an electrolyte is related to its microstructure which is investigated using an AC-impedance spectroscopy.
- The GDC electrolyte represented the highest ionic conductivity but its weakness is the bending strength.

6.2 Composite electrolytes

- The higher sintering temperature and longer sintering time do not represent the phase change of the TZP/YSZ composite electrolytes. They are more crystalline phase at higher sintering temperature and longer sintering time.
- The phases of TZP/YSZ composite electrolytes present more tetragonal phase with increasing amount of the TZP content.
- The densities of TZP/YSZ composite electrolytes increase with increasing sintering temperature, time and amount of the TZP content.
- The TZP/YSZ composite was shown to be mixed-phase between small and large grains, corresponding to the tetragonal and cubic phases, respectively. TZP particles in composite electrolytes hampered the grain growth of YSZ. The grain sizes of YSZ decrease with increasing amount of the TZP content.
- The bending strength of various composite electrolytes also increases with increasing TZP content. TZP enhances the mechanical strength of the TZP/YSZ composite electrolytes.
- The electrical conductivity of the TZP/YSZ composite electrolytes increase at lower temperature (T<550°C) with addition of TZP particles.
- The mixtures of GDC and YSZ represent low bending strength caused by the diffusion between YSZ and GDC. It is resulting in more pores. The bending strengths decrease with increasing the porosity.
- The GDC/YSZ composite electrolyte is not suitable as an electrolyte for SOFC due to the high porosity compared to the single material electrolytes of GDC or YSZ.

6.3 Recommendation

The GDC electrolyte represented the highest ionic conductivity but its weakness is the bending strength. The TZP electrolyte showed the highest bending strength among the three single-phase materials used in this study. These two single materials are interesting to mix as GDC/TZP composite electrolyte. However, the property of GDC/TZP electrolyte maybe the same as that of GDC/YSZ electrolyte which showed low bending strength caused by the diffusion between YSZ and GDC because TZP and YSZ are the same as atomic composition; Yttriam (Y) and Zirconium (Zr).