



Chapter 1 Introduction

In recent years, air pollution (especially from fossil fuel combustion engine) has been seriously concerned in many countries. In addition, the limited production of the fossil fuel resulting in an increase of its price is the major problem. Therefore, many efforts to provide an effective power generation with negligible pollution are approached. Fuel cell is one promising as a candidate for a new power generation system. Due to the direct conversion of the chemical energy to the electrical energy, the fuel cell can provide higher efficiency than the conventional methods. Moreover, it has modularity, sitting flexibility, multiple capability, and potential for co-generation.

In general fuel cell consists of two electrodes (anode and cathode) separated by electrolyte as shown in Fig 1.1 ⁽¹⁾.

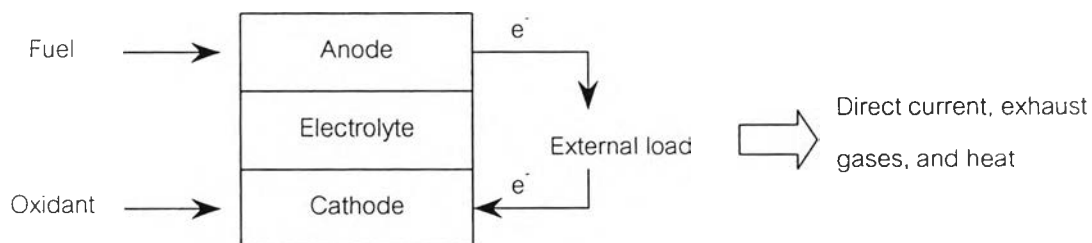


Fig 1.1 Schematic diagram of fuel cell. ⁽¹⁾

Fuel (e.g. hydrocarbon or H_2) is fed to the anode, undergoes an oxidation reaction, and releases electrons to the external circuit. Oxidant (e.g. O_2 or air) is fed to the cathode at which electrons from external circuit travel to and undergo a reduction reaction. The electrons moving from the anode to the cathode produce direct current. The electrolyte conducts ions (O^{2-} or H^+) between the two electrodes ^(1,3).

Practical fuel cells are connected in electrical series as a stack to produce useful power. Each cell is connected by a bipolar plate or an interconnect. Its function is to conduct electrons from the anode of one cell to the cathode of the next cell in a stack (Fig. 1.2). ⁽³⁾

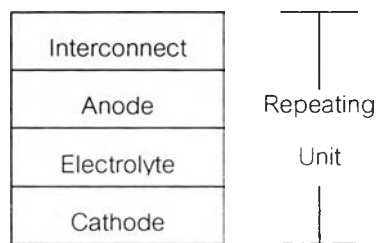


Fig. 1.2 Fuel cell component³

There are several types of fuel cells. The most common classification of fuel cells is by either its operating temperature or the type of electrolyte.

1. Alkaline fuel cell (AFC)

In this type, the electrolyte is potassium hydroxide (KOH). The fuel and the oxidant must be pure. Even the small amount of the carbon dioxide or sulfur can react with KOH to form potassium carbonate which degrades the fuel cell performance.

2. Phosphoric acid fuel cell (PAFC)

The PAFC uses liquid phosphoric acid as the electrolyte. Hydrogen as fuel gas must contain less than 1-2 percent of CO and 50 ppm of the sulfur. The oxidant may be air or oxygen. The major disadvantage of this type is the corrosion from the acid electrolyte.

3. Polymer electrolyte fuel cell (PEFC)

The polymer membrane is used as the electrolyte in the PEFC. The corrosion problems are minimal because there is no other liquid except water in cell. As a result, water management should be concerned. This type is suitable for transportation application due to its low operating temperature (80°C).

4. Molten carbonate fuel cell (MCFC)

The MCFC uses molten carbonate salt mixture as its electrolyte. Because of high operating temperature (650°C), internal reforming of fuel is possible. From this result, natural gas or coal-derived can be used as a fuel. The major disadvantage is corrosion because of containing carbonate salt.

5. Solid oxide fuel cell (SOFC)

Since all components of SOFC are solid, a corrosion problem is eliminated. Similar to MCFC, the very high operating temperature of SOFC ($800\text{-}1000^{\circ}\text{C}$) can internally reform the fuel. Therefore it can readily use many common hydrocarbon fuels such as natural gas, gasoline, alcohol, and coal gas. In addition, waste thermal-energy can be used in co-generation system.

Table 1.1 Summary of types and their operating condition

	AFC	PAFC	PEFC	MCFC	SOFC
Temp.($^{\circ}\text{C}$)	150-250	160-210	60-100	650	800-1000
Electrolyte	KOH	H_2PO_3	Nafion	Li_2CO_3 K_2CO_3 (Na_2CO_3)	YSZ
Anode	Pt/Au	Pt on C	Pt on C	Ni	Ni/YSZ cermet
Cathode	Pt/Au	Pt on C	Pt on C	NiO	LSM
Fuel	H_2 (no CO,S)	H_2	H_2	HC	HC
Oxidant	O_2	air	Air	air	air
Carrier ion	OH^-	H^+	H^+	CO_3^{2-}	O^{2-}
Uses	Spacecraft	Medium electric powerplants	Buses, cars	Large electric powerplants	All sizes of electric powerplants
% Efficiency	40-60	40-50	40-50	60	60-70

Solid oxide fuel cell whose all components are solid exhibits several advantages. However the operating temperature is rather high (1000°C) that may cause some disadvantages. To obtain high efficiency, the operating temperature should be reduced. Several researchers have investigated the new perovskite oxide compositions accompanying higher ionic conductivity to replace yttrium stabilized zirconia and can be operated at lower temperature ($600\text{-}800^{\circ}\text{C}$).

Perovskite type oxide, especially doped lanthanum gallate, has been intensively investigated. Ishihara et al.⁽⁴⁾ reported that the ionic conductivity of $\text{La}_{0.9}\text{Sr}_{0.1}\text{Ga}_{0.8}\text{Mg}_{0.2}\text{O}_{3-\delta}$ was higher than that of Sc doped ZrO_2 and slightly lower than that of Bi_2O_3 . Also, it exhibited only ion conductivity in a wide range of oxygen partial pressure. Although doped LaGaO_3 offers desirable characteristics, gallium is rather expensive. Replacement of Ga by a cheaper metal can reduce cost. P.S. Anderson et al.⁽⁹⁾ entirely used Al for B-site and its ionic conductivity at 1000°C $2.4 \times 10^{-3} \text{ Scm}^{-1}$ was reported. Several researches have studied characteristics of LaAlO_3 . However, studies on doped both A- and B- site cations in LaAlO_3 have not been investigated. This present thesis investigated the effect of Sr and Mg on the properties of LaAlO_3 .

The objectives of this thesis are the followings:

1. To study the effect of strontium- and magnesium- doped lanthanum aluminate on the electrical property.
2. To determine the crystal structure, phase and thermal expansion coefficient of the modified compositions.