CHAPTER I

INTRODUCTION

Alternative energy sources are the topic of much interest due to the increasing demand of energy and the major energy sources relied on today are non-renewable. Hydrogen gas is the energy source of choice for it has many merits. It is a clean energy and has high energy release per unit compared to other sources [1]. It also has many applications, for instance, fuel cell.

1.1 Hydrogen Production

Production of hydrogen gas from petroleum hydrocarbon employs hydrolysis, dry reforming, steam reforming, partial oxidation or gasification in which reformings are the most common. Methane reacts with either steam or carbon dioxide as shown in the following equations.

1. Steam Reforming

   $CH_4 + H_2O \longrightarrow CO + 3\,H_2$ $\quad \Delta H\ 298) \quad = 206 KJ/mol$

2. Dry Reforming

   $CH_4 + CO_2 \longrightarrow 2CO + 2H_2$ $\quad \Delta H\ (298) \quad = 247\ KJ/mol$

3. Partial Oxidation

   $CH_4 + \frac{1}{2} CO_2 \longrightarrow CO + 2H_2$ $\quad \Delta H\ (298) \quad = -36\ KJ/mol$

4. Gasification Reaction

   $C + H_2O \longrightarrow CO + H_2$

5. Electrolysis of water

   $2H_2O(l) \longrightarrow 2H_2(g) + O_2(g)$

1.2 Hydrogen Purification and Intermetallic Diffusion

Both processes require a purification step to obtain a high-purity product and typically employ a membrane reactor in which the reforming and purification steps can be operated in a single unit. The membrane in the reactor is a palladium for it is specifically permeable to hydrogen gas so obtaining product of high purity can be easily achieved. The palladium membrane is also stable at high operation temperatures [2].

Palladium layer of limited thickness is coated on a support by electroless plating [3]. The permeability of palladium membrane to hydrogen gas is in inverse proportion to its thickness [4]. The supports are including ceramics and glass but the most common is stainless steel primarily due to its cheapness, ease of welding and high strength. However, while dry reforming of methane over Al_2O_3 catalyst takes place at temperatures 670-700°C [5], diffusions of metal components of the support into the membrane, this phenomenon called 'intermetallic diffusion' and becomes the major drawback of the stainless steel support, at temperature above 400°C [6] and results in contaminated, poor-selective and shorter-life membrane.

A barrier between the membrane and the support is an effective solution. Such an intermetallic diffusion barrier can be coated on the support by (1) thermal oxidation of the stainless steel support, (2) electroplating of metal atom followed by thermal oxidation and (3) sputtering of metal or compound species with or without thermal oxidation.

1.3 Objective

This study aims to develop an effective Cr-based intermetallic diffusion barrier on stainless steel (SS) support. The extents of intermetallic diffusion from four Cr_2O_3 and one CrN-coated SS supports were examined and compared to that of the unoxidized stainless steel. The Cr_2O_3-coated supports were formed either by (1) thermal oxidation, (2) electroplating of Cr with oxidation, (3) sputtering of Cr with post oxidation or (4) sputtering of Cr in O_2 atmosphere and the CrN-coated by reactive sputtering of Cr in N_2 atmosphere. The testing condition was dry reforming of methane [7].