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Test Fuel Cell using Hydrogen Storage Alloy

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In utilization of a fuel cell, higher cost and decrease of the performance of a catalyst are important subject. Therefore, catalysts in relevance to electrolyte have been developed from various kinds of aspects. Moreover, in case of direct connection to hydrogen source, a stable hydrogen gas supply may become difficult. $LaNi_5$, which is a well-known hydrogen storage alloy, has the high reaction probability of hydrogen dissociative absorption. Additionally, $LaNi_5$ has stable resistivity against to contaminants of H_2O and oxygen in comparison with Mg and Ti-based hydrogen storage alloys. In this study, a fuel cell using $LaNi_5$ as an electrode was made as a test cell from a viewpoints of reducing the Pt catalyst and performance with an output which was less influenced even the supplying pressure of hydrogen gas was unstable. In this fuel cell, parfluoro carbon sulfonic acid was used for electrolyte and Pt was used as additional catalyst. Graphite (extruded) was used for cathode and $LaNi_5$ was used for anode. The output was measured under hydrogen and oxygen gases of 0.18MPa base pressure at RT. $LaNi_5$ electrode exhibited less catalytic performance, however, drastically modified stable cell output, i.e. H_2 was once absorbed in $LaNi_5$ and H was supplied to the electrolyte.
Key words: Polymer electrolyte Fuel Cell, Hydrogen storage alloy, $LaNi_5$,

1. INTRODUCTION

Today, environmental issues have been aggravated by increasing use of fossil fuel consumption. System using natural energy has been desired as a new clean energy system, which may take the place of fossil fuel energy system. However, the natural energy is characterized by low energy density and unstableness. Accordingly, hydrogen energy system, using hydrogen as energy medium, has been expected as new energy system. In this system the hydrogen storage materials, such as $LaNi_5$, has been expected as useful materials, which enlarges the possibility of system utilities. Especially, since $LaNi_5$ is easy activated and also readily keeps the surface activated in hydrogen gas even after exposures of the alloy to air [1].

Fuel Cells are electrochemical energy converters that convert chemical energy of fuel, typically hydrogen, directly into electrical energy. In utilization of a fuel cell, cost and decrease of the performance of a catalyst are important factors[2,3]. Catalysts in relevance to electrolyte have been, therefore, developed from various kinds of aspects. Moreover, in change of energy resources, a stable hydrogen supply may become difficult, when hydrogen of fuel is manufactured using natural energy. In addition, when considering the simple system, such as the hydrogen generated using natural energy is directly supplied to a fuel cell, the output was influence by the change of hydrogen supplying pressure.

In this study, the fuel cell using $LaNi_5$ alloy as a part of negative electrode was made as a test cell from viewpoints of reducing Pt catalyst by substituting some Pt by $LaNi_5$ and a performance with an output, which was less influenced even the supplying pressure of hydrogen was unstable.

2. EXPERIMENTAL

The test fuel cell was made as shown in Fig. 1. In the test fuel cell, parfluoro carbon sulfonic acid (Nafion117, Dupont Co.) was used for electrolyte. Pt of about 0.3mg/cm^2 (with $LaNi_5$) or 0.6mg/cm^2 (without $LaNi_5$) was deposited on electrolyte and electrodes as catalyst by using an ion sputter (E-1010, HITACHI). Graphite (extruded) was used for both the anode and cathode. On anode graphite, $LaNi_5$ of 1-2 micron-m was deposited by flash evaporation. Ultra high purity hydrogen gas (7N) and high purity oxygen gas (4N) were supplied to anode and cathode, respectively. Output of the cell, load resistance and current were measured by voltmeter 1, 2 and ammeter, respectively. Output was measured under constant hydrogen and oxygen gas pressures of 0.18Mpa as base pressure. The quantity of the water added to polymer electrolyte was first set to 0.05ml/cm^2.

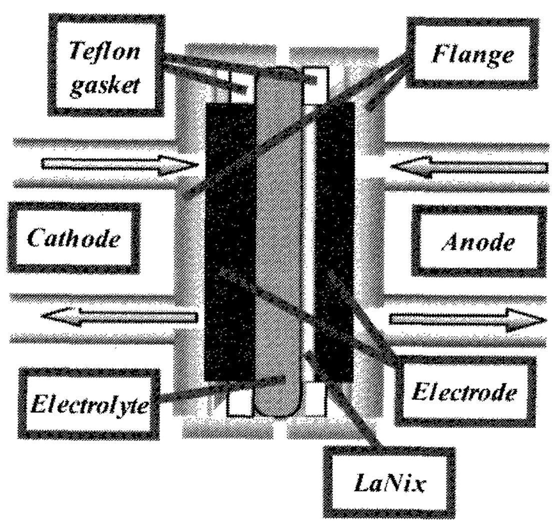

Fig. 2 Schematic diagram of test fuel cell

A standard cell using only graphite was also made and compared with the test cell. All the experiments were carried out at RT.

V-I characteristic of the test cell was measured at the first stage. After generating output for 10 minutes, the current, the electromotive force and the load resistance were measured by varying the load resistance gradually.

The influence of the change of hydrogen supplying pressure upon the cell maximum output was also investigated. The hydrogen gas supply was stopped after the test fuel cell generated electricity for 300 minutes. After that, the hydrogen pressure was changed from 0.18MPa to 0.25MPa, with and without supplying.

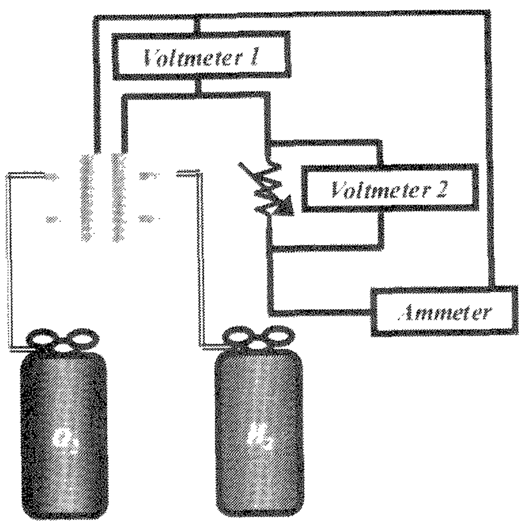

Fig. 3 Schematic diagram of measuring system

3 RESULTS and DISCUSSION

3.1 V-I characteristics of the test fuel cell

Figure 4 shows the initial V-I characteristics of the test fuel cell with and without $LaNi_5$. The lower output at this initial stage of the cell with $LaNi_5$ was surly caused by lower H_2 dissociative reaction on the negative electrode because of less amount of Pt. The maximum outputs measured by changing load resistances were also strongly different for the cells with and without $LaNi_5$ as shown in Fig.5.

H.Uchida et al. reported the reaction probability; r, of H_2 on the surface of $LaNi_5$. The value r, ranging from 1 to 10^{-6}, changes drastically depending on the amount of oxide layer and heat treatment [1]. This results suggests that if the surface is covered with less amount oxide, the surface may exhibit relatively higher reactivity, which can be obtained by activations through hydrogenation.

Additionally, $LaNi_5$ with some H_2O pretreatment exhibits drastically modified absorption reactions [4]. After the H_2O treatment the surface can be kept as activated even after strong air oxidations. Surface Ni clusters on La oxide segregated by oxidation yield accelerated catalytic reaction. This modified surface structure can be obtained by some oxidation of the $LaNi_5$ surface.

From these points of view, we measured subsequent output characteristics of the test fuel cells.

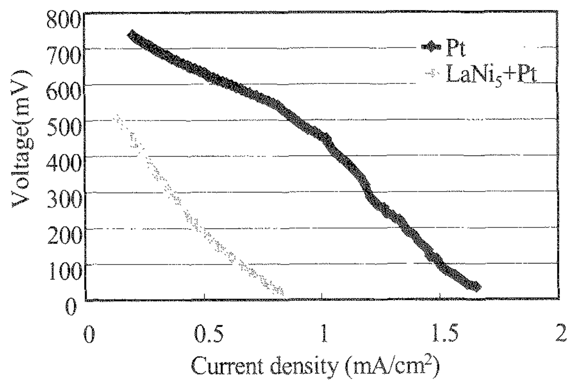

Fig. 4 The comparison of V-I characteristics of the test fuel cell and the standard polymer electrolyte fuel cell measured at RT.

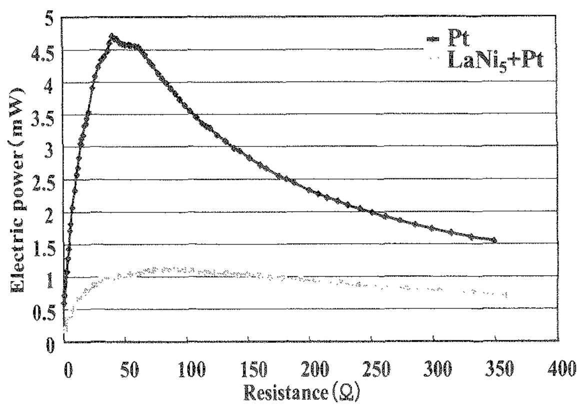

Fig. 5 The relationship between the electric power of the test fuel cell and the load resistance compared with the standard polymer electrolyte fuel cell measured at RT.

3.2 The change of the output by continuous electric power generation

Figure 6 shows the change of the output of the test fuel cells with and without $LaNi_5$ layer measured at RT under continuous electric power generation. Both fuel cells exhibited the maximum output at the initial stage of the generation. Thereafter, the output of the cell without $LaNi_5$ layer exhibited the tendency that falls gradually. The decreasing output attributed to the increase of hydrogen ion concentration in the polymer electrolyte and/or the contamination of electrode by the produced H_2O decreases the H_2 dissociative reaction on the electrode surface. In case of the cell with $LaNi_5$ layer, the low level output once decreases but after 40min increases again and exhibits equivalent value to the output of the cell without $LaNi_5$. This result can be considered as follows. The $LaNi_5$ layer is activated and also the surface structure is modified by the output generation. This results in almost the same output of the cell without $LaNi_5$ layer (electrode with only Pt). This indicates the possibility that hydrogen storage alloy of $LaNi_5$ may substitute at least partially the high cost Pt catalyst if the electrode with $LaNi_5$ layer is properly pretreated and activated.

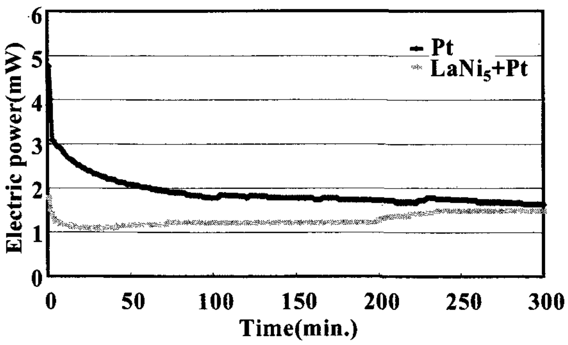

Fig. 6 The change of the output of the test fuel cell and the standard polymer electrolyte fuel cell at continuous electric power generation measured at RT.

3.3 The influence of change of hydrogen supplying pressure upon the output

Figure 7 shows the influence of change of hydrogen supplying pressure upon the output of the cells with and without $LaNi_5$ layer on the electrode. The output of the cell without $LaNi_5$ is drastically influenced by the change of the hydrogen supplying pressure, especially

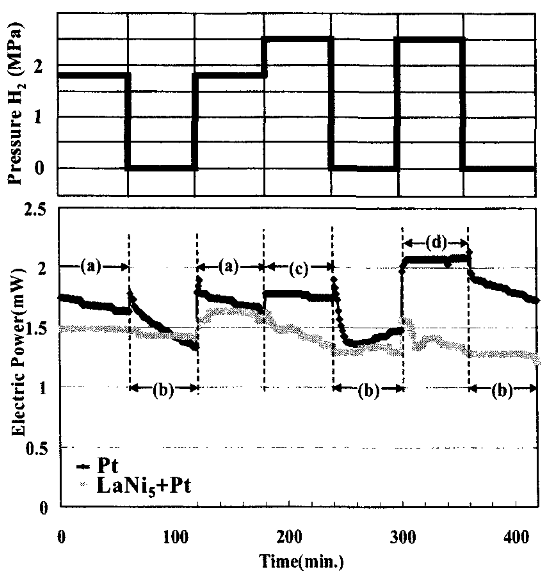

Fig.7 The influence of change of hydrogen supplying pressure upon the output of the test fuel cell and the standard polymer electrolyte fuel cell measured at RT. (a): the hydrogen gas was supplied at 0.18 MPa , (b): the hydrogen gas supplying was stopped, (c): the hydrogen gas supplying pressure changed 0.18 MPa to 0.25 MPa, (d): the hydrogen gas was supplied at stopping the supply (shown as (b)). The width of the fluctuation of the output in vertical direction in Fig.7 is ca.0.8mW for the cell without $LaNi_5$ layer. On the other hand, the cell with $LaNi_5$ layer exhibits less fluctuation (smaller than 0.4mW) even the supplying pressure is equivalently changed. This modification of more stable output of the cell with $LaNi_5$ layer is attributed to the hydrogen storage in the $LaNi_5$ layer on the electrode, which absorbs the fluctuation caused by the supplying pressure change. The hydrogen is once absorbed in $LaNi_5$ layer deposited on anode and H is supplied to electrolyte continuously resulting in more stable output. If the cell is connected to the natural energy sources, more stable output can be expected.

4 CONCLUSION

In this paper, a test fuel cell with $LaNi_5$ layer on the anode was constructed. We demonstrated the possibility that the hydrogen storage $LaNi_5$ layer could be expected as a part of catalyst and hydrogen storage buffer, which resulted in decreased use of Pt and more stable output under unstable fuel supplying. The catalytic effect can be expected, however, after some activation of the electrode, where the output once drops but recovered after several ten minutes of power generation. For the hydrogen supply with varying pressure, the $LaNi_5$ layer exhibits stable output of the cell, which results in the compensations for the instability of the natural energy utilization. More quantitative investigations are necessary for more detailed characteristics of the fuel cell with $LaNi_5$ hydrogen storage alloy.

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