Reversible Fuel cells using $LaGaO_3$ electrolyte and Fe fuel

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Introduction: Recently, reversible fuel cells, which operates both steam electrolysis and fuel cell, is now attracting much interest for averaging electricity from solar cell or wind mill. On the other hand, metal-air battery is also attracting much interest because of large energy density. In this study, we focused on the combination of solid oxide fuel cells (SOFC) with Fe fuel because iron was environmentally compatible and it has huge theoretical energy density. Because H_2 is easily formed with oxidation of Fe by steam even in low temperature such as 100℃, Fe is available for the fuel instead of H_2 for fuel cells.

Experimental: 8mol% Y doped ZrO_2(YSZ) and $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_3$ (LSGM) were used for the electrolyte. In order to confirm the concept proposed, the YSZ cell (Pt / YSZ / Pt) was connected on a zirconia oxygen sensor tube, which contains iron powder inside, then we can measure oxygen partial pressure during electrolysis and fuel cell mode simultaneously. For LSGM cell, Ni-Fe (9:1) and $Sm_{0.5}Sr_{0.5}CoO_3$ electrode were used for anode and cathode, respectively.

Results and discussion: In order to confirm the concept proposed, Pt / YSZ / Pt cell was used, and it was confirmed that electrolysis and fuel cell mode were successfully performed with ca. 250mAh/g-Fe at 1000℃. However, because of small efficiency on charge and discharge, we applied LSGM high oxide ion conductor for electrolyte of this Fe fuel cell. It was found that the observed power density was much improved and capacity of 640mAh/g-Fe, which is 45 % of theoretical efficiency of Fe fuel, was observed at 800℃ with 50mAcm^{-2} of current density. Lower operation temperature was also tried. By using LSGM cell, 817mAh/g-Fe was achieved at 600 ℃ with 10mAcm^{-2} of current density. Consequently, this study reveals that new concept for fuel cells using Fe fuel successfully works.

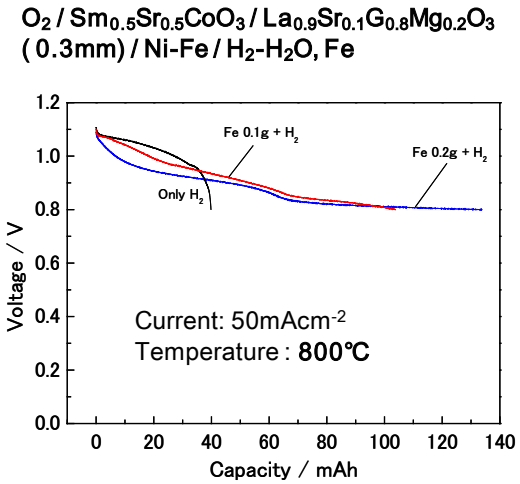

Figure 1 Discharge curves with the Fe fuel cell using Ni-Fe / LSGM / SSC cell introduced different amount of iron powder.