Rechargeable Fe-air battery using LaGaO$_3$ oxide ion conductor for electrolyte.

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Recently, rechargeable battery with large capacity is strongly requested from the viewpoint of energy storage and decrease in CO$_2$ emission. Li-air battery with organic electrolyte are now attracting great attention because of the high capacity, however, Li metal is high reactive and hydroxide or carbonate is easily formed. On the other hand, iron is rich in natural resource and compatible for environment. In this study, we proposed the new type of Fe-air rechargeable battery and for this purpose, we applied solid oxide fuel cell (SOFC) using oxide ion conductor of LaGaO$_3$ based oxide.

La$_{0.9}$Sr$_{0.1}$Ga$_{0.8}$Mg$_{0.2}$O$_3$ electrolyte was obtained by sintering at 1773K for 6h. Ni-Fe(9:1) was used for anode and Sm(Sr)CoO$_3$ was used for cathode. For discharge measurement, Fe powder was inserted into the alumina tube of anode side. The cell was fabricated with Al$_2$O$_3$ tube and sealed with molten glass.

Comparing with simple H$_2$ used cell, potential plateau was observed around 0.9 and 0.8 V, which could be assigned to the oxidation of Fe into Fe$_3$O$_4$ and Fe$_2$O$_3$, respectively. With increasing the amount of iron powder, discharge capacity at 0.9V increased suggesting that the oxidation of Fe occurs. The observed capacity of the present cell was corresponded to 900 mAh/g-Fe, which is close to the theoretical value to formation of Fe$_3$O$_4$. This suggests that the application of Fe for fuel of SOFC leads to a new type of metal air battery. On this cell, there is no influence of water and carbonate and so ideal as a new type of rechargeable battery. Oxidation state of Fe after discharge was analyzed with XRD and TG-DTA analysis. The results suggests that the oxidation of Fe proceeds to the formation of Fe$_2$O$_3$ and still many metallic Fe reminded. Therefore, further larger capacity will be expected by increasing the oxidation reaction of Fe.

This study reveals that combination of SOFC with Fe for a solid fuel is a new type of air battery with large capacity.