All Solid-State Iron-air Redox Battery for Advanced Energy Storage

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Metal-air batteries are an attractive option for electrical energy storage (EES) due to extremely high energy density and readily-available cathode oxidant (air). However, conventional metal-air batteries are limited by poor reversibility, fast capacity decade and electrode deformation, *etc*. Most of these problems are common in liquid based metal-air batteries.

To cope with those problems, we recently demonstrated an all solid-state iron-air battery [1-3] with a completely new energy storage mechanism centered on the solid oxide fuel cell (SOFC) as the electrical functioning unit and iron/iron oxide redox couple as the energy storage unit. Fig.1 shows the working principle of this battery: the free-standing iron-based redox couple is situated at the fuel electrode chamber of the battery where a mixture of H_2O/H_2 is present to mediate the electrical-chemical energy conversion. The governing chemistry of the battery is:

$$Fe + \frac{x}{2}O_2 \underset{charge}{\overset{discharge}{\rightleftarrows}} FeOx \qquad (1)$$

which suggests the nature of an iron-air battery. Different from conventional iron-air batteries, all of its components are solid materials, which avoids the strong chemical reactions occurred between liquid electrolyte and solid electrodes.

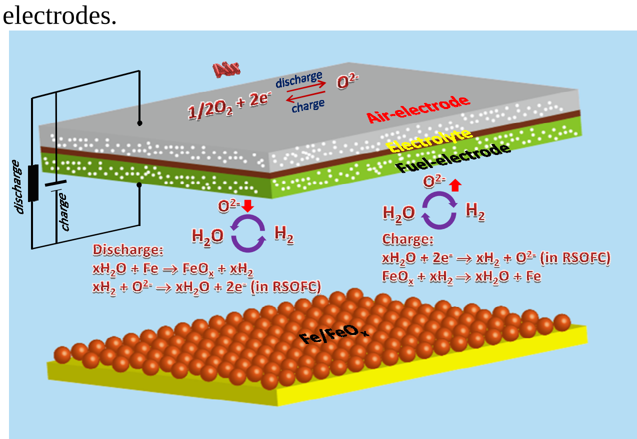

Fig. 1. Working principle of the all solid-state iron-air battery: Energy storage unit is decoupled from the electrode of the SOFC (A planar configuration is used for illustration purpose)

In our previous study, the all solid-state iron-air battery working at 800°C has been successfully demonstrated [1] and systematically studied [2]. In this study, we report our recent development in intermediate temperature battery (550°C). Fig. 2 shows the preliminary result of a most recently optimized iron air battery. Within one cycle of t=2 hours under a current density of 10 mA/cm^2, the newly developed battery yields a discharge specific energy of 1,271 Wh/kg Fe, which is up to 93.5% of maximum theoretical specific energy. It also demonstrated a round trip efficiency of 85.4%, compared with the CSE=1,489 Wh/kg Fe. All these results show that the all solid state iron air battery is a promising electrical energy storage mechanism.

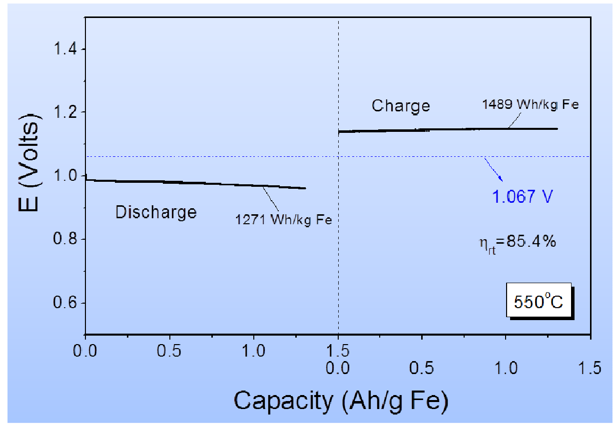

Fig. 2 One cycle performance of the optimized battery operated at 550°C with single-cycle duration of 2 hours under a current density of 10 mA/cm^2

References

[1]N. Xu, X. Li, X. Zhao, J.B. Goodenough, K. Huang, *Energy & Environmental Science* **4** (2011) (12) 4942.
[2]X. Zhao, N. Xu, X. Li, Y. Gong, K. Huang, *RSC Advances* **2** (2012) (27) 10163.
[3] X. Zhao, N. Xu, X. Li, Y. Gong, K. Huang, *ECS Transactions*, to be published in volume 50.