Primary Lithium/Air Cell and Pack Development

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Since the first reported Li-O_2 cell by Abraham[1], a number of groups have become involved in this relatively new and growing field for obvious reasons. With an open circuit voltage of approximately 3.0 V, the theoretical specific energy density for the reactions forming LiOH (Eqn. 1) and Li_2O_2 (Eqn. 2) are 5,200 Wh/kg and over 11,000 Wh/kg, respectively. Harnessing such potential in a safe and reliable battery system would be a tremendous accomplishment, with practical estimates for a fully optimized cell believed to be on the order 700 Wh/kg or more[2].

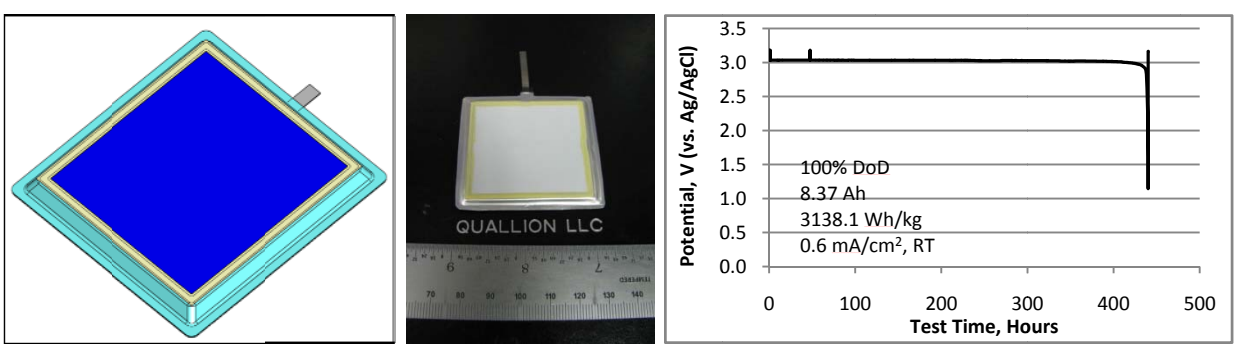
Equation 1: $4\ Li + O_2 + 2\ H_2O \rightarrow 4\ LiOH$
Equation 2: $Li + O_2 \rightarrow Li_2O_2$

Herein, we report on recent efforts to commercially produce aqueous primary lithium air cells and packs using a double sided protected lithium anode design[3]. Advantages of this lithium/air battery design include unlimited cathode material which is not stored in the cell, immersion in either aqueous or non-aqueous electrolytes, higher open circuit voltage than zinc-air with much higher specific energy densities, and negligible self discharge.

An eighteen month program was undertaken in April 2009 under CERDEC contract GTS-S-09-1-052 to design, scale up, and produce lithium/air cells and packs. Early efforts focused on optimizing a concept cell design and maximizing the energy densities through a series of engineering alterations. These changes in the initial design increased the theoretical energy density of the concept cell from 162 Wh/kg to 461 Wh/kg.

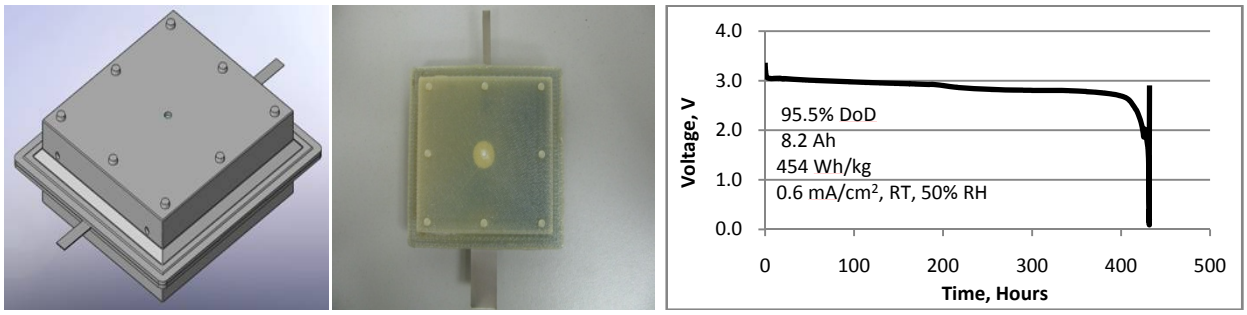
The protected lithium anode designed had a theoretical energy density of 3152 Wh/kg. Shown in Figure 1 is a representative discharge profile for such an anode at 0.6 mA/cm^2. As can be seen, the anodes coincide closely with the design, with an observed energy density for this particular anode of 3138 Wh/kg and complete depletion of the lithium metal.

Figure 1. Protected lithium anode (a) concept design (b) fabricated (c) discharge profile.



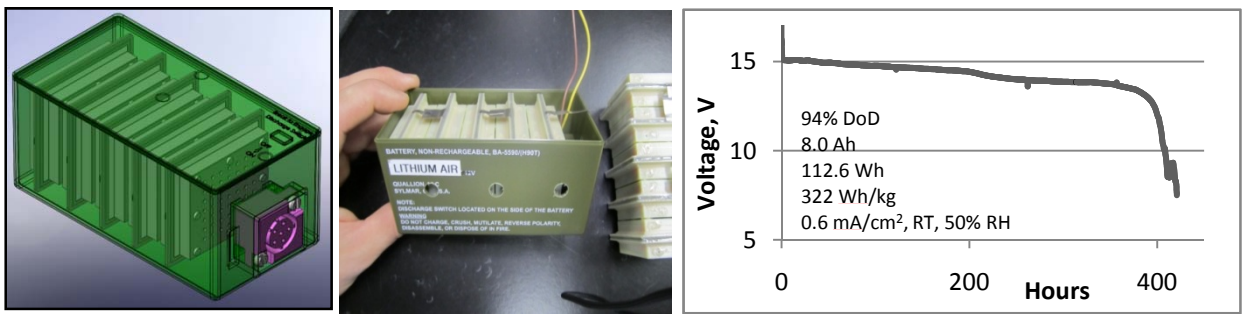
Full cells based on the design were then fabricated and optimized through a similar series of iterations which incorporated these anodes. The performance (Figure 2) exceeded the project goal of >400 Wh/kg at the cell level in April 2010.

Figure 2. Li/Air cell (a) concept design (b) fabricated (c) discharge profile.



Lastly, packs were contructed and tested. The design allowed for 5 cells to be placed inside a ½ BA pack (Figure 3) with observed energy densities on the order of 325 Wh/kg.

Figure 3. Li/Air pack (a) concept design (b) fabricated (c) 5S discharge profile



A summary of project results will be presented along with the latest efforts to implement second generation cells performing at >500 Wh/kg.

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[1] K. M. Abraham and Z. Jiang, *J. Electrochem. Soc*., **143**, 1 (1996).

[2] (a) T. Zhang et. al., *J. Electrochem. Soc*., **155**, 12 (2008). (b) B. Kumar et. al., *J. Electrochem. Soc*., **157**, 1 (2010). (c) T. Ogasawara et. al., J. Am. Chem. Soc., **128**, 1390 (2006)

[3] Visco, S., et. al. US7282295 (2007).