NEXCAP Whitepaper, March 2013

POTENTIAL APPLICATIONS OF MyBIG'S PSEUDO-CAPATTERY (NEXCAP) TECHNOLOGY

Energy efficient and robust power devices are the keys to overcoming the challenges of daunting climate change and the depletion of the earth's fossil fuels. As a result of an extensively diversified and globalised energy market, electrochemical capacitors, which are also known as supercapacitors, are becoming one of the vital energy-storage devices of the 21st century. This is because electrochemical capacitors bridge the crucial performance disparity between high energy density fuel cells or batteries and high power density traditional capacitors. However, the storage systems presently available in the market are optimised mainly for providing increased power capability in the seconds time range, whereas the minutes/tens of minutes range, which is relevant to power levelling applications, remains still not covered with a proper storage device. One type of device with the prospective of meeting these needs is NEXCAP. NEXCAP combines both electrical double layer and reversible intercalation mechanisms, resulting in an energy storage system that has both high energy and high power density, while maintaining a long cycle life. Both the energy and power density of a NEXCAP are achieved via few very important physical parameters including the effective surface area of the electrode, the capacity of the electrode active material (typically a transition metal oxide), the resistivity of the electrode active component, the conductivity of the oxide support, the molarity and conductivity of the electrolyte, and the advanced configuration of the device.

Objective

The objective of MyBIG's NEXCAP development is to custom fabricate electrode materials to provide a extensive range of electrochemical properties that result in long-lifetime, high-energy rechargeable energy storage system defined by fast charging and discharging properties in the minutes or tens of minutes range, covering the area of power and energy density previously uncovered by supercapacitors and Li-Ion batteries.

Approach

MyBIG has developed a class of novel materials for NEXCAP in energy storage applications. These novel NEXCAP electrode materials are composed of transition metal oxide nanoparticles deposited onto a conductive, high-surface-area sustainable conductor, and bound together with a polymeric compound. The NEXCAP is composed of this solid-state nanocomposite electrode with an environment-friendly electrolyte.

As these advanced nanocomposites can be custom-fabricated to offer a large range of electrochemical characteristics, the initial development has been focused in two main critical areas. The first is in the area of long-lifetime, high-energy rechargeable storage system where

high energy density can be achieved closed to that of Li-Ion batteries at a much slower charging-discharging period than the existing commercially available supercapacitors in the market and lifetime greater than >8000 charging-discharging cycles with minimal performance degradation. The second area is ultra-fast discharge, to cater for high-burst peak power requirements. The performance targets for both these areas include discharge times on the order of the minutes or tens of minutes, with energy density exceeding 20 Wh/kg and up to 30 Wh/kg and power density exceeding 10 kW/kg.

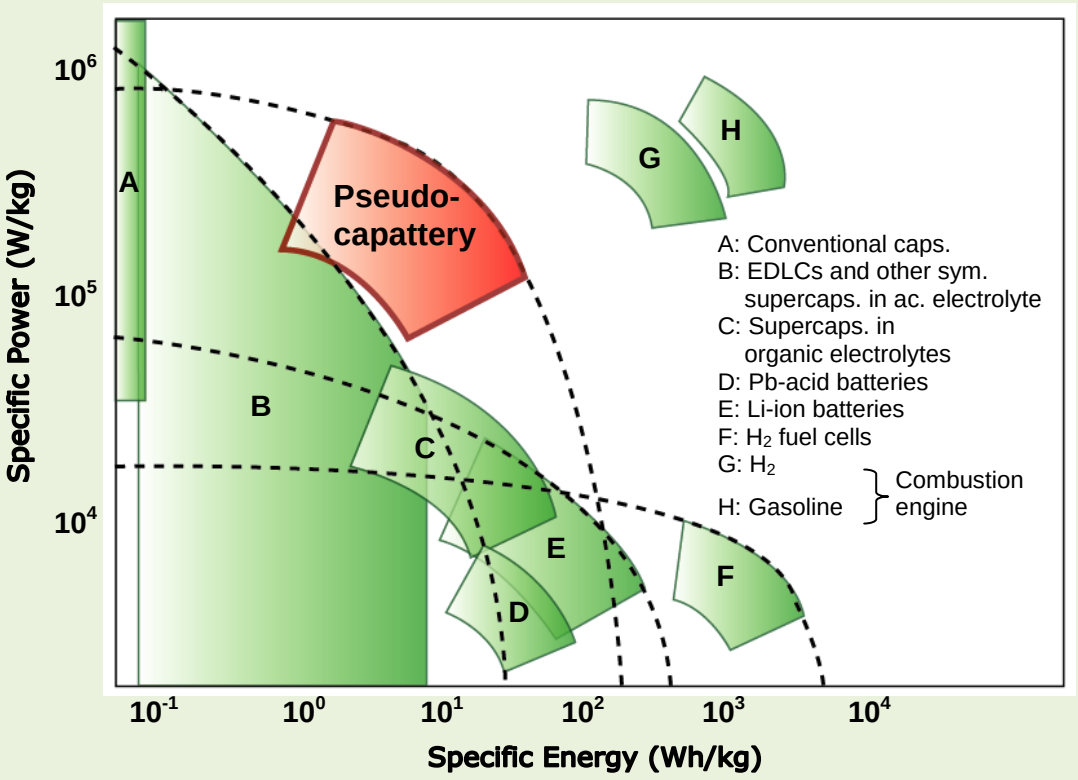

Figure 1. Ragone plot depicting recent MyBIG NEXCAP results

Recent experimental results, are shown in Figure 1. The horizontal and vertical axes plot the power density and energy density respectively. As can be seen in Figure 1, with new breakthroughs in MyBIG's research, NEXCAP is able to extend the region in the Ragone plot traditionally occupied by the existing Electrochemical Double Layer Capacitors (EDLC), commercial and organic supercapacitors to one with a higher specific energy and power in some cases. The right combinations of nanomaterials of high specific capacitance in the NEXCAP developed by MyBIG have resulted in the increase in specific power, thus, occupying the new region indicated in red which was previously unachievable by the symmetric and traditional supercapacitors. Nonetheless, it should also be noted that organic supercapacitors extend the specific energy further into the regions of the Li-ion battery, but lack the specific power possessed by MyBIG's NEXCAP. MyBIG's recent testing has concentrated on devices where the charging-discharging times are in the range of minutes to tens of minutes.

Application of NEXCAP Technology

The NEXCAP device can be used to successfully improve the performance of an electric or hybrid vehicle, or other device requiring bursts of power much larger than its steady-state requirement. If we assume the application requires steady-state power of 7.2 kW for 10 hours, with occasional peak power of 80 kW for a few seconds to tens of minutes at a time, we can use the data presented in Figure 1 to determine how this NEXCAP technology would be of benefit.

In a first case scenario, we assume that the vehicle is powered solely by Li-ion batteries, with energy density of 100 Wh/kg and power density of 0.1 kW/kg. Here, the total energy requirement of 72 kWh requires 720 kg of Li-ion batteries. These batteries can provide 72 kW of power at maximum, thus not meeting the burst requirement of 80 kW of the occasional peak power which may also cause the over-discharging of the Li-ion batteries if stretched. To achieve the required peak power, the Li-ion batteries would need to be sized-up with an extra 80 kg. By combining Li-ion batteries of 720 kg and 0.8 kg of NEXCAP however would allow this peak power requirement to be met, thus a savings of 79.2 kg of the total weight of the energy storage.

In a second case scenario, we assume that the electric vehicle is powered by Ni-Cd batteries, with energy density of 70 Wh/kg and power density of 0.06 kW/kg. Here, the total energy requirement of 72 kWh can be supplied by 1029 kg of batteries. These batteries are capable of providing 61.7 kW at maximum power, which is less than the maximum power requirement. To achieve maximum power of 80 kW, the vehicle would actually need to carry 1334 kg of Ni-Cd batteries, or an extra load of 305 kg. This extra power of 10.3 kW could alternately be supplied by a 2 kg Psedo-capattery using MyBIG's technology, for burst times of a few seconds to tens of minutes.

Similar performance benefits would be obtained when fuel cells replace batteries as the primary power source, as the energy density is higher and power density is lower for fuel cells. In this case, the MyBIG NEXCAP technology could provide burst power with less mass than either Li-ion batteries or commercial supercapacitors.