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Editorial

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Exploring Mg Ion Battery - A Sustainable Path towards Future Energy Storage Need

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Introduction

The latter part of the 20th century witnessed the commercialization of the first Li-ion battery system which triggered major research efforts worldwide mainly to provide viable energy storage solutions to the use of portable consumer and professional electronic devices. The last decade witnessed significant research activity in the area of energy storage systems for automotive applications largely targeting automotive transportation systems in the form of hybrid electrical vehicle (HEV), plug-in hybrid electric vehicles (PHEV) and the all-electric vehicle (EV) systems. Despite advances in materials chemistry and electrochemical technologies there are major hurdles to be overcome. This is primarily due to the burgeoning global demand for energy following the rapid growth of emerging economies in Asia, particularly in India and China and elsewhere along with the continued surge to sustain and improve the quality of life for an expanding world population. The concomitant harsh realization of depleting natural resources and fossil fuels and other environmental concerns further exacerbates the problem of generation, storage, transmission and distribution of energy, demanding greater attention towards addressing this massive global problem.

Over the last few years, with the concentrated efforts in conserving natural resources and providing a greener solution to the complex energy problems worldwide, there has been a major emphasis towards harnessing energy from wind, turbines, solar and other non-polluting renewable energy resources. Integration of these systems with the electrical power grid to provide effective storage, transmission and distribution (TD) for stationary and distributed power further adds to the complexity. With current generation of power grids approaching the end of their useful life, policymakers are calling for the construction of a new electrical grids or so-called ‘smart grid’ incorporating new technologies to allow for affordable and efficient power supply and the integration of power generated from renewable energy sources. The common vision for the electrical smart grid will be "a 21st century electric system that connects everyone to abundant, affordable, clean, efficient, and reliable electric power anytime, anywhere”. It is envisioned that the system will serve to provide a platform for consumer engagement in load management, national energy independence, innovation, entrepreneurship, and economic security [1]. There is therefore a tremendous demand to provide cost effective and efficient energy storage strategies to meet the growing demand of not only the transportation industry and the consumer market, but also industrial and government establishments, and residential complexes. Large scale electrical energy storage (EES) devices therefore need to be used for smart grid technology where an electrical power grid can be used to adapt energy production to energy consumption, both of which can vary randomly over time (Figure 1) [2,3].

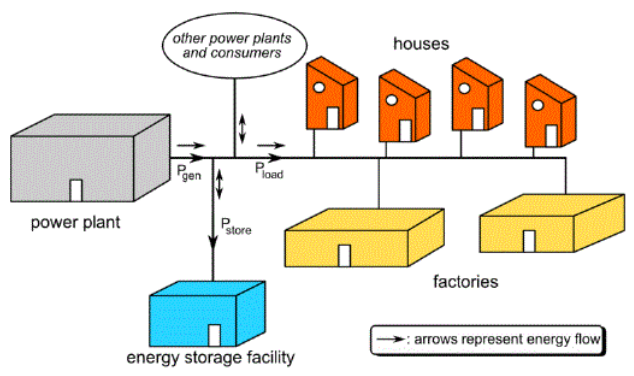

Figure 1: Electric grid with implemented energy storage facility.

Challenges

EES will also be critical for effective around-the-clock delivery of electricity generated from solar, wind, or nuclear sources. For example, EES devices will be required to store electricity generated from solar sources for use at night. Generally, energy use rises during the day, and electricity generated during the low-demand periods at night need to be stored efficiently for use during peak demand. EES devices are also needed to mitigate short-term fluctuations in power, which represent a major problem in the current electrical supply grid. Current EES systems fall far short to meet these future electrical energy supply needs requiring energy densities of 32 MW to support hundreds of homes and businesses connected to many miles of distribution circuits with 1-2 h back up of times. Without these advanced EES systems, the vision of transitioning to emerging technologies for alternative (non-CO_2 generating) electricity generation will not be realized. Current battery technologies comprising Li-ion, Vanadium Flow and Na-S fail to meet these challenging energy storage demands making it imperative to explore and identify new systems.

Mg-ion battery-a possible solution

Magnesium is lightweight and offers two electrons providing a theoretical energy density of 2205 Ah/kg [4] making it an attractive high energy density battery system garnering much attention in recent years. Mg is also abundant and is reported to be 24 times less expensive than Li [5,6]. Mg is more chemically stable (e.g. reactivity with environment and container materials) compared to Li and Na and consequently large scale Mg EES device have the potential to be simpler to engineer and pose less safety concerns compared to Li and Na technologies [7]. Moreover, Mg has been recently identified to be a novel biodegradable metal that can be easily excreted into the urine [8]. System with proper design and architecture could also lead to energy densities of 300-400 Wh/kg with open circuit voltage in a range of 2.0-3.5 V making it an attractive candidate for stationary power and electrical grid energy storage. Interest in Mg based systems was first reported by the excellent review reported by Novak [6] in 1999 following which research in this attractive system has been steadily escalated [9]. Of late, Pellion technologies have filed several patents identifying promising electrolytes, cathodes and commercially known Mg alloys in the AZ (Aluminum-Zinc) series [10]. However, there is still much scientific progress to be made in terms of identifying more efficient anodes comprising intermetallics (Mg_2Sn, Mg_3Sb_2) and their composites, compared to pure Mg, and improved cathodes ($MgMn_2O_4$, $Mg_xMo_6S_{8-x}Se_x$), and phenolate Grignard reagents (ROMgX; X=Cl, R=alkyl, aryl) based non-aqueous electrolyte systems (voltage windows greater than 3.5 V) which will be the focus of future research.

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