NANOBATTERIES

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INTRODUCTION:

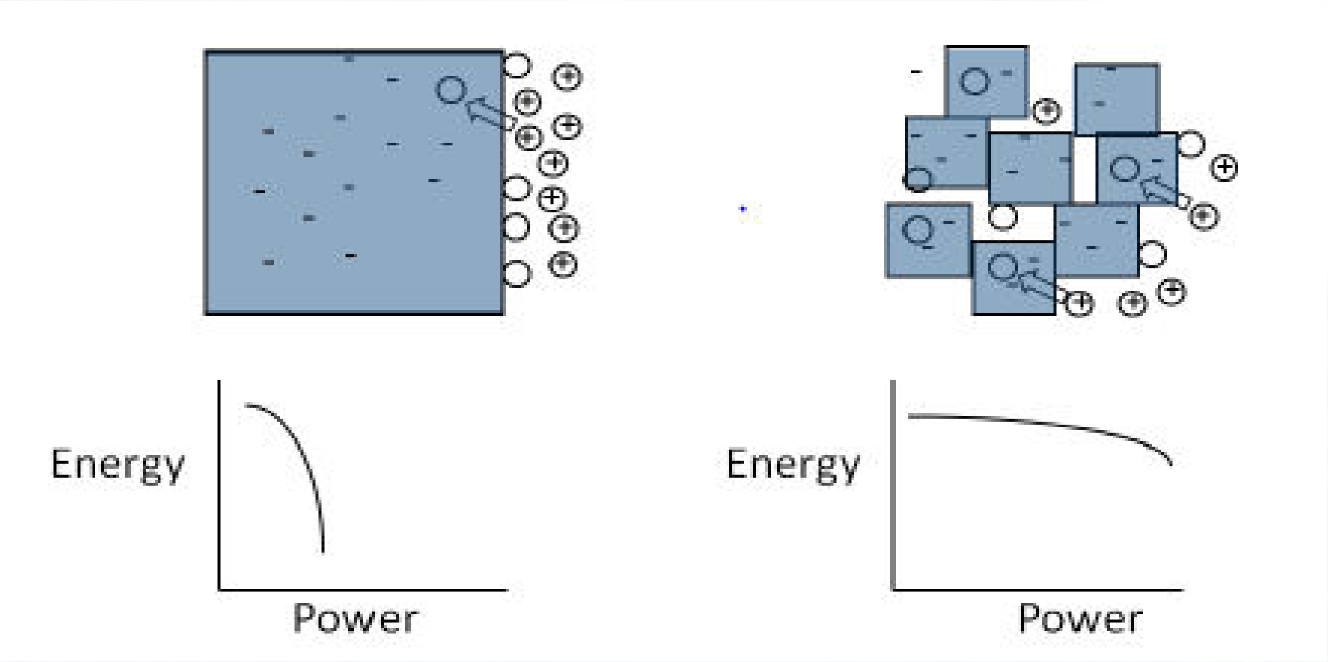
We're increasingly dependent upon our batteries, so finding ways of building ones with enhanced lifetimes would make a lot of people happy. Research on batteries has ranged from trying new materials to changing the configuration of key components. Nanobatteries are fabricated batteries employing technology at the nanoscale, a scale of minuscule particles that measure less than 100 nanometers or 10^{-7} meters. In comparison, traditional li-ion technology uses active materials, such as cobalt-oxide or manganese oxide, with particles that range in size between 5 and 20 micrometers (5000 and 20000 nanometers - over 100 times nanoscale). It is hoped that nano-engineering will improve many of the shortcomings of present battery technology.

Nanobatteries are generally described by three sections:
1)anode
2)cathode
3)electrolyte
In lithium ion batteries the anode is almost always graphite, so most research is being done on the cathode and electrolyte materials. By reducing the size of the materials used in a nanobattery, higher conductivity can be reached, leading to an increase in power, in both charge and discharge.

There are some technologies which are mainly used in nanobatteries:
1)Nanophosphate technology
2)Nanopore battery technology
3)Lithium ion battries (using lithium titanate)

NANOPHOSPHATE TECHNOLOGY:

The overall performance and reliability of an advanced battery system depends largely on the chemistry used in the cell.Nanophosphate should not be confused with standard lithium iron phosphate (LFP), which is has lower rate capability and Power.Nanophosphate is lithium ion battery cathode founded by professor yet-ming chiang and his group.Nanophosphate particles are divided into two groups i.e. Primary and secondary. Conversely, the chemical reactions created in the nanophosphate technology increase the cathode surface area with the electrolyte, which allows for faster lithium insertion and thus more power. At the same time, however, all of the bulk volume is still used to store energy.(as shown in given figure)

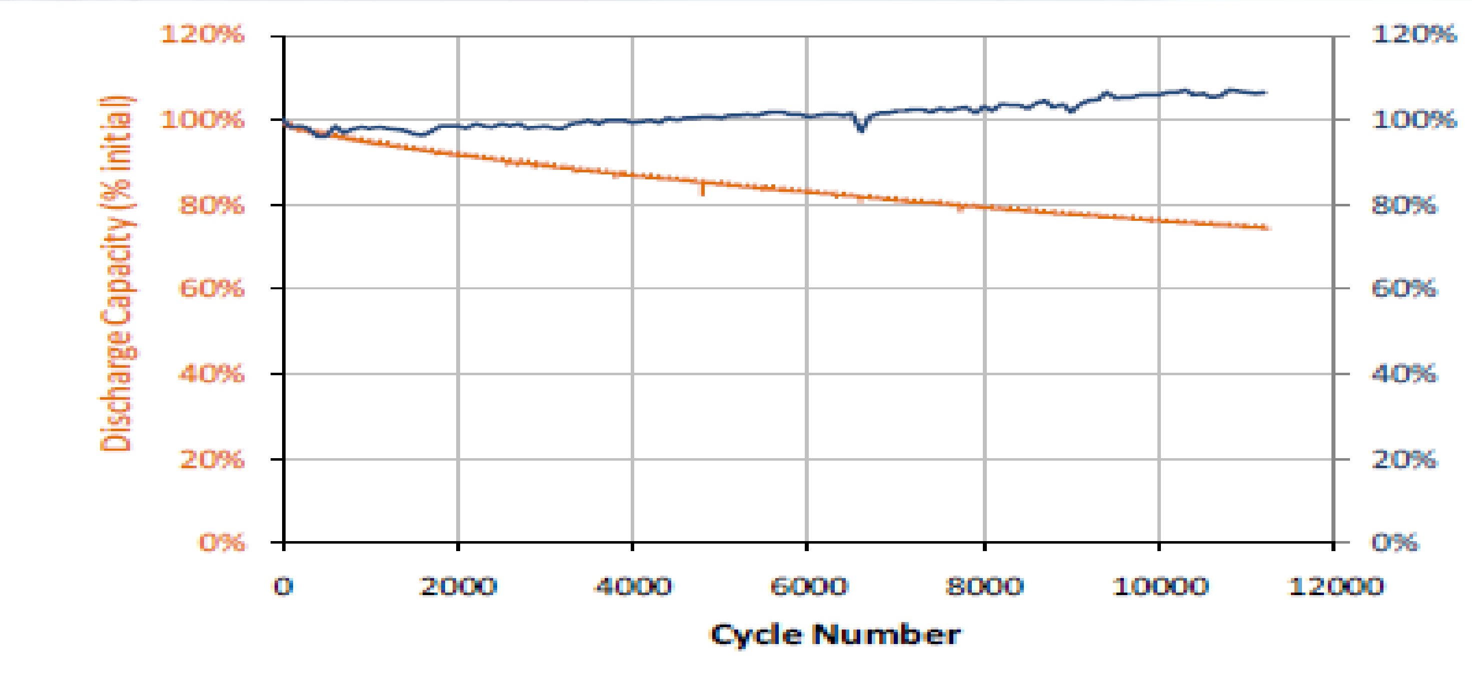


(Chemical reaction and energy/power balance of standard battery vs. Nanophosphate battery)

Another significant feature of the nanophosphate technology is the consistent power capability over a wide range of states-of-charge (SOC). Most battery technologies have significantly lower power capability at low SOC.

Nanophosphate has excellent abuse properties. In these chemistries, all of the lithium ions are transferred during a complete charge/discharge event. In the case of most metal oxide cathode materials, including cobalt and nickel-based materials, only half of the available lithium is transferred during normal operation. When those metal oxide cells are overcharged, the excess lithium from the cathode cannot be inserted into the anode, which is already completely full. The result is that the lithium plates onto the surface of the anode, creating a hazard since metallic lithium is much more reactive than ionic lithium. Since all of the lithium ions in the nanophosphate chemistry are transferred to the anode during charging, it is much less likely for lithium metal to plate onto the anode surface during an overcharge event.

Cycle life is typically defined as the number of times a battery can be charged and discharged before its capacity falls below 70 to 80 percent of its original capacity or nameplate energy. Similarly, calendar or shelf life is defined as the ability of a battery to maintain discharge and regeneration energy over time, irrespective of use conditions. In given fig, batteries designed using nanophosphate deliver more than 7,000 cycles when charged and discharged at a one-hour (1C/1C) rate.

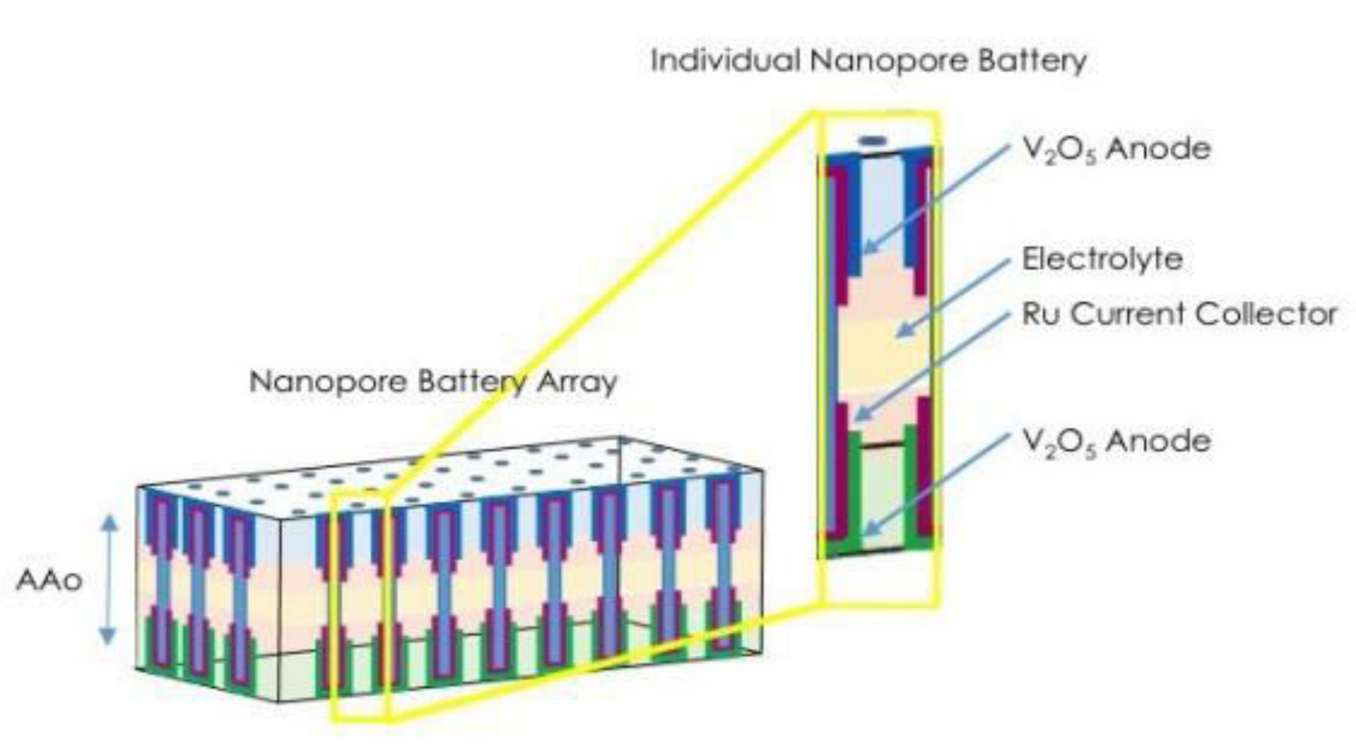


When subjected to calendar life tests at elevated temperatures, the prismatic cells are projected to have a lifespan of 15 years or longer in automotive applications. This battery is develoveped by a123.

NANOPORE BATTERY TECHNOLOGY:

Now, researchers have managed to restructure the materials in a nano-battery, then bundle lots of these individual batteries into a larger device. Previously, researchers had developed 3-D nanostructured batteries by placing two electrodes within a nanopore (made of anodic aluminum oxide) and using ultrathin electrical insulating material to separate them. While this system had improved power and energy density, use of such thin electrical insulators limits charge retention and requires complex circuits to shift current between them—it's difficult to retain the benefits of the 3-D nano-architecture due to spatial constraints of the material.

Instead of using wired circuits, liquid solutions of electrically conductive ions (electrolytes) have been used to connect battery circuits. However, nano-batteries that use electrolytes have shown low charge storage; moreover, when used in conjunction with 3-D structures, uneven ion concentration gradients resulted in uneven current densities. Recently, researchers have overcome these limitations through the design of a battery that more effectively combines several components. The new battery is composed of a parallel array of nanobatteries,.



each an individual nanotube containing electrodes and a liquid electrolyte confined within nanopores made of anodic aluminum oxide. Each nanotube was comprised of a current collector formed by an outer nanotube of ru and an inner nanotube of V_2O_5 as the energy storage material. Each end of the nanopore was coated with either V_2O_5 or a chemically modified form of V_2O_5, to serve as the electrodes—the cathode and anode, respectively.

The performance of both individual electrodes was determined (called a half-cell configuration), as was the full-battery construct containing both electrodes, in full-cell configuration. Both configurations showed excellent electrical storage retention and a long charge-discharge cycle lifetime. Electrical storage retention was ~80 mah/g (a bit less than existing lithium batteries) with more than 80 percent of initial energy storage retained after 1000 cycles. Compared to previous nanowire battery devices using the same material, this nanopore battery has triple the electrical storage capacity and an order of magnitude longer cycle life.

Researchers attribute the superior cycle lifetime to the coaxial tubular structure. The influence of this structure was investigated by comparing electrical storage obtained with the V_2O_5/ru nanotube configuration to that obtained with a V_2O_5/planar au arrangement. The nanotube configuration was found to have a much higher electrical storage potential than the planar arrangement.

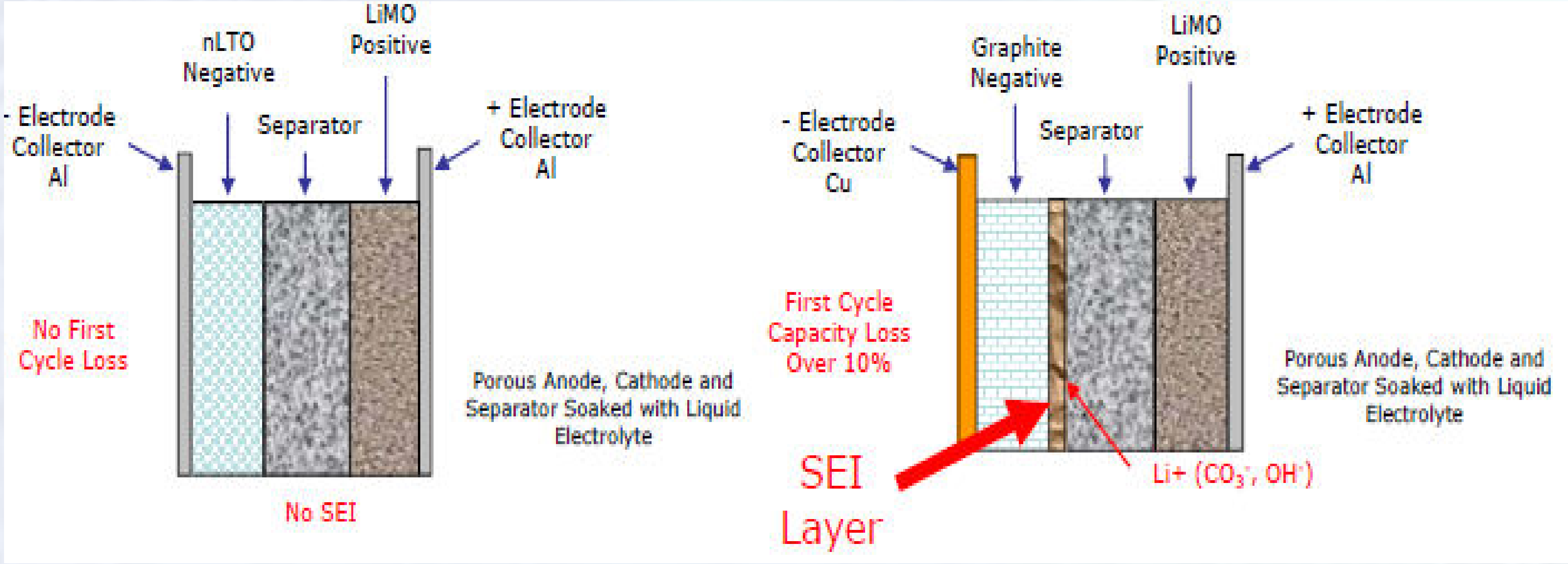
These researchers have demonstrated that properly scaled nanostructures are a viable option for improved battery constructs. An enhanced discharge lifetime and cycle lifetime could make this particular construct an option for future portable devices including phones, tablets, and more.

NANO-STRUCTURED BATTERY :

Lead-acid battery technology , conventional Li-ion technology etc. are failed to meet the requirements like extended life, safety, remote UPS(uninterruptable power supply) applications. And these technologies can't tolerate the abusive conditions like short circuit , over recharge , exposure to extremely high or low temperature , over discharge.

ALTAIRNANO company developed battery using nanotechnology which eliminates some drawbacks of conventional batteries. ALTAIRNANO's Li-ion technology is different then commonly used Li-ion technology. They replaced the graphite material which is used in conventional batteries with nano-structured lithium titanate.

(figure-1) (figure-2)



[Comparison between nano structured battery (*fig.1*) and traditional graphite battery (*fig.2*)]

COMPONENTS OF BATTERIES:

COMPONANTS	NANO LITHIUM TITANATE BATTERY	TRADITIONAL GRAPHITE BATTERY
Electrode collector(cathode side)	Aluminium	Copper
Anode	LiMO	LiMO
Cathode	nLTO	Graphite
SEI*	Not required	Li^{+}(OH^{-})
Electrode collector(anode side)	Aluminium	Aluminium

* (SOLID ELECTROLYTE INTERFACE)

CHEMICAL REACTION IN NANO LITHIUM TITANATE BATTERY :

$$Li_4Ti_5O_{12} + 3Li^{+} + 3e^{-} \rightarrow Li_7Ti_5O_{12}$$

(NANO LITHIUM TITANATE)

ADVANTAGES AND RESEARCHING COMPANIES:

Company	Product	Advantages
A123Systems	Lithium-ion battery with the cathode made from nano-phosphate.	Higher power, quicker recharge, less combustible than standard lithium-ion batteries
Mphase Technologies	Battery with chemicals isolated from electrode by "nanograss" when the battery is not in use	Very long shelf life
Altairenano	Lithium-ion battery with the anode composed of lithium titanate	Higher power, quicker recharge, less combustible than standard lithium-ion batteries
Zpower	Silver-zinc battery using nanoparticles in the silver cathode	Higher power density, low combustibility

Conclusion:

Many of us would like to believe that, by 2040, the world will be far along the path toward a green industrial future with renewable fuels providing the bulk of our energy supplies. The demand of energy is growing with increase in population. To fulfil these requirements nanotechnology is the most preferable technology because of it is green technology. In production of power source we can use Li-ion technology, Nano pore technology, Nano-phosphate technology etc.

REFRANCES:

- http://www.understandingnano.com/batteries.html
- http://en.wikipedia.org/wiki/Nanobatteries
- http://www.a123systems.com/lithium-iron-phosphate-battery.html
- Large format Li-ion batteries performance and applications by BOB MISBACK,ALTAIRNANO,Inc.
- PSMA NANO SESSION 1 TO 4.
- NANOPHOSPHATE® BASICS: AN OVERVIEW OF THE STRUCTURE, PROPERTIES AND BENEFITS OF A123 SYSTEMS' PROPRIETARY LITHIUM ION BATTERY TECHNOLOGY, A123 SYSTEMS, INC.