Expanding Applications from Electric Vehicles to Energy Storage Systems - Unique Technology Offering High Safety and High Power

From the electrodes of energy storage batteries mounted in the Nissan EV "Leaf" to the drive batteries of e-bikes and household energy storage systems, the forerunners of the new era of renewable energy are taking advantage of NEC's unique technologies

Readers may already know that Nissan Motor's EV "Leaf" became a front page topic by twice winning the Car of the Year Japan (2011-2012), and the RJC Car of the Year (2012) awards. But do you know that its key components apply products and technologies of NEC? NEC Energy Devices, Ltd. is a company currently attracting attention with its manufacture of the electrodes of storage batteries mounted on the "Leaf" and the battery packs for NEC's household energy storage system. The company specializes in the battery business and is currently developing and producing laminated type manganese lithium-ion batteries. Backed by the rising needs for environmental compatibility, the company started mass-production and shipment of electrodes in 2010. Already, the Wall Street Journal has reported that the Automotive Energy Supply Corporation, to which NEC Energy Devices ships electrodes, is the world's top shipper of lithium-ion batteries for EVs. NEC Energy Devices is planning further cost reductions and production enhancements aiming at continuing future growth. The power of the company and where such power comes from will be revealed in this report.

NEC's battery business features 20 years of history and unique achievements

NEC Energy Device, Ltd. was established in 2010 for the development and manufacture of lithium-ion batteries. Although it is now only two years since the present company was established, the precursor businesses and technological developments have a history of over 20 years (**Fig. 1**).

NEC has been pursuing battery business by focusing on compact batteries for mobile phones and digital still cameras for consumer use. Although the company names and management structures have changed a great deal since the establishment of the joint venture Moli Energy Limited in 1990. The unique NEC technology that supports the present NEC business was the manganese positive electrode material developed by the NEC research laboratories. After the start of the serious development

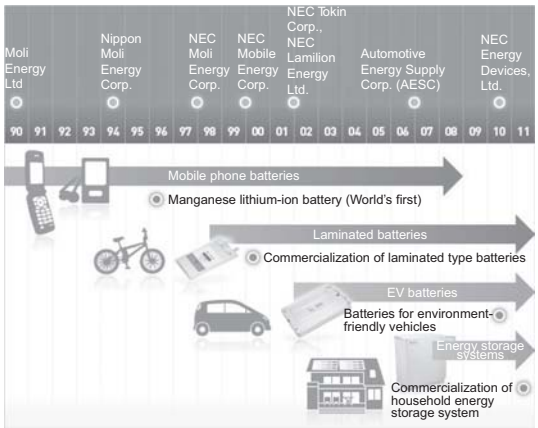

Fig. 1 History of NEC's battery businesses.

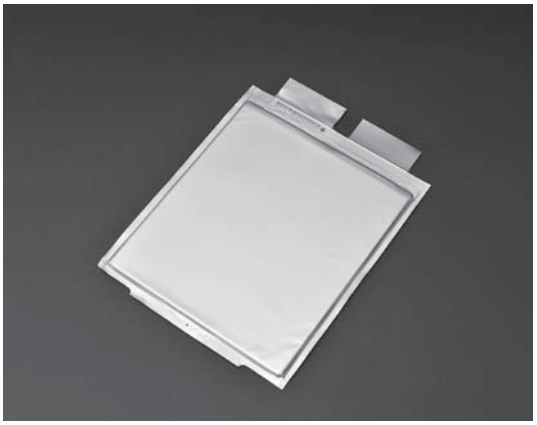

Photo 1 Laminated lithium-ion battery (cell).

of this material in the early 1990's, a manganese lithium-ion battery was marketed for a world first time and was applied to the mobile phone battery in 1996. Since then, the compact battery market has entered a competitive field focused on capacity, and the manganese lithium-ion battery is applied mainly in fields requiring high safety such as for games machines.

The unique technologies of NEC are most powerfully applied in the domains that feature large capacity, large scale and high safety. The pursuit of safety is seen typically with the laminated type storage battery developed in the year 2000 for use in power-assisted bicycles. Meanwhile, development of a storage battery technology for environmentally friendly vehicles was started from the early 2000's under the leadership of the NEC research laboratories. The electrodes for EVs business got under way in the year 2010 with the establishment of NEC Energy Devices, Ltd. In 2011, this company went on to develop battery packs for use in household energy storage systems.

Nissan Motor's "Leaf" is probably the EV product most widely known to the general public. The cells and battery packs used in the lithium-ion batteries mounted on "Leaf" are manufactured by Automotive Energy Supply Corporation (AESC), which is a joint venture of Nissan Motor Co., Ltd., NEC Corporation and NEC Energy Devices, Ltd. The shipment volume of the lithium-ion batteries of AESC was ranked highest in the world while beating many Asian competitors (with more than twice their shipment volume) by the Wall Street Journal of December 5, 2011 (comparing the 2011 total shipment volumes)*.

Unique technology that features high safety and a long lifespan: Meeting the needs for large-capacity lithium-ion batteries

Rechargeable batteries refer to cells that are usable repeatedly by recharging and are already very popular among general consumers. They can be classified into several types according to the materials used for their cathode electrodes, which include lead, nickel-metal hydride and lithium ions. From the viewpoint of battery structure, they can also be classified into the rolled-up type with which a jellyroll winding of the electrode and separator are inserted into cylindrical or rectangular containers and the laminated type with which the electrodes and separators are laminated and sealed or are housed in a can. Among these, NEC Energy Devices are specialists in the development and production of the "laminated manganese lithium-ion batteries" (**Photo 1**).

Mr. Masato Shirakata, the company's Supervising Manager, Development Division explains the reason for this strategy:

"The properties of rechargeable batteries vary depending on the materials used. The features of the lithium-ion battery are high volume, high specific energy and about three times higher

* "Battery Companies in Need of a Boost" THE WALL STREET JOURNAL, DECEMBER 5, 2011 http://online.wsj.com/article/SB10001424052970204443404577051832763572816.html

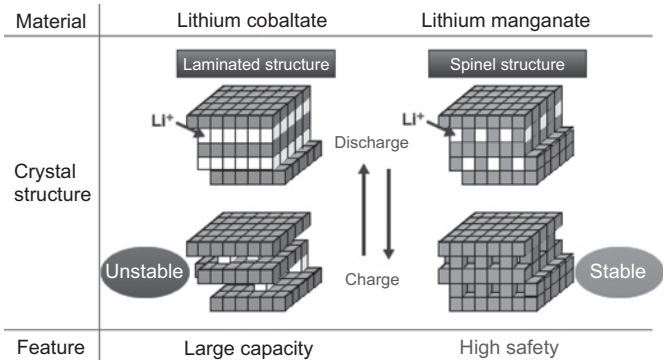

Fig. 2 Structures and features of cathode electrode materials.

Material	Manganese Mn	Cobalt Co	Nickel Ni
Power density	◎	○	○
Energy density	○	◎	◎
Lifespan	△→○※	○	○
Safety against overcharge	◎	△	△
Material cost of main element	◎	△	△
Environmental load tolerance	◎	△	△

※Improved by NEC's unique technology. ◎: Very good ○: Good △: Poor

Table Comparison of cathode electrode materials.

operating voltage than the nickel-metal hydride (Ni-MH) and nickel cadmium (Ni-Cd) batteries. In other words, they are compact and lightweight but can output high energy. Storage batteries are expected to increase in size in the future, and the key to the adoption of the Li ion battery will lie in the fields of safety and cost.

The reason we use manganese and not cobalt or nickel, for the cathode electrodes of lithium-ion batteries is because of its stable crystalline structure called the spinel structure. This stable crystalline structure of the material even in an overcharged state enables high product safety (**Fig. 2**). This is why the high energy, lithium-ion battery can be used safely with EVs and with HEVs (Hybrid Electric Vehicles). In addition, since manganese occurs in large deposits, a stable supply is readily available and the material procurement cost can be reduced."

Considering such a wide range of excellent properties, it seems that the manganese lithium-ion battery market might be crowded with many competitors. But Mr. Shirakata continued, "We have the advantages of a unique technology and a proven mass-production capability.

Manganese materials do have the issue that they have a shorter charge/discharge life than other materials. However, NEC's unique technology has succeeded in extending the lifespan (**Table**). The use of the laminated type design has improved safety thanks to its excellent heat radiation properties and output power has been increased thanks to its large current handling capability.

The origin of the EV electrode business of the NEC Group was when Nissan Motor recognized the attractive prospects of NEC's unique technology and proceeded to participate in joint development with NEC. However, there have been many twists and turns in the development of the mass-production of the electrodes that was assigned to us. The electrode is manufactured using the three process steps of producing slurry from the electrode material, coating it on a sheet and compressing the dried sheet. We sorted out the anticipated problems in the prototyping stage by fabricating a small number of prototypes. When proceeding to large scale mass-production, we gathered staff with experience in the coating process of various devices to help mature suitable techniques by integrating the knowledge already gained in NEC's MONOZUKURI Industrial Innovation and Standardization Division. In particular, with regard to the quality, we incorporated our expertise in 100% in-line inspection and impurity elimination for each process that is considered to be suitable for application in the EVs. We believe that the quality and production of our EV electrodes are currently much superior to those of our competitors."

Is it possible then for the company to continue to retain its superior position in the future? Mr. Masaki Kondo, Department Manager of Business Planning Department, answered: "The device business should beat worldwide competition with Korean and Chinese enterprises. Though we were able to lead in the beginning, we cannot rest with regard to improvements for production capabilities and cost reduction. We plan to enhance collaboration with NEC research laboratories and the MONO-

Photo 2 Household energy storage system.

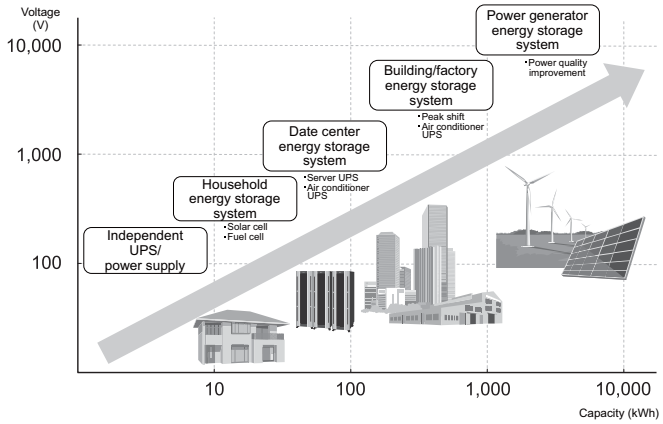

Fig. 3 Deployment in the energy storage market.

ZUKURI Industrial Innovation and Standardization Division for increasing the speed and scale of the production facilities and for developing a basic material technology so that continual technological innovations are possible."

Applications migrating from EVs to household energy storage systems

Since the 2011 Tohoku Earthquake, the Japanese Government has been undertaking a review of its energy policies, while the awareness of the people toward energy saving is also changing significantly. As there is also the global-scale issue of reducing the environmental load of carbon dioxide, strategies for the integration of communications and electrical energy supply based on new concepts such as the smart grid are being proposed in various countries and regions. All of these trends are serving as a spur to the large-capacity battery business, which is also being witnessed in the expansion of the fields of applications of the products supplied by NEC Energy Devices. Such representative applications are the EV battery for the Nissan "Leaf," etc., the drive batteries for power-assisted bicycles (e-bikes), power-operated wheelchairs, and the household energy storage system for which NEC started shipments in July 2011 (**Photo 2**).

The energy storage system is a product responding to the rising needs of electricity saving. It can reduce electricity consumption by charging the electricity generated by a photovoltaic system or purchased in the nighttime with low power demand and discharging it in the daytime. The core devices of this system consist of a control system that connects the electricity to a household distributor panel and the lithium-ion battery packs produced by NEC Energy Device.

With regard to the future deployment of the company's business, Mr. Kondo said:

"Our main business for the present is the production of EV electrodes. The EV market has a much larger scale than the existing electronic equipment market. For example, the electrodes used in a single cell of the lithium-ion battery for an EV is equivalent to about 50 lithium-ion batteries for a mobile phone. Since about 200 units of these cells are mounted per EV and the sale of Nissan "Leaf" has reached about 20,000 in the year after the launch, we have already shipped batteries equivalent to about 200 million mobile phones. While the worldwide new vehicle market has a scale of about 70 million a year, the sale of 20,000 vehicles is a very small fraction of the anticipated volume of battery shipments. This fact demonstrates how huge the potential market scale will be. Since the EV market is expected to grow further in the future, we will continue to enhance the development and production of our batteries.

The size of the market scale is an important factor in the development of device markets. With the drive-force batteries, we are looking for markets that can meet this scale requirement, and we think that the e-bike markets in China and Southeast Asia are the most promising candidates. We are presently demonstrating products of low cost with high added values that can compete evenly with the gasoline driven machines and the lead battery based e-bikes.

From the standpoint of a company of the NEC Group, the energy storage system market is very important because it can be the core of smart grids. We will develop battery packs that service the core energy storage systems. Previous small-scale UPS (Uninterruptible Power Supplies) are going to evolve into household-oriented products and the applications are expected to expand at various scales in offices, buildings and factories as well as in the power generation plants (**Fig. 3**). We are planning to hasten the development of technologies and products with long life spans and large capacities in collaboration with NEC's Smart Energy and Green Business Operations Unit."

From the EV market to the energy storage system market, we must not take our eyes off the inevitable growth of the NEC Energy Device market.

"We hope that the products that we manufacture will contribute to the implementation of the NEC Group Vision for 2017, 'a leading global company leveraging the power of innovation to realize an information society friendly to humans and the earth.' We have taken off as an electrode business company, but the full maturity of our battery business remains to be experienced in the future.

Mr. Kondo stated at the end of the interview that "NEC Energy Devices is a company that was built on the expertise of many forerunner organizations of the NEC Group, but we hope to build a new internal corporate culture and also to succeed in the battery business."

Business operations

NEC Energy Devices, Ltd. is tackling the development, manufacture and sale of large-capacity laminated lithium-ion batteries and their electrodes. The products of the company are used in EVs, e-bikes and power-assisted vehicles and also as the core devices of the energy storage systems for households and large electrical grids. They are expected to become the core products of the growing environment and energy business of the NEC Group.

Profile

SHIRAKATA Masato
Chief Manager
Development Division

KONDO Masaki
Department Manager
Business Planning Department

Corporate Profile

Company Name	**NEC Energy Devices, Ltd.**
Head Office	1120, Shimokuzawa, Chuo-Ku, Sagamihara, Kanagawa 252-5298, Japan
Overseas Office	NEC Energy Devices (Wujiang) Co., Ltd. Jiangsu, China (Manufacture of batteries for driving motor-assisted bicycles)
Established	April 1st, 2010
Capital	400 million yen (NEC100%)
Major Operations	Development, manufacture, sale, and maintenance of large-capacity laminated lithium-ion rechargeable batteries and electrodes, and the products about environment and the energy field
Representative	Mamoru SATO, President
Employees	NEC Energy Devices, Ltd.: 481 (Dec, 2011) NEC Energy Devices, Ltd. and Consolidated Subsidiaries: 771 (Dec, 2011)
Website	http://www.neced.co.jp/

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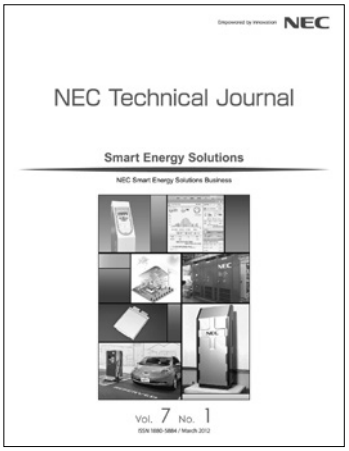

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