Development of Large-Capacity Laminated Lithium Ion Rechargeable Battery (High Power Type)

ZAMA Kouichi, KUMEUCHI Tomokazu, ENOMOTO Shinsuke, DAIDOJI Takao

Abstract

The applications of lithium ion rechargeable batteries have recently been expanding in the high current requirement fields as these devices begin to be used in electrical tools such as for impact drivers and hammer drills.

NEC TOKIN has newly developed and commercialized a 3Ah class, high power, large-capacity lithium ion rechargeable battery by applying its expertise in materials technology and associated techniques that have been gained in the commercialization of large-capacity batteries. The newly developed high power, large-capacity lithium ion rechargeable battery, "IML126070" is capable of a continuous 30A discharge and a quick 13-minute discharge (90% recharging) due to; 1) the use of electrode materials proven in the development of electrically assisted bicycles; 2) a review of electrode specifications to provide compatibility with high current discharge and rapid charging, and; 3) improvement and optimization of the current collector structure to provide compatibility with high current and higher energy levels.

Keywords

high power, rapid charge, manganate lithium ion rechargeable batteries, power tools, laminate case

1. Introduction

The lithium ion rechargeable battery is used widely in mobile equipment such as mobile phones and digital still cameras as its larger capacity per weight or volume than the nickel-cadmium and nickel-hydride batteries facilitates reduction in the overall size and weight of the equipment. In addition, it is free of environmentally polluting substances such as cadmium, lead and mercury and is also attracting public attention as an environmentally friendly type of battery. At NEC TOKIN, we recognized its stable crystalline structure and were aware of the abundant availability of manganese. We were thus able to commercialize a world first manganese lithium-ion rechargeable battery. We are presently offering various products including rectangular and high-capacity laminated batteries to the market[1-4] for use according to applications requirements.

Lithium ion rechargeable batteries have recently begun to be used in power tools and for other high current and mobile equipments.

Due to these market trends, we have newly developed and commercialized the "ILM126070," a 3Ah class, high power, large-capacity lithium ion rechargeable battery. This was achieved by applying our commanding position in materials technology and related techniques that have been cultivated via the commercialization of large-capacity batteries. In this paper, we will describe and introduce the new IML126070.

2. Product Characteristics

The newly developed IML126070 uses an anode made of lithium manganate that has been commercially proven for high capacity laminated batteries for use in electrically assisted bicycles and a cathode made of graphite. The electrode specifications and the current collector arrangement are improved and optimized to deal with a high current output. The following sections describe the details.

2.1 Design and Form

Table 1 shows the design, weight and other characteristics such as the high 120Wh/kg weight/energy ratio of the IML126070 and **Photo 1** shows the external view. The most

Table 1 Characteristics of IML126070.

Item	Characteristics
Thickness	12mm
Width	60mm
Length	70mm
Weight	87g
Capacity	2.7Ah
Impedance	5mΩ @1kHz

Photo 1 External view of IML126070.

significant feature of the exterior is that the outer case uses an aluminum based laminate film to enable size reduction. During the development of this product, we placed emphasis on achieving a high current discharge by improving the arrangement of the current collector, which collects current from inside the battery and also on the output terminals.

2.2 Battery Configuration

Fig. 1 shows the main configuration of the IML126070. It was fabricated a layered form by stacking the elements in the order of cathode (graphite material) cut in a rectangular shape, separator and anode (lithium manganate material). We then placed it in a laminated container, injected electrolyte solution and sealed it. This method of manufacture was identical to the previous large-capacity laminated type batteries of NEC TOKIN. The IML126070 is capable of using a large number of electrode terminals and is therefore suitable for a high current discharge[5].

The ILM126070 also features the following improvements and optimizations for meeting market requirements for current increase and size reduction.

(1) The electrodes are newly designed and the number of layered elements is optimized to enable high current flow.

(2) The design and material of the output terminals are changed in order to deal with a continuous discharge current of 30A. This improvement has led to a characteristically low heat generation even under the continuous discharge of high current.

(3) The current collector arrangement inside the battery is reviewed in order to enable size reduction without compromising the high current discharge characteristic.

(4) The electrode layering method employs the traditional method already proven in mass-produced products to ensure high levels of safety and reliability.

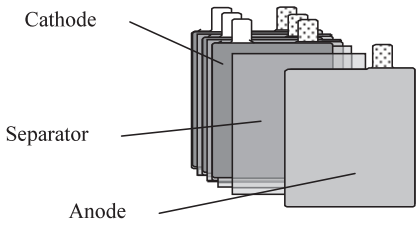

Fig. 1 The electrode layer structure inside the battery.

2.3 Battery Characteristics

As shown in **Fig. 2**, the IML126070 is usable in a 27A (10C) continuous discharge at a variable discharge rate and discharge capacity of 2.7 Ampere hours. The discharge capacity is the value obtained by charging a cell at a constant current of 2.7A up to 4.2V in a 20°C environment and then charging it at a constant voltage, recharging it for a total of 2.5 hours (this procedure will hereafter be referred to as rated charging) and discharging it at a constant current.

The internal impedance was 5mΩ (measured at 1kHz AC) to enable high current discharge. **Fig. 3** shows the internal resistance (10-second value) obtained with actual DC charge/discharge. It was 11mΩ (@ 50% charge) so a high 100A current can be discharged for up to 10 seconds.

The internal resistance was calculated by adjusting the

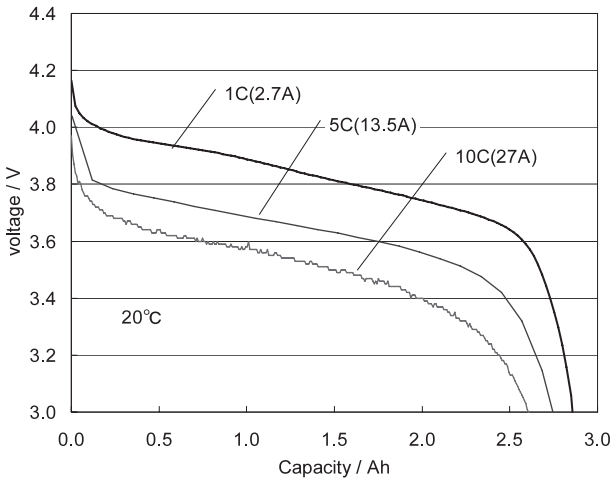

Fig. 2 Discharge curve of IML126070.

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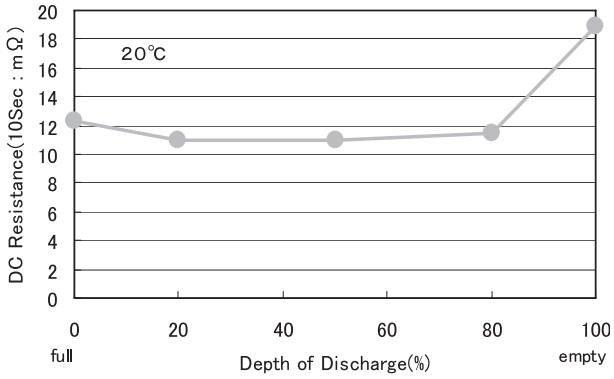

Fig. 3 DC resistance of IML126070.

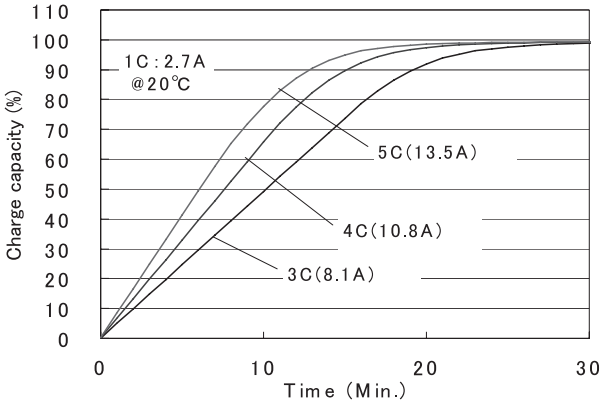

Fig. 4 Charge characteristics of IML126070.

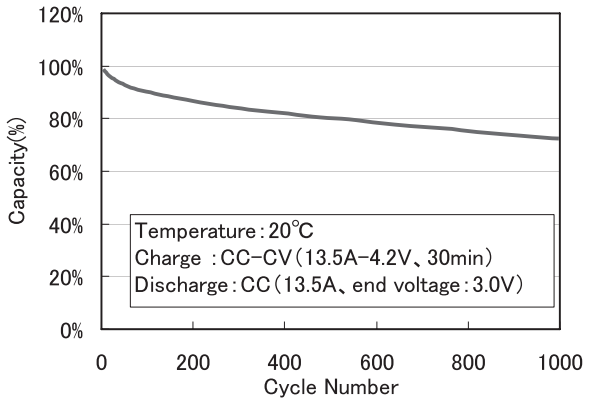

Fig. 5 5C cycle characteristics of IML126070.

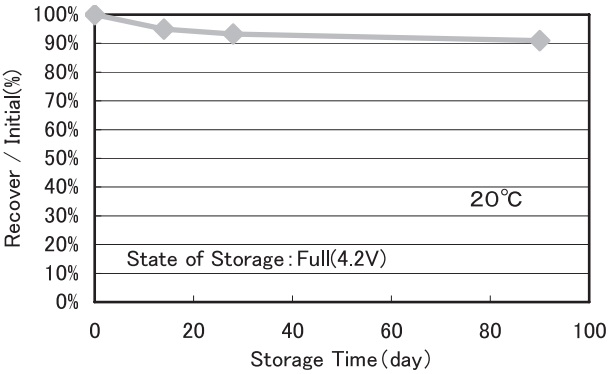

Fig. 6 Storage characteristics (recovery characteristics) of IML126070.

battery to the target charged status, discharging or charging it for 10 seconds at a constant current by varying the current value at 2 or more points and then measuring the voltage and current values 10 seconds later. These values provide the relationship between the voltage and current, and its inclination corresponds to the internal resistance value[6].

For the charge characteristic, 5C(coulomb) charging is possible as shown in **Fig. 4**, and a quick charge to 90% is possible in 13 minutes. This charge characteristic has been achieved by improving the electrode specifications.

Fig. 5 shows the results of 13.5A (5C) charge/discharge cycles. It shows that a capacity retention rate of 70% is obtained after 1,000 cycles and an absence of no significant degradation due to a high rate of charge/discharge is witness to the reliability. These results confirm that the quick charge does not cause any practical problem.

The storage characteristics are also at an identically practical level to the previous large-capacity laminate battery as shown in **Fig. 6**. **Fig. 7** shows that due to the use of an electrolytic

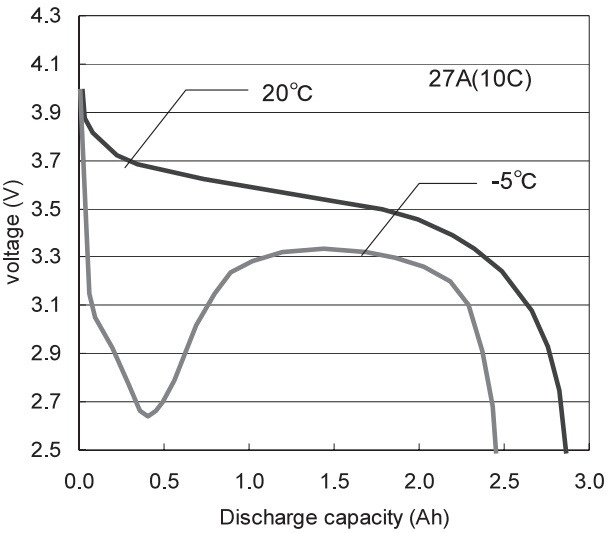

Fig. 7 Low-temperature characteristics of IML126070.

solution, the IML126070 can achieve a high low-temperature characteristic in spite of its high charge/discharge rate.

The high reliability of the IML126070 is also assured by its low inherent heat generation thanks to the low impedance operation for high current compatibility.

3. Battery Applications

A power tool battery assembly was fabricated using four IML126070 units and the characteristics were evaluated as shown in **Table 2**. The characteristics shown in the table are values obtained from the assembly of four IML126070 units stacked and connected in series, and do not take the protection circuitry and devices into consideration (**Photo 2**).

With regard to the fabrication of the battery assembly, we improved the traditional structure for series connection of batteries by enlarging the welding area on the external terminal connection sections and reducing the current paths. This strategy has enabled a space-saving, high current discharge-compatible and low-impedance battery assembly.

Table 2 Characteristics of the power tool battery assembly.

Item	Characteristics
Thickness	70L×60W×48T mm
Mass	350 g
Voltage	12.0～16.8 V
Capacity	2.7Ah
Impedance	20mΩ @1kHz

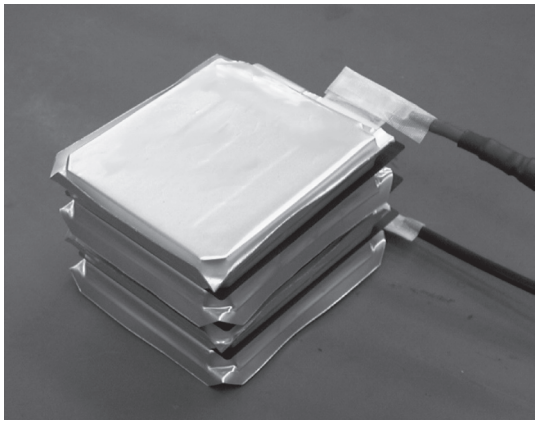

Photo 2 Appearance of the power tool battery assembly.

4. Conclusion

In the above, we outline the characteristics of the newly developed IML126070, a large-capacity laminate lithium ion rechargeable battery. As the market for large-capacity, high power applications anticipates much from the high reliability and excellent characteristics of the lithium ion rechargeable battery, the market for this battery will certainly grow significantly in the future.

At NEC TOKIN, we are advancing the development of back-up power supplies and large batteries for electrically assisted bicycles in order that we may propose more new products featuring larger capacity and a higher current discharge capability as well as higher reliability.

In closing this paper, we would like to express our gratitude toward all those who were concerned with or assisted in the present development.

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Authors' Profiles

ZAMA Kouichi
Manager,
Laminate Business Promotion Dept.,
Battery Division,
NEC TOKIN Corporation

KUMEUCHI Tomokazu
Assistant Manager,
Laminate Business Promotion Dept.,
Battery Division,
NEC TOKIN Corporation

ENOMOTO Shinsuke
Staff,
Laminate Business Promotion Dept.,
Battery Division,
NEC TOKIN Corporation

DAIDOJI Takao
Staff,
Laminate Business Promotion Dept.,
Battery Division,
NEC TOKIN Corporation

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Related URLs:

http://www.nec-tokin.com/product/lithiumion/summary.html

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