

High performance Li-S secondary battery using CNT electrode

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In recent years, the lithium-sulfur (Li-S) secondary battery has been energetically researched worldwide as a good candidate for next-generation secondary batteries. The sulfur active material has a theoretical capacity of 1675 mAh g^{-1} and is abundant and highly inexpensive. However, several issues are associated with the use of Li-S secondary batteries, such as low utilization due to the insulating property of sulfur and the redox shuttle phenomenon caused by the dissolution of polysulfides generated during the discharge process.

In the present work, we have developed a Li-S secondary battery using the carbon nanotube (CNT) technology. Multiwalled-CNTs were directly grown on a nickel current collector by using the thermal chemical vapor deposition (CVD) method. The CNT films were used as the electrode for the Li-S battery. The S-CNT cathode was fabricated by impregnating it with molten sulfur. Then, sulfur powder was uniformly placed on the CNT film and heated at more than the melting point of 388 K. Our CNT has a diameter of 10-15 nm and a length of 100-500 μm . Therefore, the CNT electrode has a wide reaction area owing to its large specific surface area. In addition, the active materials can react rapidly because the electrons quickly access through the CNTs that connect directly with the current collector.

We reported on coin-cell-type Li-S batteries with a high sulfur loading amount of up to 20 mg cm^{-2} by using CNT electrode [1]. An energy density exceeding 300 Wh kg^{-1} was obtained by this sulfur loading amount, but it could only be operated at a low current density (0.25 mA cm^{-2}). We considered that the conductivity of the CNT became insufficient due to the increase in sulfur content in the electrode. Therefore, we attempted to increase the number of CNTs by using embossed Ni foil with larger surface area than conventional Ni foil. The internal resistance of the electrodes could be reduced even if the length of the CNTs was about half of CNT grown on conventional Ni foils. By using the embossed Ni foils, we confirmed operation of Li-S battery with sulfur content of 15 mg cm^{-2} at a high current density of 1.0 mA cm^{-2} .

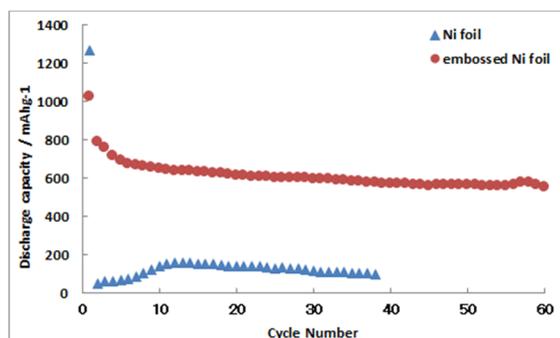


Fig. 1 Cycle characteristics of Li-S coin cell using 15 mg cm^{-2} sulfur loading CNT cathode. Initial discharge current density is 0.5 mA cm^{-2} , and thereafter it is 1.0 mA cm^{-2} .

Reference:

[1] Y. Fukuda, presented at The 18th International Meeting on Lithium Batteries, Chicago, 2016(unpublished)