Fabrication of transparent all-solid-state thin film lithium ion battery

Ji-Won Choi
Yaelim Hwang, Haena Yim
Korea Institute of Science and Technology (KIST), 5, Hwarang-ro 14 gil, Seongbuk-gu, Seoul 02792, Republic of Korea
jwchoi@kist.re.kr

Abstract

In recent years, as the development of smart paper, smart windows, medical diagnostic smart lenses, and transparent displays is accelerated, the development of next-generation energy sources with flexibility or transparency is required. However, the production of transparent batteries is difficult to fabricate since the materials acceptable in Lithium Ion Batteries are not transparent except electrolyte. All of the transparent battery research reported so far has a structure using a fine line width, and this method is a battery made to appear opaque but transparent by creating a micro-pattern below the human eye resolution. This method has limitations such as complicated process, low energy density, and packaging system occupying a large volume. [1,2] Therefore, we have developed a battery in which all materials are transparent by laminating transparent battery materials.

In previous research, we have developed transparent cathode, $LiFePO_4$.[3] Its wide bandgap of 3.7 eV, high transparency (76.3%) makes it promising candidate for cathode of transparent battery. However, a full-cell has never been fabricated due to the absence of a transparent anode. Therefore, we developed a transparent anode that does not require an anode current collector for full cell production.

In this study, we developed an Zn doped SnO_2(ZTO)/$AgTi_{0.0007}Cr_{0.067}$(ATC)/Zn doped SnO_2 (ZTO) multilayer anode that exhibits high transmittance (90%), low sheet resistivity (8.8 Ω /sq), and high discharge capacity (1036.9 μAh/cm^2·μm). Due to the high electrical conductivity of the anode itself, anode current collector is not required, therefore the fabrication process can be simplified.

All-solid-state full cell was fabricated with $LiFePO_4$ cathode and ZTO/ATC/ZTO anode, LiPON with radio frequency (RF) sputter. Using glass substrate with ITO deposited as a cathode current collector, we created a cell with a total thickness of 1.5μm excluding substrate. Electrochemical analysis is done in the glove box, checking charge/discharge profiles with 100 cycles. The transparency of full cell was verified by UV Spectroscopy in 550 nm.

References

[1] Yuan Yang et al., PNAS , 108 (2011) 13013-13018
[2] Sami Oukassi et al., ACS Appl. Mater. Interfaces, 11 (2019) 683-690
[3] HyunSeok Lee et al., J. Nanosci. Nanotechnol., 15 (2015) 8627-8631

Figures

Figure 1: Photographic image of transparent thin film battery.