Fabrication of flexible an all solid state thin film lithium battery with high volumetric energy density and safety

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Wearable electronics have a market of $16.04 billion in 2013 and are expected to grow to over $80 billion by 2024. The growth of wearable electronics is towards the development of lightweight, slightness and being close to people life. Batteries used in wearable electronics require not only high energy density but also other characteristics such as cell size, safety, thickness and flexibility. However, the size and shape design of traditional Li batteries are limited because of their liquid electrolytes which are lithium salts in an organic solvent. In addition, liquid electrolytes have safety and health issues as they use flammable and corrosive liquids.

Flexible all-solid-state thin film lithium batteries (TFLB) are composed of solid materials and are assembled layer by layer. It is easy to make them thin and small size. Solid-state lithium batteries have high energy density and power density and are safety. In this study, we applied radio-frequency magnetron sputtering to produce flexible an all-solid-state TFLB on the flexible stainless steel substrates. Electrochemical characterization of this flexible TFLB revealed a discharge capacity of 570 µAh (or 47.3 µAh um^{-1} cm^{-2}) and the volumetric energy density was 177 $\mu Whcm^{-2}\mu m^{-1}$(or 1,770 Wh/L) between 3V and 4.3V. This TFLB has volumetric energy density three times higher than the traditional lithium battery. The maximum capacity retention in excess of 83 % was achieved after 50 charge-discharge cycles between 4.2V and 3V. During the folding, hitting, penetrating, or burning test, the TFLB was no vapor, no fire, and no explosion. Those tests can prove this TFLB has more safety.

Keywords: all solid state, thin film lithium battery, flexible, high volumetric energy density

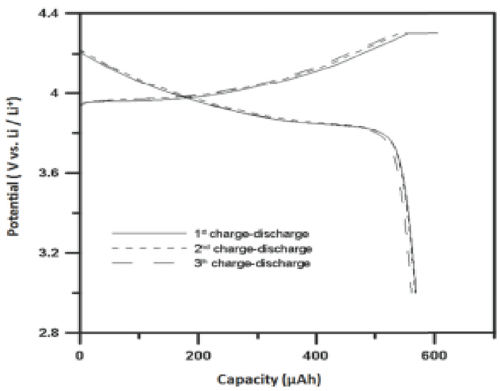

Figure 1. Charge and discharge behavior of a thin film all solid state lithium batteries at the first three cycles.

Table 1. Compare of the all solid state thin film lithium battery with international companies.

	Infinite Power Solutions [Cytech Technology Products, 2015]	Front Edge Technology [Front Edge Technology, Inc , 2000-2014]	STMicroelectronics [Merecicky, 2014]	KAIST* [Koo *et al.*, 2012]	INER**
Substrate	SUS430, Si	Mica	Mica	Mica	SUS304
Cathode (thickness)	$LiCoO_2$ (-)	$LiCoO_2$ (-)	$LiCoO_2$ (5 µm)	$LiCoO_2$ (5 µm)	$LiCoO_2$ (3 µm)
Solid electrolyte	LiPON	LiPON	LiPON	LiPON	LiPON
Anode	Li	Li	Li	Li	Li
Cell size (mm)	25.4 × 25.4	20 × 25	25.7 × 25.7	25.4 × 25.4	20 × 20
Discharge capacity (µAh)	700	100~1000	700	683	570
discharge areal capacity ($\mu Ahcm^{-2}$)	108	20~200	108	106	142
discharge volumetric capacity ($\mu Ahcm^{-2}\mu m^{-1}$)	-	-	21.6	21.2	47.3

* KAIST (Korea Advanced Institute of Science and Technology).
** INER (Institute of Nuclear Energy Research).

References

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