Doctoral Dissertation

Study on Stretchable Power Supply Systems Using Liquid Metal

液体金属を用いたストレッチャブル電源機構に関する研究

Department of Mechanical Engineering, Material Sciences, and Ocean Engineering

Graduate School of Engineering Science

Yokohama National University

Nyamjargal Ochirkhuyag

(ニャムジャルガル オチルホヤグ)

Supervisor: Professor Hiroki Ota

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Abstract

Stretchable electronics that enable next-generation wearable electronics applications have been studied and various stretchable electronics have been developed, such as sensors, energy storage devices (batteries), transparent devices, and heaters. For next-generation wearable applications, all-in-one systems or integrated systems will gain more attention. The all-in-one system device composes of stretchable substrate, stretchable conductor/electrode, stretchable battery, and electronic circuits. As stretchable conductor/electrode, liquid metal can be used because of its unique properties such as high electrical conductivity, self-healable, capability of deformations, and being liquid at room temperature. Liquid metal is often used in flexible sensor applications, health care applications, and batteries.

In this dissertation, the method using liquid metal is developed for storing and feeding the power. The batteries require high impermeable packaging film to ensure stable operation because moisture and gas permeations degrade the operation of battery. Therefore, stretchable packaging film with high barrier behavior for highly deformable/stretchable battery is developed and demonstrated by assembling lithium-ion stretchable battery.

This dissertation is composed of five chapters. Chapter 1 discusses the general background information of this study followed by its purpose with structure of the dissertation. Chapter 2 discusses the stretchable packaging film for highly deformable battery that is fabricated via layer-by-layer method using liquid metal and thermoplastic polyurethane film. The stretchable packaging film shows high gas impermeability even while stretching and lower moisture permeation. In chapter 3, the highly deformable battery which is packaged by stretchable packaging film is described. The highly deformable battery exhibits a reliable operation in the air, even under mechanical deformations, including twisting, bending, and stretching. In chapter 4, the stretchable power supply system as an all-in-one device is fabricated with

integration of highly deformable battery which is discussed in chapter 3. Lastly, chapter 5 summarizes the outcomes of this study and further improvements.