Mechanically Flexible Vapor-Deposited Polymeric Thin Films for Electrochemical Devices

by

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Abstract

The concept of self-powered wearable electronic system has been emerging. Such a system consists of three units: an intelligent end-user electronic device for exporting functions, an energy generation/conversion device responsible for harvesting/scavenging renewable energy, and additionally an energy storage device to ensure non-intermittent operation. The three units should be matched up in terms of energy and power, which demands substantial efforts in research for advancing all the components – the power consumptions of the electronics need to be reduced, the efficiencies of the energy scavenging devices ought to be improved, and the capacities of the energy storage devices are desired to be enhanced. An additional requirement is that the three units should all be made "human-friendly", namely lightweight, flexible and wearable. This necessitates the fabrication of all to be compatible with the unconventional substrates, such as papers and plastics. Along the way to these goals, tremendous opportunities and challenges with regards to materials and device designs are present.

This thesis focuses on the development of mechanically flexible thin-film materials for electrochemical devices, towards the achievement of self-powered wearable electronic systems. Initiated chemical vapor deposition (iCVD) and oxidative chemical vapor deposition (oCVD), which are non-destructive to fragile substrates, have been employed for the synthesis of the polymeric thin films. As an effort to enhance the functional end-users, pinhole-free ionic liquid gels with thickness down to 20 nm have been prepared for the first time via iCVD. They show great promise as soft gate insulators for low-power high-speed thin film transistors, which are central to a variety of wearable electronics. To improve the energy storage unit, supercapacitors, a promising energy storage device for low-power devices, have been vapor-printed via oCVD onto flexible low-cost substrates, papers and nylon membranes. Additionally, an ultrathin gel electrolyte coating has been developed to boost the performance stability of polymeric capacitive materials.

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