Flexible Current Collectors for Printed Primary Batteries

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Abstract : Portable batteries are reliable source of mobile energy to power smart wearable electronics, medical devices, communications, and others internet of thing (IoT) devices. There is a continuous increase in demand for thinner, more flexible battery with high energy density and reliability to meet the requirement. For a flexible battery, factors that affect these properties are the stability of current collectors, electrode materials and their interfaces with the corrosive electrolytes. State-of-the-art conventional and flexible batteries utilise carbon as an electrode and current collectors which cause high internal resistance (~100 ohms) and limit the peak current to ~1mA. This makes them unsuitable for a wide range of applications. Replacing the carbon parts with metallic components would reduce the internal resistance (and hence reduce parasitic loss), but significantly increases the risk of corrosion due to galvanic interactions within the battery. To overcome these challenges, low cost electroplated nickel (Ni) on copper (Cu) was studied as a potential anode current collector for a zinc-manganese oxide primary battery with different concentration of NH4Cl/ZnCl2 electrolyte. Using electrical impedance spectroscopy (EIS), we monitored the open circuit potential (OCP) of electroplated nickel (different thicknesses) in different concentration of electrolytes to optimise the thickness of Ni coating. Our results show that electroless Ni coating suffer excessive corrosion in these electrolytes. Corrosion rates of Ni coatings for different concentrations of electrolytes have been calculated with Tafel analysis. These results suggest that for electroplated Ni, channelling and/or open porosity is a major issue, which was confirmed by morphological analysis. These channels are an easy pathway for electrolyte to penetrate thorough Ni to corrode the Ni/Cu interface completely. We further investigated the incorporation of a special printed graphene layer on Ni to provide corrosion protection in this corrosive electrolyte medium. We find that the incorporation of printed graphene layer provides the corrosion protection to the Ni and enhances the chemical bonding between the active materials and current collector and also decreases the overall internal resistance of the battery system.

Keywords : corrosion, electrical impedance spectroscopy, flexible battery, graphene, metal current collector
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