BIOGRAPHICAL SKETCH

Bibek Tiwari received his Bachelor of Engineering degree in Electrical and Computer Engineering from Tribhuwan University, Nepal in 2010. He worked as a Service Engineer in Titan International Company, Nepal for three years.

Currently he is a Ph.D. candidate in the Electrical and Computer Engineering Department at Tennessee Tech University, Tennessee, USA. He has been working as an instructor for Digital System Lab since 2016 and was a TA for electric circuit courses and labs. Bibek joined SOLBAT-TTU Energy Research Laboratory in 2014 where he worked in the design and modeling of high efficiency multijunction solar cells. His area of research is investigating new cathode materials for sodium ion battery technologies and developing algorithms for accurate state of charge and state of health estimation of those battery technologies. He also aims to use machine learning algorithms to find high energy density materials for rechargeable batteries.

EDUCATION

Ph.D. – Tennessee Tech University
(Expected graduation: December 2018)
Electrical & Computer Engineering

BS – Tribhuwan University, 2010
Electronics and Communication Engineering

College of Engineering

TENNESSEE TECH

The Department of

Electrical & Computer Engineering

Announces the Dissertation Defense

of

Bibek Tiwari

In Partial Fulfillment of the Requirements

For the degree of

Doctorate of Philosophy

Thursday, October 25, 2018 at 11:00 p.m.

Held in

208 Brown Hall
115 West 10^{th} Street
Cookeville, TN
Tennessee Tech University

FIELD OF STUDY

Sodium Ion Battery

State of Charge/State of Health Estimation

DISSERTATION TOPIC

SYNTHESIS OF HIGH CAPACITY NOVEL P2-TYPE $Na_{0.7}Ni_{0.3}Mn_{0.59}Co_{0.1}Cu_{0.01}O_2$ CATHODE FOR SODIUM ION BATTERIES AND DEVELOPING ALGORITHMS FOR ACCURATE STATE-OF-CHARGE ESTIMATION

EXAMINING COMMITTEE

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Electrical & Computer Engineering

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ABSTRACT

Cost effective and high energy density batteries are very critical to address the rapidly increasing energy demands of the world. The applications of energy storage technologies range from hybrid, plug-in hybrid and electric vehicles, connecting renewable energy sources to power grid and powering portable electronic appliances. Commercially available lithium ion battery technology has high energy density, however limited availability of lithium and higher cost encourage researchers to search for alternative battery technologies. Sodium is the sixth most abundant element on earth and is way cheaper than lithium. The chemical properties of sodium is very similar to that of lithium. Hence it does not require any industrial infrastructure upgrade for fabrication. However the larger ionic radius of sodium ion can be a challenge for the structural stability of the cathode to host it.

In this dissertation we proposed a novel cathode material for sodium ion battery having a high discharge capacity and longer cycle life. Among the cathode materials for sodium ion battery, the layered manganese based sodium transition metal oxide ($NaMO_2$, where M = Transition metals) compounds are promising materials for their higher theoretical capacity relative to other sodium cathode technologies. The higher the specific discharge capacity, the higher will be the energy density. However the capacity is limited by the crystallographic structure and the composition of the materials. The layered structure of sodium transition metal oxide cathodes enhance the intercalation and deintercalation of sodium ions. We synthesized a novel P2-type $Na_{0.7}Ni_{0.3}Mn_{0.59}Co_{0.1}Cu_{0.01}O_2$ cathode material and performed material characterization and electrochemical analysis. Citric acid assisted sol gel method was used in the synthesis process of cathode material. The discharge capacity of cathode material $Na_{0.7}Ni_{0.3}Mn_{0.6}Co_{0.1}O_2$ was increased from 130 $mAhg^{-1}$ to 150 mAg^{-1} when discharged through the voltage window of 1.5 – 4 V due to the copper doping. Also due to the reduction in the concentration of Jahn Teller prone Manganese ions (Mn^{3+}), the stability of the structure was improved. The lesser polarization loss during cycling and stable structure of the prepared cathode material helped to retain 94% of its maximum discharge capacity even after 80 cycles. The state-of-charge of a battery is defined as the percentage of charge available in the battery, which also corresponds to the total electrical energy remaining in a battery. We proposed a model using cascaded neural network to estimate the state- -of-charge of our fabricated battery. This is very important for efficient battery management and acts as a gauge for displaying the present status of the battery. This estimation will be helpful for battery manufacturers, automotive companies and customers driving hybrid or electric vehicles.