Dr. Kumar is co-founder & CTO of Envia Systems Inc. Previously, Dr. Kumar worked as a senior scientist for Greatbatch, leading the development and scale-up of nano-crystalline silver vanadium oxide cathode material. He served as principal scientist at Nanogram Devices Corporation, where he developed battery components used in implantable medical devices, and as a project manager at Nanogram where he led several energy storage and photonics device projects. Dr. Kumar has a Ph.D. in Materials Science from the University of Rochester and Bachelors in Engr from I.I.T., Varanasi. He is the inventor of over 40 patents.

Title: Energy density limit of Lithium ion Batteries

Author: Sujeet Kumar
Envia Systems, Newark, CA, USA
skumar@enviasystems.com

ABSTRACT:

Batteries are the main limitation to the wide spread adoption of electric vehicles and plug in hybrids. Battery energy density must be improved to increase EV driving range and lower battery cost. State of the art high energy lithium batteries use NCA cathode and graphite anode e.g. cylindrical 18650 cells that can provide specific energy up to 250 Wh/kg. Replacement of graphite with silicon based anode is mandatory to further boost specific energy. However, cells with silicon based anode have poor cycle life and very high swelling. Proper selection of cathode is also important to attain high energy density when paired with Silicon based anode. Although the capacity of Si-based anode materials are high, their intercalation potential is much higher than that of Li or graphite which translates to a lower overall cell voltage (at least 0.4V lower) resulting in lower energy density. A high capacity and high average voltage cathode is required to compensate the overall drop in the average voltage.

Consumer devices have lower cut off voltage of 3.0V while automotive batteries desire capacity above 2.5V. Envia's previously reported 400 Wh/Kg cell had specific energy between voltage range of 4.6V-2.0V in which over 20 % specific energy was in un-useable range of 3.0V-2.0V. In this work, large format pouch cells having specific energy of 350 Wh/Kg is reported having all specific energy between voltage range of 4.47V-2.5V. Envia has developed a high voltage Cobalt-Rich Composite (CRC) cathode that contains significant amount of Nickel and Manganese. The resulting CRC cathode does not exhibit any voltage fade upon cycling at higher voltages (>4.45V) as observed in lithium rich manganese rich composite cathode. CRC cathode has been complemented with a high capacity SiO_x-based anode electrode in a high energy cell. Typical commercially available Si-based materials suffer from large volume expansion resulting in pulverization and poor cycle life. We present high capacity SiO_x-based anode (>1400 mAh/g) electrodes with high percent active content (>80%) that has shown to cycle over 500 times. Swelling, cycling and abuse testing results of the cells will be presented. The cells show excellent rate capability as required for automotive and drone applications.