Conductive Polymer Binder and Silicon Composite Anode for High Energy Lithium Ion Battery

Gao Liu

Si material has over ten times of lithium storage capacity than that of state of the art graphite materials in the current generation of lithium ion battery. However, the over 300% volume change of Si associated with lithiation and delithiation process has led to both material and electrode level failures. Nano-sizing Si material allows the volume changes during the electrochemical process without inducing material breakdown. However, it is extremely challenging to assemble Si nano-particles into a traditional composite electrode structure. The volume change of Si has led to breakdown of electronic pathway in the electrode, resulting in fast capacity fade. I will discuss an effective solution to the volume change by using conductive polymer binders. A class of new conductive polymers was developed through a combination of material synthesis, x-ray spectroscopy, density functional theory, and battery cell testing. In contrast to other polymer binders, the new polymers with tailored electronic structure enable lithium doping under the operation condition of Si anode. The polymers thus maintain both electronic conductivity and mechanical integrity during the battery operation. More importantly, this Si/conductive polymer approach is compatible with the lithium ion slurry manufacturing process. The silicon/polymer composite anodes exhibit extraordinary cycling performance with 2100 mAh/g for Si, after 650 cycles without any conductive additive in the electrode. This work implements the concept of combining mechanical binding with electronic conductivity in the electrode binder, to enable high-capacity and large volume-change materials in stable electrode structure for high energy lithium ion battery.