**Intel International Science & Engineering Fair 2014**
**Los Angeles, USA**

## ABSTRACT

**Project No.:** Intel2014_009

**Title:** Metal Oxides @ Polypyrrole Nanowire-based Pseudocapacitor


There is currently a great interest in development of thin, flexible, lightweight, and environmental friendly supercapacitors as the booming of smartphones and other mobile electric devices. In our research, two novel designs of $MnO_2$@PPy and $V_3O_7$@PPy nanowire-based pseudocapacitors were invented. $MnO_2$ and $V_3O_7$ nanowires were fabricated by template/surfactant-free hydrothermal method, followed by immobilization of polypyrrole (PPy) to give $MnO_2$@PPy and $V_3O_7$@PPy nanowires. Nanostructured morphology and crystallinity of as-prepared materials were examined and confirmed by SEM and XRD analysis, as β-$MnO_2$ (JCPDS 24-0735) and $V_3O_7 \bullet H_2O$ (JCPDS 85-2401) respectively. $MnO_2$@PPy or $V_3O_7$@PPy nanowire was loaded on the preloaded reduced graphene oxide (RGO) copper cloth to form $MnO_2$@PPy/RGO/Cu/Cloth or $V_3O_7$@PPy/RGO/Cu/Cloth composite as the electrode. Symmetric-solid-state pseudocapacitors were assembled by two pieces of identical nanowire electrodes (work area: 1.2 cm × 0.6 cm, areal density: 0.2 mg $cm^{-2}$ to 4 mg $cm^{-2}$) with polyvinyl alcohol PVA/LiCl as a gel electrolyte.

Generally, various $MnO_2$@PPy and $V_3O_7$@PPy nanowire-based pseudocapacitors show a wide range of specific capacitance ranging from few F $g^{-1}$ to over 150 F $g^{-1}$. The relationships between specific capacitance and areal density, scan rate, structure and morphology of electrode materials were studied. From the experimental result, it is believed that the highly conductive architecture in such films enables efficient charge transport and electrode stability, allowing the films with high capacity (128 F $g^{-1}$ for $MnO_2$@PPy nanowire and 150 F $g^{-1}$ for $V_3O_7$@PPy nanowire), high capacitance retention of 82% ($MnO_2$@PPy nanowire) and 91% ($V_3O_7$@PPy nanowire) after over 1000 cycles respectively, and stable specific capacitance. Superior electrochemical performance of metal oxides@PPy nanowires can be attributed to the large accessible surface area of the porous structure, low interfacial resistance as the result of more extensive aggregation of nanowires and cloth substrate. The flexible 3D $MnO_2$@PPy hybrid nanowire-based and $V_3O_7$@PPy hybrid nanowire-based pseudocapacitors exhibit a promising capacitive performance of 128 F $g^{-1}$ and 150 F $g^{-1}$ with high capacitance retention of 82% and 91% respectively, opening up new possibilities for the production of environmental friendly, cost efficient and lightweight energy storage system. This research might also provide a method for flexible, lightweight, high-performance, low-cost, and environmental friendly materials used in energy conversion and storage system.