SYNOPSIS

Li-ion thin film battery technology has attracted much attention in recent years due to its highest need in portable electronic devices. Development of new materials for lithium ion battery (LIB) is very crucial for enhancement of the performance. LIB can supply higher energy density because Lithium is the most electropositive (-3.04V vs. standard hydrogen electrode) and lightest metal (M=6.94 g/mole). LIBs show many advantages over other kind of batteries such as, high energy density, high power density, long cycle life, no memory effect etc. The major work presented in this thesis is on the development of nanostructured materials for anode of Li-ion battery. It involves the synthesis and analysis of grapheme nanosheet (GNS) and its performance as anode material in Li ion battery. We studied the synthesis of GNS over different substrates and performed the anode studies. The morphology of GNS has great impact on Li storage capacity. Tin and Tin oxide nanostructures have been embedded in the GNS matrix and their electrochemical performance has been studied.

Chapter 1 gives the brief introduction about the Li ion batteries (LIBs), working and background. Also the relative advantages and characterization of different electrode materials used in LIBs are discussed. **Chapter 2** discusses various experimental techniques that are used to synthesize the electrode materials and characterize them.

Chapter3 presents the detailed synthesis of graphene nanosheet (GNS) through electron cyclotron resonance (ECR) microwave plasma enhanced chemical vapor deposition (ECR PECVD) method. Various substrates such as metallic (copper, Ni and Pt coated copper) and insulating (Si, amorphous SiC and Quartz) were used for deposition of GNS. Morphology, structure and chemical bonding were analyzed using SEM, TEM, Raman, XRD and XPS techniques. GNS is a unique allotrope of carbon, which forms highly porous and vertically aligned graphene sheets, which consist of many layers of graphene. The morphology of GNS varies with substrate.

Chapter 4 deals with the electrochemical studies of GNS films. The anode studies of GNS over various substrates for Li thin film batteries provides better discharge capacity. Conventional Li-ion batteries that rely on a graphite anode have a limitation in the capacity (372 mAh/g). We could show that the morphology of GNS has great effect in the

electrochemical performance and exceeds the capacity limitation of graphite. Among the electrodes PtGNS shown as high discharge capacity of ~730 mAh/g compare to CuGNS (590 mAh/g) and NiGNS (508 mAh/g) for the first cycle at a current density of 23 $\mu A/cm^2$. Electrochemical impedance spectroscopy provides the various cell parameters of the electrodes.

Chapter 5 gives the anodic studies of Tin (Sn) nanoparticles decorated over GNS matrix. Sn nanoparticles of 20 to 100nm in size uniformly distributed over the GNS matrix provides a discharge capacity of ~1500 mAh/g mAh/g for as deposited and ~950 mAh/g for annealed Sn@GNS composites, respectively. The cyclic voltammogram (CV) also shows the lithiation and delithiation process on GNS and Sn particles.

Chapter 6 discusses the synthesis of Tinoxide@GNS composite and the details of characterization of the electrode. SnO and SnO_2 phases of Tin oxide nanostructures differing in morphologies were embedded in the GNS matrix. The anode studies of the electrode shows a discharge capacity of ~1400 mAh/g for SnO phase (platelet morphology) and ~950 mAh/g for SnO_2 phase (nanoparticle morphology). The SnO phase also exhibits a good coulumbic efficiency of ~95%.

Chapter 7 describes the use of SnO_2 nanowire attached to the side walls of the GNS matrix. A discharge capacity of ~1340 mAh/g was obtained. The one dimensional wire attached to the side walls of GNS film and increases the surface area of active material for Li diffusion. Discharge capacity obtained was about 1335 $mAhg^{-1}$ and the columbic efficiency of ~86% after the 50^{th} cycle.

The research work carried out as part of this thesis, and the results have summarized in **chapter 8.**