Figure Caption

Chapter 1:

**Figure 1.1:** Crystal structures of ZnO (a) *rock-salt*, (b) *zinc-blende*, and (c) *wurtzite*.

**Figure 1.2:** Two forms of GNR (a) A-GNR and (b) Z-GNR.

**Figure 1.3:** Various strategies used to tune properties of TMDs.

**Figure 1.4:** Valley polarisation in monolayer MoS$_2$.

**Figure 1.5:** Unit cell of a spinel structured material.

Chapter 2:

**Figure 2.1:** Schematic representation of PLD deposition system.

**Figure 2.2:** Typical cyclic voltammogram shows oxidation and reduction peaks.

**Figure 2.3:** Potential energy of an electron $V(x)$ in eV as a function of its distance $x$ to the surface in Å.

**Figure 2.4** (a) Optical photograph of the all metal field electron emission system and (b) load lock chamber.

**Figure 2.5** Schematic diagram of the planar diode configuration.

**Figure 2.6:** Schematic and photograph of electrochemical deposition set up.

**Figure 2.7:** Muffle furnace used for hydrothermal synthesis, inset shows stainless steel autoclave with Teflon liner.

**Figure 2.8:** Schematic diagram of Bright field imaging.

**Figure 2.9:** Schematic illustration of the possible processes occurs in Photoluminescence [66].

Chapter 3(a):

**Figure 3(a).1:** TEM images of pristine MWCNTs.

**Figure 3(a).2:** TEM images of GNRs at different magnification.

**Figure 3(a).3:** (a) AFM image of GNR and (b) corresponding height profiled.

**Figure 3(a).4:** Current versus voltage (I-V) characteristic of MWCNTs and GNR.

**Figure 3(a).5:** Raman spectra of MWCNTs using laser wavelength of (a) 532 and (b) 633 nm.

**Figure 3(a).6:** Raman spectra of GNRs using laser wavelength of (a) 535 and (b) 632 nm.
Figure 3(a).7: Raman Spectrum of GNR for (a) 48hrs and (b) 67hrs time of oxidation.

Figure 3(a).8: Schematic showing unzipping mechanism of MWCNTs.

Figure 3(a).9: Field emission from graphene nano-ribbon. (a) Applied electrical function of emission current density. (b) F-N plot showing linear behavior typical of quantum mechanical tunneling.

Figure 3(a).10: Field emission current stability (I-t) plot of the GNRs/Si emitters at preset value of 1 and 10 µA over duration of 3 hrs.

Figure 3(a).12: The field emission images of graphene nanoribbon field emitter recorded after the switch on of Spellmen high voltage power supply at various current densities (a) 50 µA/cm², (b) 100 µA/cm² (c) 250 µA/cm² and (d) 500 µA/cm²

Figure 3(a).13: The field emission images of graphene nanoribbon field emitter recorded at different time during 3 hrs stability at an emission current of 5µA.

Chapter 3(b)

Figure 3(b).1: Crystal structure of WS₂ nanosheets, the yellow colored balls represents S atoms and the black colored represents W atoms.

Figure 3(b).2: Raman spectra of (a) pristine GNR and (b) WS₂ nanosheets.

Figure 3(b).3: Raman spectra of GNR-WS₂ nanocomposite.

Figure 3(b).4: SEM images of (a) GNR, (b) WS₂ nanosheets and (c, d) GNR-WS₂ nanocomposite.

Figure 3(b).5: J-E plot of GNR and GNR-WS₂ nanocomposite.

Figure 3(b).6: Energy band diagram of GNR-WS₂ hetrojunction.

Figure 3(b).7:Typical F-N curve of GNR and nanocomposite indicating linear behaviour.

Figure 3(b).8: Typical long term field emission current stability of GNRs and nanocomposite, recorded at 1 µA over a period of three hrs indicating stable field emission current.

Figure 3(b).9: Field emission pattern of GNR and nanocomposite taken during the long term stability study of the emitter.

Chapter 4(a):

Figure 4(a).1: Crystal structure of VS₂.

Figure 4(a).2: XRD pattern of VS₂ nanosheets using hydrothermal method.
Figure 4(a).3: (a,b) XPS of VS$_2$ nanosheets using hydrothermal method.

Figure 4(a).4: FESEM images of few-layer VS$_2$ nanosheets. Inset shows the magnified image of VS$_2$ nanosheets.

Figure 4(a).5: TEM analysis of VS$_2$ sheets (a) low magnification image, (b) high resolution TEM image and inset of (b) fast Fourier transform of the electron diffraction pattern of a few layers of VS$_2$.

Figure 4(a).6: Schematic of hydrothermal growth process of VS$_2$ nanosheets.

Figure 4(a).7: (a) The unit cell orientations of VS$_2$. (b, c) The out-of-plane electrostatic potential and work function for VS$_2$.

Figure 4(a).8: Field emission from few-layered VS$_2$ nanosheets. (a) Applied electrical field as a function of emission current density. (b) F-N plot showing linear behaviour indicating emission current from the metallic emitter.

Figure 4(a).9: Field emission current stability (a) at preset value of 1µA and 10 µA for a period of about 3 and (b) long term stability at 1 µA indicating good emission current stability.

Figure 4(a).10: Field emission micrographs of a few layered VS$_2$ nanosheets at a current density of (a) 50 µA/cm$^2$ and (b) 100 µA/cm$^2$.

Chapter 4(b):

Figure 4(b).1: XRD spectrum of the VS$_4$-RGO nanocomposite.

Figure 4(b).2: FESEM images of the VS$_4$-RGO nanocomposite.

Figure 4(b).3: TEM image of the VS$_4$-RGO nanocomposite showing presence of both the VS$_4$ and RGO nanosheets, and (b) HRTEM images showing (110) lattice planes of VS$_4$. Inset of Fig. (b) is FFT of VS$_4$.

Figure 4(b).4: (a, b, c) shows the out-of-plane electrostatic potential and work function for VS$_4$ with and without a graphene substrate. (d) shows the unit cell orientation of bulk VS$_4$.

Figure 4(b).5: (a) Applied electrical field vs. field emission current density (J-E) plot and (b) corresponding F-N plot of VS$_4$ emitters.

Figure 4(b) 6: Long term field emission current stability at 1 and 10 µA indicating fluctuations in stability due to adsorption and desorption of gas molecules.

Figure 4(b).7. Field emission micrograph of VS$_4$ at two different current density.
Chapter 5(a):

**Figure 5(a).1:** FESEM image of (a) blunt tungsten tip and (b) MoS$_2$ film on the tip. Inset of (a) shows low magnification image of a blunt W-tip.

**Figure 5(a).2:** FESEM image of the MoS$_2$ film grown on Si substrate recorded at (a) lower and (b) higher magnifications, respectively.

**Figure 5(a).3:** Comparative Raman spectra of bulk MoS$_2$ and pulsed laser deposited MoS$_2$ thin film on Si substrate.

**Figure 5(a).4:** (a) Typical I-V characteristics of MoS$_2$ thin film recorded using STM at room temperature and (b) the typical I-V characteristic of bare p-type Si recorded using STM.

**Figure 5(a).5:** Schematic of field emission set-up used for (a) MoS$_2$/W and (b) MoS$_2$/Si.

**Figure 5(a).6:** (a) Field emission behavior of PLD MoS$_2$ films on W tip substrates. (a) J-V characteristics, (b) F-N plot showing non-linear behavior indicating that the emission current from semiconducting emitter.

**Figure 5(a).7:** Emission Current vs time (I-t) plot of the PLD MoS$_2$ film on W-tip recorded at preset values of 1 and 10 µA. Inset shows the field emission image recorded at 3.2 kV.

**Figure 5(a).8:** (a) Field emission behavior of PLD MoS$_2$ film on Si substrates. (a) J-E characteristics (b) Corresponding F-N plot.

**Figure 5(a).9:** Emission Current vs time (I-t) plots of the PLD MoS$_2$ film on Si substrate recorded at the preset values of 1 and 10 µA. Inset shows the field emission image recorded at 3.5 V/µm.

Chapter 5(b):

**Figure 5(a).1:** Crystal structure of (a) unit cell, (b) corner-connected octahedra MoO$_3$ viewed from the $ab$ and $bc$ planes.

**Figure 5(b).2:** X-RD pattern of the synthesized layered α-MoO$_3$ crystals.

**Figure 5(b).3:** Raman spectrum of an exfoliated α-MoO$_3$ flake (* corresponds to Si).

**Figure 5(b).4:** (a) SEM images of mechanically exfoliated MoO$_3$ flakes. (b)-(c). Magnified images of the flakes tilted at 45°, clearly indicating multiple layers.
**Figure 5(b).5:** SEM images of MoO$_3$-MoS$_2$ hetrostructure.

**Figure 5(b).6:** AFM image of the flakes presented in SEM images Fig. 5(b).4, and their corresponding thickness profiles. The thicknesses of these flakes were observed to be ~11 nm which corresponds to 8 fundamental layers of $\alpha$-MoO$_3$.

**Figure 5(b).7:** TEM image of a mechanically exfoliated MoO$_3$ flake, depicting its layered nature. *Inset of (a) HRTEM image of the corresponding $\alpha$-MoO$_3$ flake.*

**Figure 5(b).8:** Field emission current density versus applied field (J-E) curve of the $\alpha$-MoO$_3$ and nanocomposite of $\alpha$-MoO$_3$-MoS$_2$ sheets.

**Figure 5(b).9:** Typical F-N plot for $\alpha$-MoO$_3$-MoS$_2$ composite showing almost linear behavior, indicating emission current from the semiconducting emitter.

**Figure 5(b).10:** I-t plot of (a) MoO$_3$ and (b) MoO$_3$-MoS$_2$ heterostructure. Inset of (a) and (b) shows corresponding FE image of the emitters.

**Figure 5(b).11:** Energy band diagram of MoO$_3$-MoS$_2$ heterojunction.

**Chapter 6(a):**

**Figure 6(a).1:** XRD spectra of ZnO nanorods electrodeposited on Au/Si substrate at different reaction temperatures (a) 60$^\circ$ and 70$^\circ$C.

**Figure 6(a).2:** SEM images of the ZnO nanorods synthesized at deposition temperatures (a) 65$^\circ$C, and (b) 70$^\circ$C.

**Figure 6(a).3:** SEM images of ZnO nanorods electrodeposited on Au/Si substrate at different applied potentials (a)-0.6 V, (b) -0.8 V, and (c) -0.9 V.

**Figure 6(a).4:** SEM images of ZnO nanorods electrodeposited on Au/Si substrate at different deposition times of (a) 45, and (b) 90 min.

**Figure 6(a).5:** SEM images of ZnO nanorods electrodeposited on Au/Si substrate at different pH values (a) 6, and (B) 6.11.

**Figure 6(a).6:** (a) typical TEM image of a single ZnO nanorod, and corresponding SAED pattern.

**Figure 6(a).7:** SEM image of nanotubes obtained at a bath temperature of (a) 80$^\circ$C, (b) 70$^\circ$C and (c) 60$^\circ$C.

**Figure 6(a).8:** SEM images of nanotubes kept for 90 minutes.

**Figure 6(a).9:** PL spectra of (a) ZnO nanorods and (b) ZnO nanotubes.

**Figure 6(a).10:** (a) Field emission current density versus applied electric field (J-E) plot and (b) corresponding F-N plot of ZnO nanorods.
Figure 6(a).11: (a) Field emission current density versus applied electric field \((J-E)\) plot and (b) corresponding F-N plot of ZnO nanotubes.

Figure 13: Emission current stability curves at a preset value of \(1 \mu A\) of (a) ZnO nanorods and (b) ZnO nanotubes.

Figure 14: FEM micrographs of (a) ZNRs and (b) ZNTS.

Chapter 6(b):

Figure 6(b).1: Publication statistics of 2D ZnO nanosheets. The data is compiled using web of science.

Figure 6(b).2: XRD patterns of the electrodeposited ZnO on ITO coated glass substrate (black colored) and pristine ITO coated glass substrate (red colored).

Figure 6(b).3: SEM images of the electrodeposited ZnO on ITO coated glass substrate recorded at different magnifications.

Figure 6(b).4: Raman spectrum of the ZnO nanosheets electrodeposited on ITO coated glass substrate.

Figure 6(b).5: (a) Side and view of \(O_{\text{vac}} \text{ZnO (001)}\) surface consider as the system for calculation, four big balls indicated with arrow represent here the neighbor Zn atoms of vacant O atom, (b) demonstrate the electrostatic potential as function of fraction coordinates of \(O_{\text{vac}} \text{ZnO (001)}\) surface, (c) Schematic to show the shifting of Fermi level toward vacuum due to O vacancy. Vacuum potential is indicate by \(E_v\), work function is denoted as \(\phi\) and Fermi level is denoted as \(E_f\).

Figure 6(b).6: (a) emission current density versus applied field \((J-E)\) curve, and (b) F-N plot of the ZnO nanosheets electrodeposited on ITO substrate.

Figure 6(b).7: Emission current versus time \((I-t)\) plot of the ZnO nanosheets electrodeposited on ITO substrate studied at pre-set value of \(1\mu A\) over 3 hrs duration.

Chapter 6(c):

Figure 6(c).1: FESEM images of spinel \(\text{ZnCo}_2\text{O}_4\) flowers: (a) uniform formation of \(\text{ZnCo}_2\text{O}_4\) flower-like microspheres and (b) an enlarged portion shows the 2D nanosheets which wrap up to form the spherical structure. (c) Further magnification reveals the thickness of the nanosheets which lies within the range \(\sim 20-30 \text{ nm}\). (d) EDS pattern of the ZCO sample.

Figure 6(c).2: XRD spectra of \(\text{ZnCo}_2\text{O}_4\) microflowers.
Figure 6(c).3: Raman spectra of ZnCo$_2$O$_4$ microflowers.

Figure 6(c).4: TEM and HRTEM image of ZnCo$_2$O$_4$ microflowers.

Figure 6(c).5: Growth mechanism of ZnCo$_2$O$_4$ microflowers.

Figure 6(c).6: Optimized structure of ZnCo$_2$O$_4$(111) surface (a) top view and (b) side view, the zinc, cobalt and oxygen atom are denoted with grey, blue and red balls respectively. The lattice parameter direction is indicated by the arrow shown in the inset of (b), the electrostatic potential along c-axis considering vacuum as reference energy is shown in (c). $E_f$ and $E_v$ correspond to Fermi and vacuum energy.

Figure 6(c).7 (a) Field emission current density versus applied field (J–E) curve of ZnCo$_2$O$_4$ and (b) corresponding Fowler Nordheim (F-N) plot.

Figure 6(c).8: Field emission current stability (I–t) plot of the ZnCo$_2$O$_4$ with an inset FE image captured at emission current density.