Preface

The current study focuses on the electro-optical properties of RF-sputtered thin films and nanocomposite materials. The process parameters like deposition time, RF power, and substrate temperature on the properties of RF sputtered thin films are discussed and compared to their annealed counterparts. Microstructural, morphological, optical, electrical, and resistivity experiments are carried out with RF sputtered thin films observed in different process parameters to understand their role as an absorber material and buffer layer in thin-film solar cell applications. due to its high charge capacitive behavior and distinctive optical properties, a low mobility n-type semiconductor material Cadmium sulphide (CdS), is studied for optoelectronic application. The coloration behavior of these thin films is heterogeneous, with anodic coloration in the UV area and cathodic coloration in the NIR range. Although bilayer RF sputtered thin film can be employed as a window material, its reaction kinetics are slow, and its charge capacity is limited. Improving its physical properties, we introduced graphene as an electron transport material in it. Using the reactive RF magnetron sputtering process, mixed oxides of these materials in various molar ratios were produced to optimize their physical properties working as absorber materials in different electronics applications.

The main objective of the research can be described in three points, as shown below.

1.) Deposition of high quality, better homogeneity, good adhesion Nano composite thin films by RF magnetron sputtering; annealing of the synthesized nanostructured thin films at different RF power and deposition time.

2.) Systematic analysis of the prepared thin films' structural, morphological, optical, electronic properties, and conductivities measurements to understand their interactions and characteristics.

3.) Fabrication and characterization of optoelectronic devices like thin-film solar cells using the RF sputtered thin films as absorber material, window material, and buffer layer for thin-film solar cell application that have been developed.

The present study is divided into the following chapters.

In **First Chapter,** A brief introduction of the fundamental aspects of II-IV semiconductors materials is provided, including the different basic physical phenomena and applications such as photovoltaic (PV) cells, transparent conducting oxides (TCOs), gas sensors, and spintronics, among others. The electrical and optical properties of thin-film using the RF sputtered technique are discussed in detail since they have the greatest impact on their performance. An overview of semiconductor materials like CdS, CdTe, and Molybdenum is given to illustrate the diversity of materials and their deposition techniques.

In **Second Chapter,** the basic principles of the analytical tools to obtain information on the electrical and optical properties, microstructures, composition, and surface morphology of the as-synthesized bulk and thin films of the chosen materials are summarized, since the extensive analysis has been conducted by several measuring tools, for examples, X-ray diffractometer, atomic force microscope (AFM), scanning and transmission electron microscopes (SEM & TEM), UV-VIS-NIR spectrometers, and electrical conductivity measurements, for the characterization of both the bulk materials and thin films deposited on the various substrates to obtain insight on their relevant properties.

The **third chapter** discusses the importance of thin films and their applications in the present world. Following that, the importance of nanocomposite thin film is discussed in detail, as well as their electrical characteristics. The structural, morphological, optoelectronic, and electrical properties of Cadmium sulphide with a small introduction of

Graphene (as an electron transport material) in the form of thin films, as well as their applications in scientific and technological fields, are all thoroughly addressed. The existing literature review of the resources chosen for this project has been provided as a resource. The I-V characteristics of hybrid composite films appear straight behavior and resistivity was observed to be decreased.

The **fourth chapter** discusses the various types of deposition techniques used to prepare thin films, as well as the importance of utilizing the RF magnetron sputtering technique. The preparation of targets (CdTe) and their thin films is described in detail, including the conditions used during the deposition in the deposition parameters and the annealing process. In this work, optimizing of physical properties of cadmium telluride thin film by the variation of different RF power (100 W, 150 W and 200W) and nitrogen concentrations (1, 2, 3%). The characterization approaches used in this study to investigate the properties of synthesized thin films are described in detail, along with their theoretical approach. Here, CdTe thin film deposited at 100 RF power and 2% nitrogen concentration was optimized parameters that can be used for absorber material in thin-film solar cell applications.

Chapter 5 describes the structural, morphological, optical, photo acoustic, and electrical resistive properties of the prepared Molybdenum thin films with a small amount of Nikel in them. The characteristics of corresponding films at various RF power and deposition time are also studied in detail or in comparison. For reference, thickness data obtained with a stylus profilometer for all created thin films are provided. The grain size and other structural characteristics are calculated using XRD patterns. AFM and FESEM images of the prepared thin films are used to explain the morphological analyses. The optical

characteristics of thin films are examined using transmission spectra, Raman, and Fourier transforms infrared spectra. And four-probe conductivity measurements are used to determine the improved resistivity of the prepared RF sputtered thin films. so at 200 RF Power and higher deposition time, Mo-Ni bilayer thin film that has improved crystallinity, reflectance, and resistivity can be used as a back contact material in thin-film solar cell applications.

Chapter 6 deals with the characteristics of cadmium sulphide (CdS) thin film prepared by RF sputtering process at various nitrogen partial pressures to optimize its bandgap for window material application. The structural morphological properties of mixed nitride thin films generated in different molar ratios can be compared using x-ray diffraction patterns, AFM, and FESEM images. Variations in transmittance spectra, and hence a change in the energy bandgap value of deposited thin films, are thoroughly investigated. With the variation of nitrogen concentrations, optical studies show the significant increment in transmittance >80 and the variation of the bandgap is about 2.45 eV to 2.30 eV that can be used for window material in thin film solar cell application.

Chapter 7 discusses the structural and morphological control of RF sputtered molybdenum oxide thin films and the electro-optical properties of thin films are studied by the four-probe conductivity method and UV-Vis spectroscopy technique. In Molybdenum thin film of different ratios of oxygen the emission and absorption peaks found in UV absorption spectra, and Raman peaks attributable to the stretching modes in Laser Raman spectra. The high resistivity obtained in the case of the sample annealed at the higher temperature, can be explained by the granular surface morphology with increasing roughness that electron traps in large vacancies between grains.

Chapter 8 presents the overall summary and conclusion of the current work precisely. In addition to that, the scope of the present work in the field of electronic device fabrication is also discussed.

Aim-

The main aim of this thesis is to increase the fundamental understanding of Cadmium based thin films and CdTe, CdS based solar cells. The systematic study of the properties of these thin films reveals information about how future improvements to solar cell may be made. Understanding these thin films in absorber layer electronic properties and how they change due to the application of processing step is main objective of this thesis. The novel characterization techniques were used to characterize these films. These properties were observed under various processing condition to study the characteristics of prepared Single, Double and multi-layer thin films. We determine the conductivity/Resistivity and Reflectivity of these thin films for the Solar Photovoltaic device applications.