# PREFACE

The interest in Transition Metal Dichalcogenides (TMDs) has increased rapidly in past couple of years for optoelectronic applications. Soon after the advent of graphene, the first 2D material Research and Development (R&D) community motivated researchers to explore other alternative 2D materials due to their scalability and thickness dependent optical and electrical properties. Their indirect semiconducting nature in bulk changes as direct semiconductor when layered down to monolayer and this ensues due its weak van-der-Waals interactions between layers.

In the past couple of years, 2D materials based photo-detectors have been intensively investigated. The huge light absorption and ultrathin thickness make them potential candidate for broadband, highly sensitive, and flexible photodetection. As compared to Graphene, TMDs have larger bandgap including $MoS_2$ and $MoSe_2$, hence, can have significantly longer carrier lifetimes, which make them strong contenders for realizing highly sensitive photodetectors. Though $MoSe_2$ is comparively less explored material than $MoS_2$ in the TMDs family but have several advantages over latter such as higher electrical conductivity and light absorption capacity, higher carrier mobility, superior photodetection responsivity, fast response times.

The present thesis consists of work carried out for fabrication and characterization of thermally grown $MoSe_2$ thin film based broadband photodetectors. This thesis is divided into five chapters which are briefly outlined below.

**Chapter 1** covers basic introduction to photodetectors, their classification based on structures and spectal response, their key parameters, selection of material for

photodetection. It also provides basic introduction to Transition Metal Dichalcogenides (TMDs), their optoelectronic properties and different methods for synthesis and fabrication of TMDs along with the brief description of the instruments used for device fabrication and characterization. At the end of the chapter, a brief literature review is carried out to define the scope of the present thesis work.

In **Chapter 2,** an Ag/$MoSe_2$ thin film/Ag structure based metal-semiconductor-metal (MSM) broadband photodetector fabricated on $SiO_2$ coated Si substrate is reported. The nano-powder synthesized by the hydrothermal route was used for fabricating $MoSe_2$ thin film by thermal evaporation technique. The interdigitated Ag Schottky contacts were fabricated on the $MoSe_2$ film by thermal evaporation method to obtain the desired structure. The fabricated device showed the maximum responsivity, specific detectivity and external quantum efficiency (EQE) of ~50 mA/W, ~$4.5 \times 10^{11}$ Jones and ~ 16% respectively at 415 nm under the applied bias voltage of 1.5 V. The fabricated device also showed fast time response with rise (fall) time as 17.76 ms (18.38 ms) at room temperature.

**Chapter 3** presents fabrication and characterization of an n-$MoSe_2$/p-Si heterojunction based broadband photodetector by depositing an n-$MoSe_2$ thin film on a ⟨100⟩ p-Silicon substrate (2–5 Ω-cm resistivity) by a thermal evaporation method. The facile hydrothermal route was adopted to synthesize $MoSe_2$ powder. The photoresponse of the fabricated device was measured at room temperature using monochromatic light of 300–1100 nm wavelengths. The maximum responsivity, specific detectivity, and external quantum efficiency (EQE) of the fabricated device were obtained as 316.25 mA/W, $1.54 \times 10^{11}$ Jones, and ~45%, respectively, at 890 nm with the applied reverse bias voltage of 2 V. The rise time and fall time of the device was 396 and 224 ms, respectively.

**Chapter 4**, explores an ITO/n-ZnO CQDs/n-$MoSe_2$/ Ag structure based high performance ultraviolet-visible (UV-Vis) broadband photodetector where the n-n heterojunction between ZnO colloidal quantum dots (CQDs) and $MoSe_2$ thin film fabricated on an Indium tin oxide (ITO) coated glass substrate forms the active region of the device. The ZnO CQDs synthesized by hot-injection method was spin-coated on the substrate while $MoSe_2$ nanopowder synthesized by hydrothermal method was deposited on the ZnO CQDs layer by thermal evaporation method to obtain the ZnO CQDs/$MoSe_2$ heterojunction. The heterojunction showed a broad absorption spectrum covering the UV-Vis region. Under applied bias voltage of 2 V, the proposed photodetector showed the maximum responsivity (R) of ~282 A/W, specific detectivity (D) of ~$9\times10^{12}$ Jones and external quantum efficiency (EQE) of ~90000% at 380 nm in the UV region whereas R ~16.15 A/W, D ~ $5.37 \times 10^{11}$ Jones, EQE ~3660% were measured at 550 nm in the visible region. The transient response analysis of the device measured at room temperature showed a rise time (fall time) as 7.25 sec (2.25 sec) at 380 nm and 1.2 sec (2.2 sec) at 550 nm.

In **Chapter 5**, the thesis concludes with the significant contribution and summary of the results achieved in this research work. This chapter also contains the future scope of the thesis work present in this thesis.