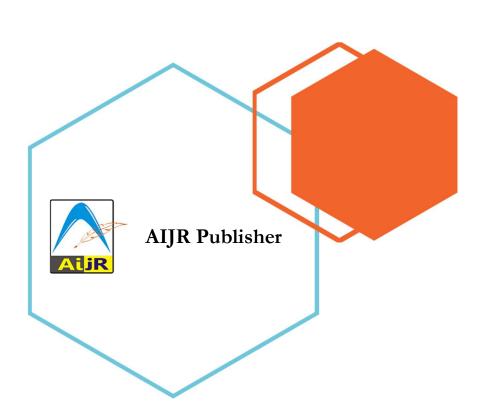
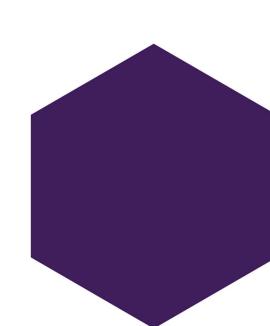




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### Preface

Nano is a familiar prefix used everywhere these days as public interest in nano materials has grown rapidly. The last forty years people have seen a number of crucial technical developments in field. These developments have initiated changes in human life of an unprecedented kind. This period has simultaneously witnessed other landmark developments. The construction of point contact transistor in 1947 rapidly led to intensive research which ultimately led crystallized in the concept and subsequent realization of the information technology (IT) era. In the 1970's, the information age per se started. We saw stepwise appearance of quartz optical fiber, III-V compound semiconductors and gallium arsenide (GaAs) lasers. During the evaluation of the information age, silicon (Si) occupied a dominant place in the commercial market, as it was used to fabricate the discrete devices and integrated circuits needs of for computing, data storage and communication.

Zinc oxide (ZnO) is a II–VI compound semiconductor with a wide direct band-gap of 3.3 eV and a hexagonal structure. ZnO is often used in the paint, paper, rubber, food and drug industries. It is also a promising material in nanotechnology applications, for example in nanoelectronics and nano-robotic technology. With its wide band-gap, high exciton binding energy and high breakdown strength, ZnO can be utilized for electronic and photonic devices, as well as for high-frequency applications. One-dimensional ZnO nanostructures have great potential applications in the fields of optoelectronic and sensor devices. Therefore, it is really important to realize the growth of ZnO nanostructures and investigate their properties. A physical vapor condensation method is used to synthesize the nanostructures of ZnO. These nanostructures are fabricated by resistive heating of Zn powder at a temperature of 400°C in the presence of oxygen and argon gases under a vacuum of order of 10-6 mbar. The transmission electron microscope (TEM) images suggest that these nanostructures have some mixed morphology. They contain nanorods as well as nanoparticles. The typical diameter of these nanorods is in the range of 80-150 nm and the length is of the order of several micrometers, whereas the size of the nanoparticles vary from 50-80 nm. Temperature dependence of dc conductivity of these ZnO nanostructures is also studied in the temperature range (303-573K). It is found that the experimental data gives a good fit for thermally activated process. Therefore, it is suggested that thermally activated process is responsible for the transport in these nanostructures.

The main objective for this book to successfully synthesis of ZnO nanostructures with investigation of the electrical and optical properties in detail by the methods of Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Field Emission Scanning Electron Microscope (FESEM) etc. The entire book has been divided into six chapters, each of which is a self-contained unit in itself.

**Chapter 1** begins with some basic introduction to nanotechnology and provides a comprehensive introduction to ZnO nanostructures It also provides some historical background and a brief summary of some basic subject matter and definitions.

**Chapter 2** presents an extensive review of the subject. This chapter provides some historical connection between the nanotechnology and ZnO nanostructures. It gives an access to most of the basic material on the structure, synthesis, general properties with electrical and optical properties production, growth mechanisms and applications of ZnO nanostructures. Many references are provided from which the reader can obtain more detailed information further.

Chapter 3 deals with techniques of synthesis and characterization of ZnO nanostructures begins with experimental details and the description of the method used to prepare the ZnO nanostructures. This includes synthesis of ZnO nanostructures by physical vapor deposition. It further provides the brief information about the characterization of ZnO nanostructures. Different characterization techniques like SEM, TEM and FESEM adopted for the characterization of ZnO nanostructures are duly incorporated in details and results are given in chapter 4, chapter 5 and chapter 6

**Chapter 4** presents results and discussion on the Electrical Transport Properties of ZnO nanostructures. The growth and characterization of ZnO nanostructures are also discussed along with their results.

**Chapter 5** includes optical and electrical characterization of ZnO thin film. It presents results and discussion on the optical and electrical properties of ZnO thin film. The growth and characterization of ZnO nanostructures are also discussed along with their results.

**Chapter 6** gives an overview of nanoparticles. It elaborates ways to produce ZnO nanoparticles with characterization including result and discussion.

Dr. Islam Uddin

## List of Symbols and Acronyms

#### **Symbols:**

μm Micrometer
A Ampere
Ar Argon
Cu Copper

E Young's Modulus

Fe Iron

GHz Giga Hertz GPa Giga Pascal H<sub>2</sub> Hydrogen

H<sub>2</sub>O<sub>2</sub> Hydrogen PeroxideH<sub>2</sub>SO<sub>4</sub> Sulphuric Acid

He Helium
K Kelvin
Li Lithium
mA Milli-ampere

MgO Magnesium Oxide

Mo Molybdenum NH<sub>3</sub> Ammonia Ni Nickel

 $\begin{array}{ccc} nm & Nanometer \\ O_2 & Oxygen \\ Pd & Palladium \\ Pt & Platinum \\ Si & Silicon \\ TPa & Tera Pascal \\ \end{array}$ 

V Volt

V<sub>s</sub> Group Velocity

W Watt W Wein

°C Degree Celsius

π Thermal Conductivity

#### **Acronyms:**

OD Zero-Dimensional
 1D One-Dimensional
 2D Two-Dimensional
 3D Three-Dimensional
 AC Alternating Current

APCVD Atmospheric Pressure Chemical Vapour Deposition

CVD Chemical Vapour Deposition

DC Direct Current

FET Field-Effect Transistor

HRTEM High Resolution Transmission Electron Microscopy

LPCVD Low Pressure Chemical Vapour Deposition

MFC Mass Flow Controller

MOCVD Metallo-Organic Chemical Vapour Deposition

MOSFET Metal-Oxide-Semiconductor Field Effect Transistor MPCVD Microwave Plasma Chemical Vapour Deposition

MWNTs Multi-walled Carbon Nanotubes

NT Nanotechnology

PECVD Plasma Enhanced Chemical Vapour Deposition

RF Radio Frequency

SEM Scanning Electron Microscopy
STM Scanning Tunneling Microscopy
SWNTs Single-walled Carbon Nanotubes
TEM Transmission Electron Microscopy

UHVCVD Ultra High Vacuum Chemical Vapour Deposition

VLS Vapour-Liquid-Solid XRD X-Ray Diffraction

