CHAPTER 1

INTRODUCTION

Wide-bandgap II–VI semiconductor materials still attract the attention of many scientific and industrial research groups. Materials of this system pose a broad range of bandgaps that they are capable of emitting many colors in the visible light spectrum. Therefore, in the field of communication and data transfer they are very promising candidates for development of short wavelength light emitting diodes (LEDs), diode lasers and other optoelectronic devices such as solar cells, X-ray detectors, photoresistors, electron beam screens, etc.

Photovoltaic energy conversion is the direct production of electrical energy in the form of current and voltage from electromagnetic (i.e., light, including infrared, visible, and ultraviolet) energy which then can be employed or stored. The basic needed for photovoltaic energy conversion is a light absorption process which causes a transition in a material (the absorber) from a ground state to an excited state. The energetic, photo-generated negative-charge carriers arriving at the cathode result in electrons which travel through an external path (an electric circuit). While traveling this path, they lose their energy doing something useful at an electrical "load" and finally they return to the anode of the cell. At the anode, every one of the returning electrons completes and combining with an arriving positive-charge carrier, which returning the absorber to the ground state.

Our main interested are the techniques for synthesis and some properties of semiconductor materials for applications in photovoltaic devices for example, dye-sensitized solar cell (DSSCs), that it can efficiently convert the energy in sunlight into usable electrical energy. Photovoltaic devices can be designed to be effective for electromagnetic spectra other than sunlight. For example, devices can be designed to convert radiated heat (infrared light) into usable electrical energy. These are termed thermal photovoltaic devices. There are also devices which directly convert light into chemical energy. In these, the photo-generated excited state is used to drive chemical reactions rather than to drive electrons through an electric circuit.

Both solid and liquid materials are used in solar cells. Homo-junction, hetero-junction, metal-semiconductor, and some dye-sensitized solar cells use all-solid structures, whereas liquid-semiconductor and many dye-sensitized cells use solid – liquid structures. These materials can be inorganic or organic. The solids can be crystalline, polycrystalline, or amorphous. The liquids are usually electrolytes. The solids can be metals, semiconductors, insulators, and solid electrolytes.

The photovoltaic effect is the creation of voltage or a corresponding electric current in a material, upon its exposure to light. Though the photovoltaic effect is directly related to the photoelectric effect, they are different processes. In the photoelectric effect, electrons are ejected from a material's surface upon exposure to radiation of sufficient energy. The photovoltaic effect is different in that the generated electrons are transferred between different bands (i.e., from the valence to conduction bands) within the material, resulting in the buildup of voltage between two electrodes.

In most photovoltaic applications the radiation is sunlight and for this reason the devices are known as solar cells. In the case of a p-n junction solar cell, illuminating the material creates an electric current as excited electrons and the remaining holes are swept in different directions by the built-in electric field of the depletion region.

Dye-sensitized solar cells (DSSCs) have been considered as a promising alternative to conventional solid-state semiconductor solar cells due to their low fabrication cost and relatively high solar conversion efficiency. First developed by Reagan and Grätzel in 1991, this class of cell has reached efficiencies of over 11%.

The basic structure of DSSCs involves a transparent (wide-band-gap) n-type semiconductor configured optimally in a nanoscale network of columns, touching nanoparticles, or coral-like protrusions. The surface area of the network is designed to be huge, and it is covered everywhere with a monolayer of a dye or a coating of quantum dots, which functions as the dye. The dye absorbs light, producing excitons, which dissociate at the dye-semiconductor interface, resulting in photo-generated electrons for the semiconductor and oxidized dye molecules that must be reduced—and thereby regenerated—by the electrolyte. The transparent semiconductor network provides the path to the cathode for the photo-generated electrons. The liquid electrolyte is the pathway from the anode for the reducing species which provide electrons for the oxidized (hole-bearing) dye molecules. The constant production of the electrolyte reduced species at the anode and the constant supplying of electrons via the cathode to the external circuit to do work. The semiconductor forming the network coated with dye molecules or quantum dots needs to be transparent to allow light to reach the absorber materials, and the network must have a huge surface area to provide the dye amount required for absorption. The electrolyte must be able to permeate the whole network to give electrical continuity; consequently, liquid electrolytes have proven very effective. A ruthenium dye was initially employed in the DSSCs, but by now several organic dyes and inorganic quantum dot "dyes" have been explored. Initially, TiO_2 (anatase) was used as the transparent, n-type semiconductor network, but other TCO-type semiconductors have been utilized, including SnO_2 and ZnO. Alternatives to the liquid electrolyte have included gels and solid phase holes conductors. The latter approach removes the holes from the oxidized dye molecules by straightforward solid-state holes transport.

In recent years, intensive development of nanocrystalline materials in nanotechnology has occurred worldwide. Among metal chalcogenide of group II–VI semiconductors, the cadmium and zinc chalcogenide have attracted special attention in recent years from both experimental and theoretical points of view, owing to their direct and rather large gap, which have been the focus of recent scientific research due to their important luminescent properties, quantum size effect and other important physical and chemical properties.

Various approaches have been suggested for the synthesis of group II–VI semiconductor crystallites or nanocrystallines, such as chemical bath deposition technique, pulsed laser deposition, hydrothermal method, solvothermal method, electrodeposition technique, acoustic wave stimulated (sonochemical) route, microwave irradiation, chemical deposition method, template-free solution methods, mechanical alloying, ultrasound-assisted, aqueous precipitation method, simple solution-phase route and solid-state synthesis. Generally, all these reactions require high temperature, and the use of toxic and highly sensitive precursors.

For the present research, the cadmium and zinc chalcogenide will be synthesized by microwave plasma technique and other technique in some material. It is inexpensive, simple process, an easier, fast reaction rate, short reaction time, highly efficient technique, energy saving and environmentally benign. The phase, average particle size, purity and optical properties (luminescence) of the cadmium chalcogenide powder can be controlled easily by changing the power operating, time period for heating and molar ratio of precursor material.

Microwave radiations with the frequency of 2.45 GHz are coherent and polarized. They are able to couple with atomic materials, and cause them to be heated up very rapidly. In general, materials are classified into three groups: reflectors: bulk metals and alloys, transparency: fused-silica and fluoropolymers, and absorbers: inorganic materials, powdered metals, metal oxides and metal halides. The use of microwaves in analytical sample preparation, materials processing and organic synthesis is becoming increasingly attractive; however, the utilization of microwaves for solid-state inorganic synthesis is limited to some extents. This is due to, in part the lack of understanding the interactions of microwaves with solids in dry media and the effect of reaction variables have on these interaction. Solid-state microwave reactions are able to access high temperatures rapidly and no requirement of a long time for completion. Reactions, which normally require hour or days via conventional heating, can be carried out in the microwave within an order of minutes. Shorter reaction procedures are advantageous, not only because they save time and are money, but also because they may allow for the synthesis of kinetically stable or meta-stable compounds, which are difficult to synthesize via other methods. Another advantage is that, unlike other alternative methods to traditional, high-temperature solid-state preparation, such as solvothermal synthesis, no solvent waste is generate in these reactions. These advantages allow solid-state microwave synthesis to be considered as a relatively green technique.

The purpose of the present research was to find the way to save the energy consumption for producing purified semiconductors CdS, CdTe, ZnTe and ZnO nano and microcrystals by a microwave plasma under 4.3±1 kPa argon absolute pressure. This synthetic process required a pressure that is not as low as previously done by Bhunia et al [66]. It is inexpensive, shorten reaction time, and environmentally benign appropriate for green environment. The semiconductors products, that our synthesis, can be applies in DSSCs as photoelectrode, polymer-electrolyte for studied and improved efficiency of solar conversion cells.

Research objectives

1. To build and develops the solid-state synthetic technique by using a microwave induced plasma system which is able to offer several advantages over other conventional heating techniques.
2. To synthesize and characterize the properties of CdS, CdTe, ZnTe and ZnO using microwave induced plasma system with nanometer and micrometer structures.
3. To synthesize and characterize the properties of ZnO using sonochemical method with nanometer and micrometer structures.
4. To study and investigate ZnO, p-CdTe, p-ZnTe and MWCNT in DSSCs