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THE USE OF II-VI COMPOUNDS IN THE ELECTRONIC APPLICATIONS

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ABSTRACT

This paper presents new and possible industrial applications of II-VI semiconductor compounds. In the recent years, wide gap II-VI compounds have considerably been utilised in the electronic applications. Having higher optical transition probabilities for absorption and luminescence, higher ionicity, smaller radiative lifetime, II-VI semiconductor materials such as CdS, CdSe, CdTe, ZnS, ZnSe, ZnO, have been capable of emitting every colour of the visible spectrum in the LED production. Moreover, the information transfer devices, solar energy converters, photoresistors, X-ray detectors and also electron beam screens have been the domain of II-VI compounds, because these materials can be produced to a high standard of purity from inexpensive and available raw materials. II-VI compounds can be produced in the form of polycrystalline layers of good optical quality by means of convenient and cheap methods as well. The surfaces and interfaces of these compounds are commonly rather stable. Because of that these semiconductors have been seen as significant rival materials against elemental other group semiconductor compounds.

1. INTRODUCTION

Important researches have been focused on II-VI compounds since the late 1950s. Because of their superiority to their rival materials, these compounds are getting more of importance day by day in the research for electronic materials. About these materials many experimental procedures have been improved and also theoretical models have been developed. However, in spite of their positive properties, crystallographic properties of the some II-VI semiconductor materials (e.g. ZnS) have been hindered due to polytypism in the electronic industry. About optoelectronic applications of the semiconductor materials significant studies have been done [1-8]. Utilising II-VI compounds thin film-based photoelectrochemical solar cells have been improved [9] and also band gap determination and magnotoresistance of the compounds have been researched by means of typical methods [10-13]. Moreover, using sometype of II-VI compounds green light emitting diodes have been produced [14] and multi-quantum wells of the low-dimensional heterostructures based on the compounds have been studied [15-21]. The studies of the quantum dots of the semiconductor materials produced by II-VI compounds have also been seen very significantly [22-23]. Some of the semiconductor materials, which have technological importance, are seen in Table-1.

Table 1. Some of the technologically important semiconductors and II-VI compounds [1].

Compound	Energy gap (eV)	Type of transition	Mobility ($cm^2V^{-1}s^{-1}$)	Effective mass	Ionicity	Lifetime (s)
Ge	0.67	Indirect	4000	1.58, 0.08	0	10^{-3}
Si	1.11	Indirect	1500	0.91, 0.19	0	10^{-3}
GaAs	1.43	Direct	9000	0.065	0.31	10^{-8}
GaP	2.30	Indirect	180	0.35	0.33	10^{-7}
CdSe	1.73	Direct	650	0.13	0.70	$< 10^{-9}$
ZnTe	2.25	Direct	100	0.11	0.61	$< 10^{-9}$
CdS	2.42	Direct	350	0.20	0.69	$< 10^{-9}$
ZnSe	2.67	Direct	200	0.17	0.63	$< 10^{-9}$
ZnS	3.66	Direct	150	0.28	0.62	$< 10^{-9}$

According to physical properties of II-VI compounds shown in Table -1, these materials have been utilised in the different application fields.

2. RESULTS AND DISCUSSION

II-VI compounds have been utilised both in the form of crystals and thin film layers. The choice of the techniques completely depend on where the electronic goods will be used. Because of that some of the optoelectronic part of the electronic devices are crystal-based and also some of them are thin-film-based. So, in the production crystal of II-VI compounds various growth techniques such as vapour, melt, hydrothermal, solution and flux growths have been utilised very effectively. Meanwhile, in the production of thin layers of II-VI compounds on the suitable substrates different techniques, such as vapour phase epitaxy (VPE, CVD, OM-CVD), liquid phase epitaxy, molecular beam epitaxy, thermal vacuum evaporation, flash evaporation, cathodic sputtering, electron-beam evaporation and spray pyrolsis, have significantly been used. Moreover, the methods of the atomic layer epitaxy and hot wall epitaxy are the new production techniques used in this area.

Current application areas of II-VI compounds in the electronic industry

Most of II-VI semiconductor materials have been used extensively in the industry because of their physical properties. These application areas of the compounds are given in Table-2.

Table-2. Illustrates the current application areas of some II-VI compounds [1].

Application fields	**The used materials**	**Optimum active surface area of the component**	**Material preparation techniques**
Absorber material for solar cells	CdTe	10-100 cm^2	Vacuum evaporation; VPE (CVT, CSVT, CVD); sintering
ac,dc electroluminescent thin film displays	ZnS, ZnSe, ZnS_xSe_{1-x}	>10 cm^2, <200 cm^2	Vacuum evaporation, cathodic sputtering; VPE
ac,dc electroluminescent powder displays	ZnS, $Zn_xCd_{1-x}S$	<100 cm^2	Settling process
Window material for solar cells	CdS, $Zn_xCd_{1-x}S$	10-100 cm^2	Vacuum evaporation, cathoic sputtering; VPE (CVT, CSVT,CVD); spray pyrolysis
Laser window material	ZnSe, CdTe	>1cm^2	Melt growth, vapour growth (seed methods)
Photovoltaic detectors	p-InO/n-CdS, p-CuInSe2/n-CdS, p-GaAs/n-ZnSe, etc.	<1cm^2	Vacuum evaporation, vapour phase epitaxy VPE (sublimation, CVT, CSVT, CVD)
Photoresistors, photoconductive detectors	CdS, CdSe, CdS_xSe_{1-x}, ($Zn_xCd_{1-x}S$)	<10 cm^2	Vacuum evaporation, cathodic sputtering, spray deposition; sintering
Cathode ray tube screens,	ZnS, $ZnS_xCd_{1-x}S$	400-5000 cm^2	Settling process
Projection colour television	ZnS, ZnSe, ZnS_xSe_{1-x}	400-5000 cm^2	Melt growth, vapour growth (seed methods)
Light emitting diodes	ZnS, ZnSe, ZnTe, ZnS_xSe_{1-x}	<1cm^2	All growth methods which provide single crystalline sample
Optical waveguides and modulators	ZnO, ZnS	~1 cm^2	Cathode sputtering, vacuum evaporation; VPE (sublimation; CVT)
Bulk-modulators and switches	ZnS, CdS	>1cm^2	Melt growth; vapour growth

Using different production methods, these II-VI compounds find different application areas in the electronic industry from to product colour television to cathode ray tube screen. From goods to goods, various parameters such as size, crystallographic properties, production techniques play important role in the use of these compounds. Concerning the physical properties of II-VI compounds, advantages and disadvantages of these materials can be seen as follows;

Advantages

- From inexpensive and readily available raw materials, these compounds can be produced to a high standard with purity
- They can be produced in the form of polycrystalline layers of good optical quality by convenient and cheap methods. The crystallite dimensions of these layers are of the order of the minority carrier diffusion length, a condition essential for all device applications which are based on minority carrier effects.
- Their surface and interfaces are commonly rather stable involving a rather low surface recombination velocity.
- Most of these compounds are readily miscible allowing the whole visible spectrum to be covered by a continuous variation of the band gap.

Disadvantages

- Comparing to III-V compounds and Ge and Si, to produce of bulk crystals is more complex and costly.
- Relating to the control of native defects and impurities and their electrical and optical properties, less knowledge is available.
- Any device based on p/n junction has not be produced using II-VI compounds up to now.

Concerning these properties of II-VI compounds, they have been seen very significant electronic materials both for current and also future industrial applications.

3. CONCLUSION

Finding very wide industrial application, so far some kinds of II-VI compounds have been hindered in order to use in the production of some " *high-tech goods* " because of their some physical properties. High degree of self-compensation of incorporated acceptors by native defects can be thought as a significant hinder in this matter. Nevertheless, concerning the new kind of techniques, such as the technique of Ion implantation, can be the last hope in the production of high-tech goods based on II-VI compounds. Making a positive approach, to produce of II-VI based-blue diode laser and blue-green light emitting diodes can be thought in this area. Because to produce p/n junction utilising II-VI compounds has been one of the most attention during the last two decades.

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