Optica Applicata, Vol. X, No. 1, 1980

Reflectivity of Zn_3As_2 and Zn_3P_2 in 0.24–1.2 μm waverange *

JAN MISIEWICZ, JERZY WRÓBEL, BARBARA SUJAK-CYRUL

Institute of Physics, Technical University of Wrocław, Wrocław, Poland.

FRANCISZEK KRÓLICKI

Institute of Inorganic Chemistry and Metallurgy of Rare Elements,
Technical University of Wrocław, Wrocław, Poland.

Reflectivity spectra of oriented Zn_3As_2 and unoriented Zn_3P_2 crystals were measured in 0.24–1.2 μm waverage at 300 K. A few singular points stated on spectral curves of both compounds have been assigned as interband transitions at the characteristics point of energy--band structure.

Introduction

The determination of the spectral dependences of the reflection index provides important information about the energy states of the electrons in a semiconductor. This enables us to determine the energy of electron in both interband and intraband transitions, depending on wavelength spectrum used. The investigation of interband transition has important meaning (for the photon energy $\hbar\omega$ greater than the energy gap E_g of semiconductor) for unknown materials, especially.

Zinc arsenide Zn_3As_2 and zinc phosphide Zn_3P_2 are poorly studied compounds among those belonging to II-V group. Reflectivity spectra of these compounds were studied only** in [1] and [2] for Zn_3As_2 and Zn_3P_2, respectively, and their energy gaps at 5-300 K are shortly reviewed in [3] and [4].

The aim of this paper is to present the reflectivity spectra of oriented Zn_3As_2 and unoriented Zn_3P_2 monocrystals and to estimate the energy values of prospective interband transitions.

Results and discussion

Specimens measured of approximate thickness of 0.5–1.5 mm, cut from monocrystals prepared by gas-transport method, were mechanically polished and then etched in 5% bromide solution of alcohol. Orientation of crystal structure on sample surfaces (for Zn_3As_2 only) has been provided at the Institute of Low Temperatures and Structural Research of the Polish Academy of Sciences, Wrocław.

* Work sponsored under contract 20/78 (IM-116).

** Some notes on reflectivity of thin Zn_3As_2 films has also been presented in [6] and Zn_3P_2 materials in [8].

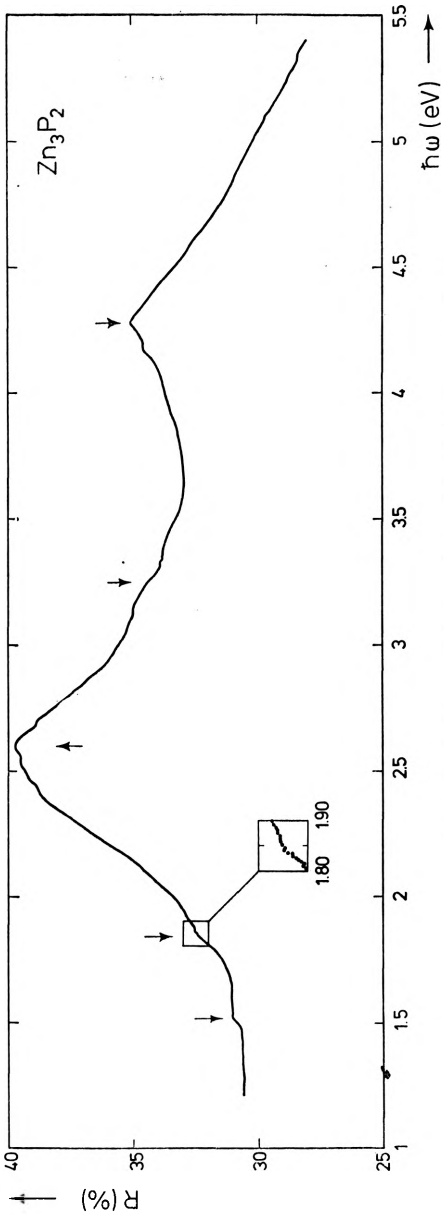

Fig. 1. Reflectivity coefficient of Zn_3P_2 vs. photon energy at 300 K

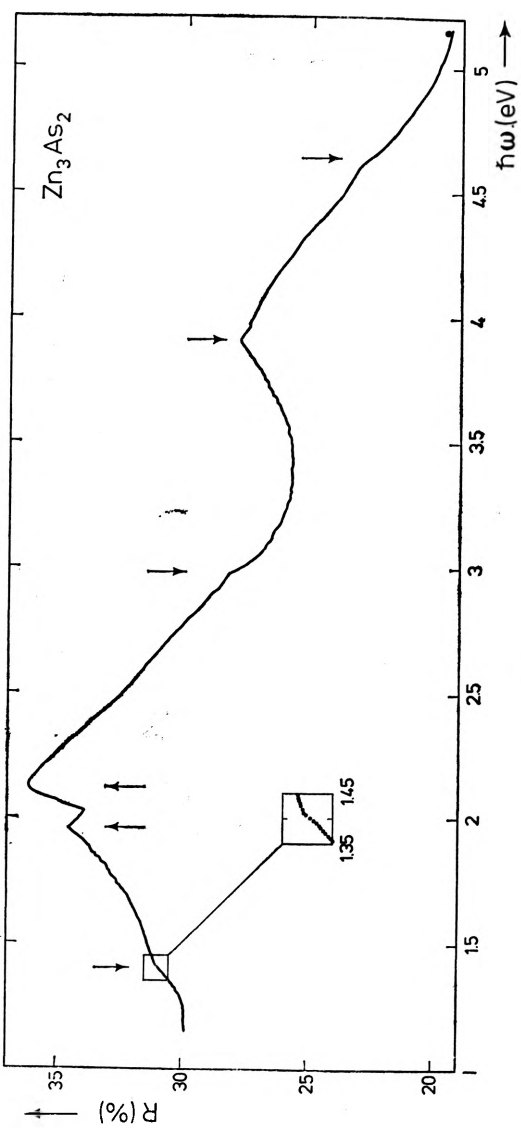

Fig. 2. Reflectivity coefficient of Zn_3As_2 vs. photon energy at 300 K

Reflectivity measurements were made in the special optical equipment (with SPM-2 monochromator and Si-68 prism) which allows to measure the absolute values of reflectivity coefficient of semiconductor with accuracy better than 1% [5].

Figures 1 and 2 show the dependences of reflectivity coefficient R on photon energy (near and above the energy gap of semiconductors measured) for examplary Zn_3P_2 and Zn_3As_2 samples, respectively. The inserts in figures indicate the accuracy with which the experimental points define the curves. The reflectivity curves presented in figures were obtained as the result of averaging (point-by-point-method) of some (not less than three) independent measurement cycles.

Two main peaks are observed for both compounds: 2.60 eV and 4.28 eV for Zn_3P_2 and 2.12 eV and 3.91 eV for Zn_3As_2, respectively. All the values have accuracy better than 20 meV. These two-peak spectral curves are characteristic of these semiconductors (see [1, 2, 8]).

The values of energies of optical-induced electron transitions (denoted by arrow in figures) were estimated as the energies of the peaks (or the steps) on reflectivity curves and are presented in tables 1 and 2 for Zn_3P_2 and Zn_3As_2, respectively.

Table 1

Energies (in eV) of experimental optical transitions in Zn_3P_2 crystal (at 300 K)

Data from [2]		Peak energires from this work
denotation of peaks*	peak energies	
		1.51
E_1, E_2	1.85	1.84
E_3, E_4	2.5**	2.60
E_5	3.16	3.20, 3.25 ***
E_6	4.32**	4.28
E_7	4.50	
E_8	5.36	

* Denotation in [2] has been taken from paper [7].

** Reflectivity peaks at 2.63 eV and 4.32 eV have also been obtained in the last paper [8].

*** Depending on the type of singularity of critical points.

Data from [1, 2] are also taken for comparison. Other singular points on curves (easy to show but not marked by arrows) require further investigations.

Assuming generally, a good accordance between our data and the cited ones are observed, excluding, however:

— low-energy transitions (at 1.51 eV for Zn_3P_2 at 1.40 eV for Zn_3As_2),

— small dissimilarities between our values of transmission energies (for Zn_3P_2) and the one cited after [2], between 2.50 eV [2] and 2.60 eV (this work), especially. It has been noted that the last results [8] rather confirm our statements.

Table 2

Energies (in eV) of experimental observed optical transitions in Zn_3As_2 crystal (at 300 K). Reflectivity from (101) surface

Data from [1]		Peak energies from this work
denotation of peaks*	peak energies	
		1.39
E_1	1.94	1.96
E_1'	2.14	2.12
E_2	3.03	2.98
E_3	3.82	3.91
E_4	4.6	4.64

* Denotation in [1] has been taken from paper [7].

These optical transitions are not possible to identify in term of lach reliable band-structure calculations.

Acknowledgments — The authors are very grateful to Doc. J. M. Pawlikowski for discussions of results and his helpful remarks.

References

[1] Sobolev V. V., Syrbu N. N., Zyubina T. A., Ugai Ya. A., Fiz. Tekh. Poluprov. **5** (1971), 3217.
[2] Sobolev V. V., Syrbu N. N., Phys. Stat. Sol. (b) **64** (1974), 423.
[3] Pawlikowski J. M., Misiewicz J., Sujak-Cyrul B., Wróbel J., Phys. Stat. Sol. (b) **92** (1979), K 123.
[4] Pawlikowski J. M., Misiewicz J., Mirowska N., Becla P., Phys. Stat. Sol. (b) **88** (1978), K 153.
[5] Misiewicz J., Becla P., Jankowska E., Report No. 308/78, Institute of Physics, Technical University of Wrocław.
[6] Kisiel A., Pawlikowski J. M., Zimnal M., Proc. of I Nation. Semin. on Physics of Thin Films, Szczyrk 1973, ed. PWN, Warszawa 1975, part 1, p. 200.
[7] Lin-Chung P. J., Phys. Stat. Sol. (b) **47** (1971), 33, and Phys. Rev. **188** (1968), 1272.
[8] Catalano et al., Proc. Internat. Conf. on Photovoltaic Solar Engery, Luxemburg 1977, ed.D. Reidel Publ. Co., Dordrecht and Boston 1978, p. 644-653.

Received, January 4, 1979

Спектры отражения Zn_3As_2 и Zn_3P_2 в диапазоне волн 0,24-1,2 мкм

Были измерены спектральные зависимости коэффициентов отражения ориентированных монокристаллов Zn_3As_2 и неориентированных монокристаллов Zn_3P_2 в диапазоне волн 0,24-1,2 мкм. Выявлено наличие на кривых характерных точек, соответствующих межзонным переходам в энергетических структурах этих соединений.