UDC 535 : 37

M.F. Bulanyi, A.V. Kovalenko, A.S. Morozov, O.V. Khmelenko

AUTOMATED SYSTEM FOR RESEARCH OF LUMINESCENCE SPECTRA CRYSTALOPHOSPHORS

Abstract. The article describes an automated system for the study of the luminescence spectra of crystal. The presence of a personal computer system obepechivaet automation of the measurement process.

Keywords: photoluminescence, recombination centers, monochromator, photomultiplier tube, single crystal, CAMAC system.

Introduction. When carrying out fluorescent studies are needed to measure various spectral-luminescent characteristics of the analyzed phosphors (brightness, quantum yield, polarization of the luminescence, photoluminescence spectra, etc.) [1,2]. These characteristics can be determined by this setting. In recent years, increased interest in the study of some crystals of the group A_2B_6 doped with transition elements (Mn, Cr, Fe, Co, Ni, Ti). In crystals, activated by these elements observed intracenter transitions in unfilled 3d-shells of atoms. This allows the use of these materials for the quantum electronics.

Effect of influence dislocations on the most important properties of some semiconductors compounds A_2B_6, in particular of zinc sulfide, can be carried out not only by direct interaction with the electron subsystem of the crystal, but also through targeted changes in their crystalline structure. It is known that in the process of plastic deformation as a result of partial motion of dislocations occurs microtwinning reorientation of the lattice crystal of ZnS crystals in one-oriented structure sphalerite [3]. It should be noted that the importance of the problems set forth increases, considering their importance not only for the zinc sulfide and other compounds of the type A_2B_6, as also for several other promising semiconductor materials (e.g., silicon carbide) having a similar structure.

The need to study the luminescence properties of ZnS phosphors to determine the possibility of purposeful management of real crystal structure of ZnS and change the local symmetry of the impurity centers under the influence dose and strain of the and electric fields due to their wide use in the display system, and with the prospect of their use in quantum electronics.

The study of the physical properties of new semiconductor materials are best carried out on single-crystal samples, in this connection, special attention is paid to the development of technology for obtaining them in the form of single crystals.

Great interest now represents growth of single crystals of solid solutions based on zinc sulphide, which are doped with different impurities, as well as studies of their properties, structure, and practical use, the processes occurring when exposed to ultraviolet and infrared excitation of an external electric field, plastic deformation, etc.. The most complete and reliable information on recombination centers can be obtained by comprehensive studies of various spectroscopic methods, including the study of the photoluminescence spectra.

Among semiconductor materials used in science and technology today, occupy a special place on the basis of semiconductor compounds A_2B_6. They differ in the structure of the crystal lattice, the band gap and the presence of various defects, but they all share a pronounced ability to luminesce in a wide spectral region at 300 K and 77 K, as well as change its conductivity under the influence of corpuscular and electromagnetic radiation in a wide wavelength range.

Despite such widespread use of these materials, many questions regarding the crystal structure, electrical and luminescent properties are not fully understood. Particularly poorly studied solid solutions of these compounds. This is largely determined by the fact that the use of the technique based on data cristalofosforov these compounds are generally powders. Heterogeneous structure powder samples limits the possibilities of experiment and interpretation of the results. Preparation and study the properties of crystals of solid solutions $Zn_{1-x}Cd_xS$, $ZnS_{1-y}Se_y$ has great practical signsfscance. These materials may be mixed in any proportions and where in many changes smoothly physical characteristics. There by it becomes possible to obtain desired values of certain parameters. The ability to change parameters, especially the transition energies, by changing the composition of the compounds is promising for laser technology.

The developed system registers the luminescence spectra over a broad spectral range, followed by mathematical processing of research results.

By its nature, luminescence refers to the structure-sensitive properties of crystals. All paramagnetic probes are either well-known centers of luminescence (Mn^{2+}, A-center, Fe^{3+}), or participate in the processes of charge transport in luminescence (Cr^{+}, Fe^{3+}).

To study the luminescent properties of the crystals we have been designed and manufactured a special automated optical spectral complex, which can be used for registration of emission and absorption spectra in the spectral range (200 ÷ 1200 nm), automatically collect information about spectral composition of the radiation and subsequent mathematical processing of the results of studies [4].

The automated complex consists of measuring the luminescence source of optical excitation system photoelectric detection and automatic control systems. Functional diagram of the complex is shown in fig. 1.

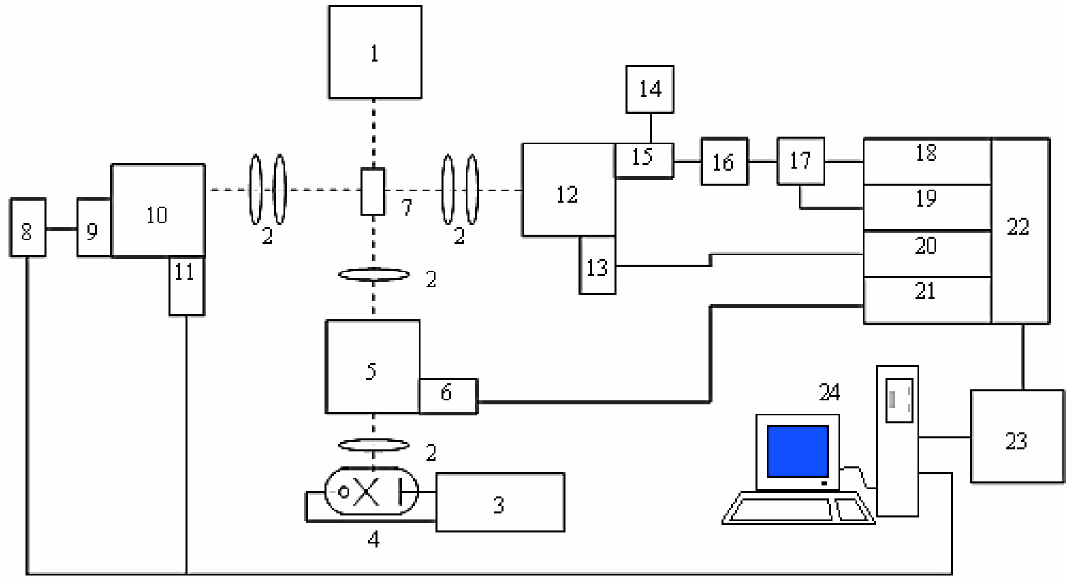

Figure 1. – Functional diagram of the automated optical spectral complex

As the source of optical excitation may be used: lazer (1 – LGI-505 with wavelength – 337 nm and average power of 120 mW), with power supply unit (2); laser (3 – LGN-517, with the wavelength of 441.6 nm radiation values, an average power of 10 mW), with power supply unit (4); xenon lamp DKsSH-1000 (5) with an average power of 1000 W with power unity (6).

For the isolation of the exciting light with a recording system, a laser beam is incident on the sample at an angle of 90 degrees relative to the optical axis of the system. The radiation intensity is adjusted using neutral filters.

When used as a source of optical excitation lamp DKsSH-1000 to isolate the desired spectral range uses a monochromator MDR-2 (8). For remote control automatic measurement, monochromator is equipped with a stepper motor – DSHI - 200-2 (9), which is connected to the control system via standard CAMAC module stepper motor control (22). This system provides automatic control accuracy of setting the excitation wavelength is not lower than 1/6 nm on one step motor. After the monochromator excitation radiation through the quartz focusing lens (7) falls on the sample placed in a cryostat (10).

The radiation pattern through the condenser (11) is fed to the entrance slit of the monochromator MDR-12 (12). For automatic remote scanning monochromator registering as excitation monochromator system is provided with a stepper motor DSHI-200-2 (9). The automatic control system monochromator MDR-12 provided a wavelength accuracy of not less than 0.01 nm. Radiation of the sample after passing through the monochromator focused on the cathode of a photomultiplier-136 (13), working in the counting mode single-electron pulses. Photomultiplier (PMT-136) with a semitransparent special photocathode, electrostatic focusing of electrons, 11-dinode system of multiplication, used as a radiation detector for the spectral range 300 ÷ 830 nm. For this type of photomultiplier dark count rate of the anode current at a temperature of 20 °C no more then 400 pulses/sec. Spectral channel reregistration system depends on the type PMT.

To decrease the thermal noise, the PMT-136 is cooled to a temperature – (20 ÷ 25) °C. For this purpose, the installation used microcoolers with power supply (27), working on the Peltier effect, cooling the hot junctions running water. Further, after PMT, electron pulses are fed to a broadband amplifier (16). After pulses are applied to the amplifier 2 a threshold discriminator (17). The voltage thresholds are specified in two 8-bit digital-to-analog converter (DAC) (21, 20), which are controlled CAMAC system (26). The output of the discriminator pulses arrive at the normalizer (18) which matches the magnitude and duration of the pulses from TTL logic levels. Next normalszed pulses are applied to the counter (19), which is a regular set of CAMAC system. The maximum number of count pulses ~ 10^5 s^{-1}. The overal management measuring system is performed using CAMAC conjugated with a personal computer IBM 486 DX (24) using the interface unit (23).

The conclusions. The results of the comparison made registration system of the photoluminescence spectra in comparison with traditional methods leads to several conclusions:

1. Investigation of the spectral characteristics of the photoluminescence conducted in developed automated installation.

2. Storage on magnetic disk allows them to quickly locate and produce mathematical processing.

3. Improve the accuracy and speed up the process of measurement.

LITERATURE

1. Левшин А.В. Люминесценция и ее измерение /А.В. Левшин, А.М. Салецкий. – М.: Изд. МГУ. – 1989. – 272 с.

2. Физика и химия соединений $A^{II}B^{VI}$ / Под ред. Медведева С.А. М.: Наука. – 1986. – 624 с.

3. Электронные свойства дислокаций в полупроводниках / Под ред. акад. Ю.А. Осипьяна. – М.: Эдиториал УРСС. – 2000. – 320 с.

4. Буланый М.Ф. / Автоматизированная система для комплексних исследований центров рекомбинации в полупроводниках / М.Ф. Буланый, С.А. Омельченко, А.Н Хачапуридзе // Тез. докл. X науч.- техн.. конф. “Датчики и преобразователи информации систем измерения, контроля и управления”. – Датчик 98. – Гурзуф. – 1998. - Т. 2, С. 345 – 348.