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LUMINESCENT PROPERTIES OF OXIDE FILMS ALUMINUM AND TANTALUM IN CONTACT WITH AN ELECTROLYTE

The results of the study of the photoluminescence spectra, electroluminescence and luminescence excited ions of the electrolyte, oxide films of aluminum and tantalum, obtained by the electrochemical method are presented. It is shown that the emission of oxide films, appearing in contact with the electrolyte, due to the processes occurring on the surface of the sample.

Recently, we have showed the possibility of storing the lightsum by oxides when they interact with water vapor as a result of its dissociation on a solid surface [1]. It was assumed that the emission of a number of semiconductor materials in contact with the electrolyte is determined by the energy parameters of the centers formed by adsorbed on the surface of the hydroxyl ions, acting as donors, and the localized electrons on them. [2]

To confirm that the observed emission of a number of semiconductor materials in contact with the electrolyte occurs in the surface layer of phosphorus, we studied the luminescence, excited by the ions of the electrolyte (LEIE), photoluminescence (PL) and electroluminescence (EL).

In this work Al_2O_3 and Ta_2O_5 film thickness of 50 microns, obtained by electrolytic oxidation of aluminum and, accordingly, a tantalum foil in a 0.5% water solution of sorrel acid in 30 minutes on an alternating voltage of 70 V. (PL), (EL) and (LEIE), recorded at room temperature in the spectral range from 400 to 600 nm. The spectra were measured for the same sample and in the same electrolyte. To measure the EL spectra of oxide films of aluminum and tantalum sample was constant voltage anodic or cathodic polarization. As a counter used a film tin dioxide applied by pyrolytic decomposition of $SnCl_2$ on a glass substrate. The electrolyte is a water solution of salts of sodium chloride and manganese (pH=5,5). Luminescence emission was focused on the entrance slit of the

monochromator. Emission coming out of the monochromator was detected by a photoelectronic multiplier operating in the mode of counting single photons in the 300-850 nm spectral sensitivity. The signal from the anode of the photoelectronic multiplier was fed to an amplifier and then to the input of the recording device, namely, the frequency counter. In the case of spectra LEIE the sample was applied alternating voltage insufficient to excite the EL.

Fig. 1 shows the curves of the spectral distribution of the PL (1), electroluminescence (2) and LEIE (3) Al_2O_3 films. As can be seen from the figure, the spectrum LEIE has fundamental and additional emission bands for PL and EL.

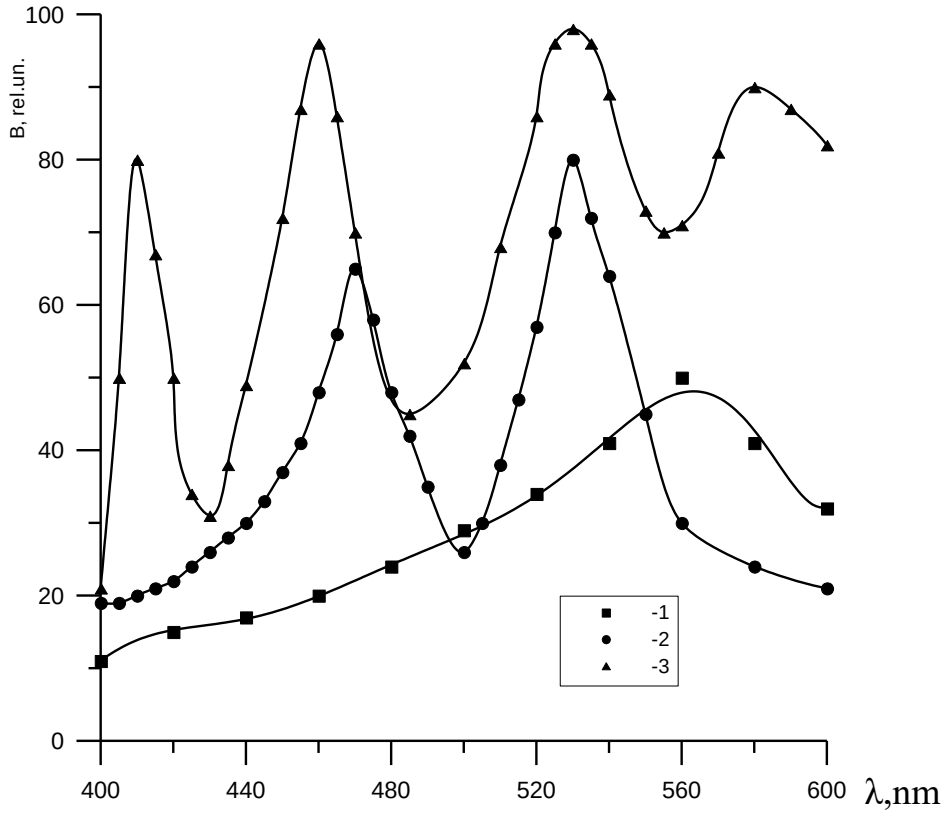

Fig. 1. Spectral distribution of the PL (1), electroluminescence (2) and LEIE (3) Al_2O_3 films.

Maximum of the band in the PL spectrum are located at 560 nm. In EL spectra bands with peaks are located by about 470 and 530 nm. In the spectrum of LEIE bands with peaks are located by about 410, 460, 530 and 580 nm. Obviously, the

band of 560 nm for the PL band and 530 nm for EL and LEIE are principal because their appearance is independent of way the excitation of luminescence.

The band at about 580 nm is observed in the spectra LEIE matter in which the electrolyte was measured and does not occur in the photoluminescence and electroluminescence. This additional band, apparently due to the centers of "biographical" nature contained in a certain amount in the phosphor [3], and does not appear in the sample with other types of luminescence, besides luminescence excited by ions of the electrolyte.

The appearance of a band at about 410 nm depends essentially on the nature of the electrolyte in contact with which is film Al_2O_3. Accoding to the electron theory of chemisorption and catalysis, the appearance of such additional band can be explained by the appearance on the film surface chemisorption luminescence centers due to the adsorption of ions of the electrolyte, in contact with which LEIE is observed.

Fig. 2 shows the curves of the spectral distribution of the PL (1), electroluminescence (2) and LEIE (3) Ta_2O_5 films. As seen from the curves of the spectral distribution emission of the films Ta_2O_5, LEIE spectrum as well as the spectrum of the films Al_2O_3, has fundamental and additional emission bands with the spectra of PL and EL.

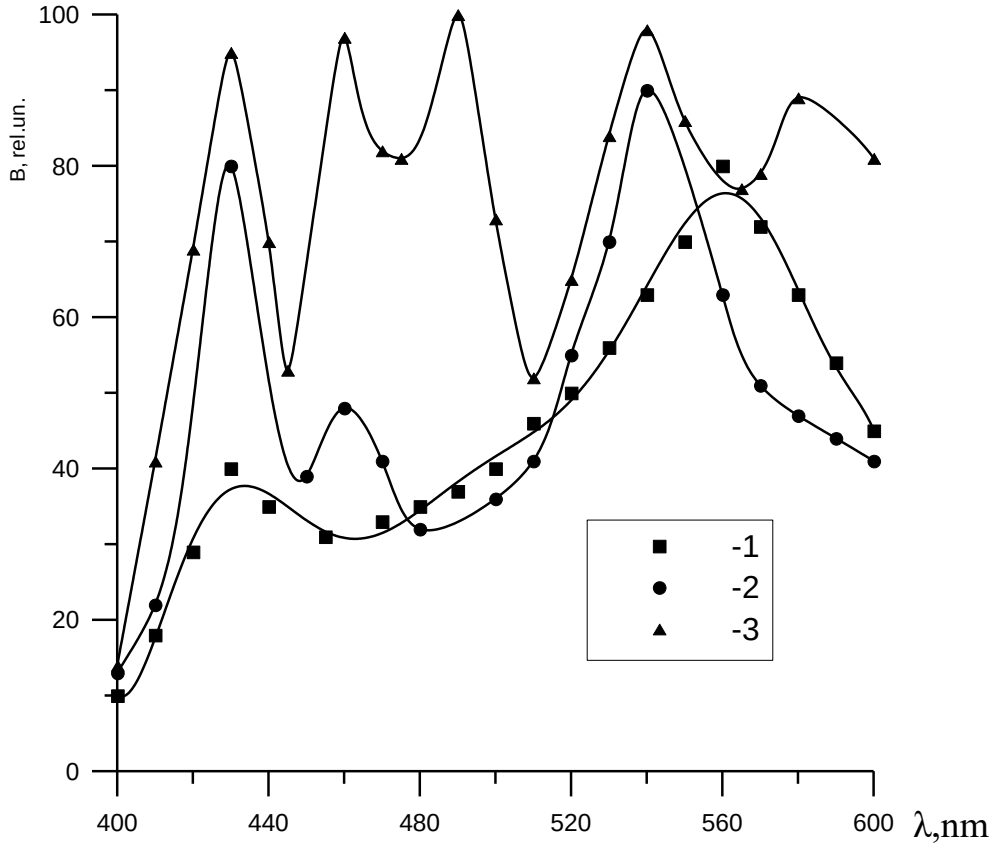

Fig. 2. Spectral distribution of the PL (1), electroluminescence (2) and LEIE (3) Ta_2O_5 films.

Bands with maxima at 430 and 540 nm in the PL spectrum of tantalum oxide films are observed, which is similar to the PL spectra of aluminum oxide film. In the spectrum of the EL tantalum oxide films bands with maxima at 430, 460 and 540 nm are also observed. In the spectral distribution of the LEIE, bands with maxima at 430, 460, 490, 540 and 580 nm are allowed.

Obviously bands with maxima at about 430 and 540 nm can be attributed to the fundamental, as they are observed as in the case of LEIE, as in the case of the PL and EL. The band at about 580 nm is observed in the spectra LEIE in any of the used electrolytes and is not observed under light or field excitation. Apparently, this band is due to the presence on the surface of the film centers "biographical" nature. Band with a maximum at 490 nm is observed only in certain electrolytes and its position depends on the nature of the electrolyte, in contact with which is film. Obviously, this additional band is related to the arising on Ta_2O_5 film surface emission adsorption centers.

In the spectrum LEIE tantalum oxide film, as well as in aluminum oxide film spectrum LEIE a band at about 460 nm is observed. This additional band, apparently, of the chemiluminescent nature and is explained by reaction occurring at radical recombination of H^+ and OH^- on the surface of the oxide film [4]. By chemiluminescent nature of this band is meant to initiate a catalytic surface of the film chemiluminescent reactions that may take place near the surface of the oxide film in contact with the electrolyte.

Oxidation of aluminum or tantalum films with manganese or being oxide films after oxidation in water solution of manganese results in an appearance of a band at about 600 nm. Obviously, the appearance of this band is caused by the presence of manganese in the film. This band is observed for the same film in different electrolytes, which indicates that it is not related to chemiluminescent reactions on the film surface and the surface centers of "biographical" nature, which are contained in the film are responsible for its origin.

Change of surface modification, by treating it before measuring spectra in different electrolytes, changes the properties of the layer of oxide films, and these changes occur in a layer about 10^{-9}m. To fix such surface changes in the study of electroluminescence and also photoluminescence impossible. Since the electrochemical obtained of aluminum and tantalum oxide films are of variable thickness [5], the PL spectrum is due to the average thickness of the physical and chemical characteristics of these films. In the case of electroluminescence electric field is concentrated in the electrode layers thickness of about 10^{-8} m, and therefore, electroluminescence spectrum is determined by properties of the film of the same order of thickness.

It is established, that only the spectra of LEIE, are sensitive to the nature of the sample and the electrolyte in contact with which it is, that is evidence in favour of what we observed emission is due to the processes occurring on the surface of the sample. This is the evidence that by the emission spectra, occuring in the contact of oxide films of Al_2O_3 and Ta_2O_5 with electrolyte we can judge adout physical and chemical properties luminofores surface.

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Abstract

The results of the study of the photoluminescence spectra, electroluminescence and luminescence excited ions of the electrolyte, oxide films of aluminum and tantalum, obtained by the electrochemical method are presented. It is shown that the emission of oxide films, appearing in contact with the electrolyte, due to the processes occurring on the surface of the sample.

Key word: luminescence, oxide films, electrolyte.

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ЛЮМИНЕСЦЕНТНЫЕ СВОЙСТВА ОКСИДНЫХ ПЛЕНОК АЛЮМИНИЯ И ТАНТАЛА В КОНТАКТЕ С ЭЛЕКТРОЛИТОМ

Резюме

Приведены результаты изучения спектров фотолюминесценции, электролюминесценции и люминесценции, возбуждаемой ионами электролита, оксидных пленок алюминия и тантала, полученных электрохимическим методом. Показано, что свечение оксидных пленок, возникающее в контакте с электролитом, обусловлено процессами, происходящими на поверхности исследуемого образца.

Ключевые слова: люминесценция, оксидные пленки, электролит.

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ЛЮМІНЕСЦЕНТНІ ВЛАСТИВОСТІ ОКСИДНИХ ПЛІВОК АЛЮМІНІЮ І ТАНТАЛУ В КОНТАКТІ З ЕЛЕКТРОЛІТОМ

Резюме

Приведені результати вивчення спектрів фотолюмінесценції, електролюмінесценції та люмінесценції, яка збуджується іонами електроліту, оксидних плівок алюмінію та танталу, отриманих електрохімічним методом. Доведено, що світіння оксидних плівок, яке виникає у контакті з електролітом, обумовлено процесами, що відбуваються на поверхні досліджуваного зразка.

Ключові слова: люмінесценція, оксидні плівки, електроліт.