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Fig. 1. Reflection spectra of initial and crystallized lead-silicate glasses in the region 200-400 mμ. 1 –spectrum of the initial glass containing 50 mol.% PbO and 50 mol.% SiO_2; 2 –spectrum of the same glass, completely crystallized at t = 700°; 3 –spectrum of the initial glass containing 66.7 mol.% PbO and 33.3 mol.% SiO_2; 4 –spectrum of the same glass, completely crystallized at t = 620°; 5 –spectrum of the initial glass containing 70 mol.% PbO and 30 mol.% SiO_2; 6 –spectrum of the same glass, crystallized at t = 620°

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Abstract

Full Text

PHYSICS

E. V. SMIRNOVA

SPECTRA OF SOME TWO-COMPONENT LEAD-SILICATE GLASSES IN THE ULTRAVIOLET REGION

(Presented by Academician A. A. Lebedev, October 21, 1964)

The study of the structure and properties of two-component lead glasses is of great theoretical and practical interest, since information obtained about them can, in many respects, be transferred to flints, which constitute a large group of optical glasses. In the present communication the spectra of some initial and crystallized glasses of the PbO–SiO_2 system in the region 0.1-1 μ will be considered.

Fig. 1. Reflection spectra of initial and crystallized lead-silicate glasses in the region 200-400 mμ.
1 –spectrum of the initial glass containing 50 mol.% PbO and 50 mol.% SiO_2; **2** –spectrum of the same glass, completely crystallized at $t = 700°$; **3** –spectrum of the initial glass containing 66.7 mol.% PbO and 33.3 mol.% SiO_2; **4** –spectrum of the same glass, completely crystallized at $t = 620°$; **5** –spectrum of the initial glass containing 70 mol.% PbO and 30 mol.% SiO_2; **6** –spectrum of the same glass, crystallized at $t = 620°$.

It is known that all lead glasses have, in the visible and ultraviolet regions, a high refractive index and large dispersion,

increasing with increasing lead oxide content in the glass and with increasing temperature. The causes of this phenomenon long interested many physicists concerned with the study of the structure of glass and with questions of light absorption in continuous media. At the end of the nineteenth century, Pulfrich ([1]), studying the optical properties of flint glasses, suggested that in lead glasses there should exist an absorption band in the ultraviolet region, which determines their high refraction. With increasing temperature this band shifts toward longer wavelengths, which causes a peculiar change in the optical properties of flints upon heating. Owing to great experimental difficulties, this question could not be clarified until recently. Only comparatively recently have works appeared confirming the existence of this absorption band in the spectrum ([2,3]); however, information on the spectral characteristics of lead glasses is still very limited. First, in the literature there are no data on spectra for the extreme ultraviolet region (at $\lambda < 200$ mμ). Second, there is a complete absence of information on the behavior of the spectra of these glasses when the lead oxide content and temperature are varied, and also during the transition from the glassy state to the crystalline state. The present communication is devoted to the study of these questions.

Fig. 2. Reflection spectra of glass with 50 mol.% Pb and 50 mol.% SiO_2 in the region 400-1000 mμ.
1 —original, 2 —crystallized

Fig. 3

Fig. 4

Fig. 3. Reflection spectra of crystalline silicates in the region 100-250 mμ.
1 —reflection spectrum of crystallized glass with 50 mol.% PbO, 2 —the same with 66.7 mol.% PbO, 3 —the same with 70 mol.% PbO

Fig. 4. Shift of the maxima of the selective-reflection bands of crystalline and glassy silicates as a function of lead oxide content. 1 —shift of the maximum lying in the region 100-250 mμ; 2, 3, 4 —shift of the maxima of the triplet lying in the region from 200-400 mμ; 5 —dependence of the refractive index on composition for the same glass samples according to the data of L. I. Demkina, obtained on a goniometer ([6])

The reflection spectra of the original and crystallized lead-silicate glasses with 50, 66.7, and 70 mol.% PbO were investigated in the ultraviolet and visible regions from 100 to 1000 mμ.

Reflection measurements in the region 200-400 mμ were carried out in unpolarized light on an SF-4 spectrophotometer with an FM-40 attachment for measuring reflection. The angle of reflection was approximately 10°. The objects of study were flat disks 40 mm in diameter. To avoid the influence on the measurement results of surface films, the specimens were ground and polished in pure

xylol; moreover, immediately before measurement the specimens were refreshed again.

The measurement results for the initial and crystallized glasses of metasilicate, orthosilicate composition, and with 70 mol.% PbO are presented in Fig. 1. For the visible region, such spectral characteristics are not given, since no bands of selective reflection were found there. In Fig. 2 the reflection spectra are given for the initial and crystallized glass with 50% PbO in the region 400–1000 mμ*.

It is seen from Fig. 1 that all the curves are triplets; moreover, the positions of the maxima in the spectra of the initial and crystallized glasses of one and the same composition coincide exactly, the difference being observed only in the intensity of the bands. Such similarity of the spectra indicates a certain similarity of the structure of the glass and the crystal.

The reflection spectra of the same crystallized glasses were investigated in the region 100–250 mμ on an SP-68 instrument (angle of reflection 11°). The measurement procedure is described in work (5). In all crystallized glasses, bands were found in the region from 180–200 mμ. The spectral curves for this region of the spectrum are shown in Fig. 2. The reflection coefficient of the crystallized glass with 50 mol.% PbO proved to be somewhat underestimated because of the presence of cracks on the reflecting surface, the influence of which is stronger as the wavelength decreases.

Comparison of the reflection spectra of glasses of different composition shows that, with increasing PbO content, a shift of the maxima of all bands toward longer wavelengths is observed; moreover, the longer-wavelength maximum shifts more than the shorter-wavelength one, as is evident from Fig. 3.

From the results presented it follows that the increase in the refractive index and dispersion of flints with increasing lead oxide content in the glass is associated with two factors: 1) with a shift of the absorption bands, i.e., the regions of anomalous dispersion, toward longer wavelengths, and 2) with an increase in the intensity of the absorption bands.

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Note: Figure translations are in progress. See original paper for figures.