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High radiation durability of optical elements made of porous glass

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Optical properties of elements made of silicate porous glass are measured after their exposure to γ-radiation. Extraordinary radiation durability of porous glass has been found and interpreted.

The development of the composition matrix materials has brought diffrent porous optical elements and opened up prospects of their application to quantum electronics [1], optics and opto-electronics [2], electronic technology [3] and other areas. In almost all of the above-mentioned works, use was made of silicate porous glass obtained by means of the acidic leaching-out of sodium-borate silicate glass Na 7/23

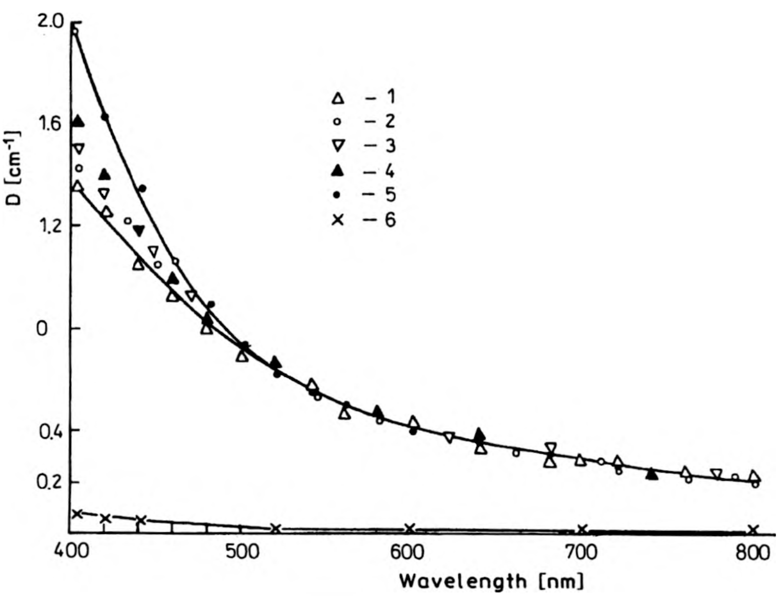

Fig. 1. Spectral dependence of optical density for the porous glass DV-1M after irradiation with γ-quanta of ^{60}Co at different exposure doses: 1 – original glass, 2 – 10^5 R, 3 – 10^6 R, 4 – 10^7 R, 5 – 10^8 R, 6 – the same for the porous glass impregnated with silicon-organic polymer at the γ-quanta of ^{60}Co exposure dose of 10^8 R.

[4]. Further extension of investigations allowed studying the various properties of porous optical components including their radiation durability.

Figure 1 shows spectra of an optical density difference for original porous glass and for the porous glass impregnated with silicon-organic compound with refractive index of about 1.47. One can see that the materials tested demonstrate high durability when exposed to irradiation by γ-quanta up to about 10^8 R. A continuous increase of optical density in the blue spectral region is due to the light scattering caused by the irregularities in the bulk of porous glass.

In order to investigate a contribution of pores to γ-radiation stability of optical density, the porous samples were thermally treated in order to make them collapse.

Figure 2 presents absorption spectra of non-porous quartz-like fabricated by means of thermal processing of originally porous glass after exposure to γ-radiation. In the same figure spectra of original sodium-borate-silicate glass and quartz glass KU are compared.

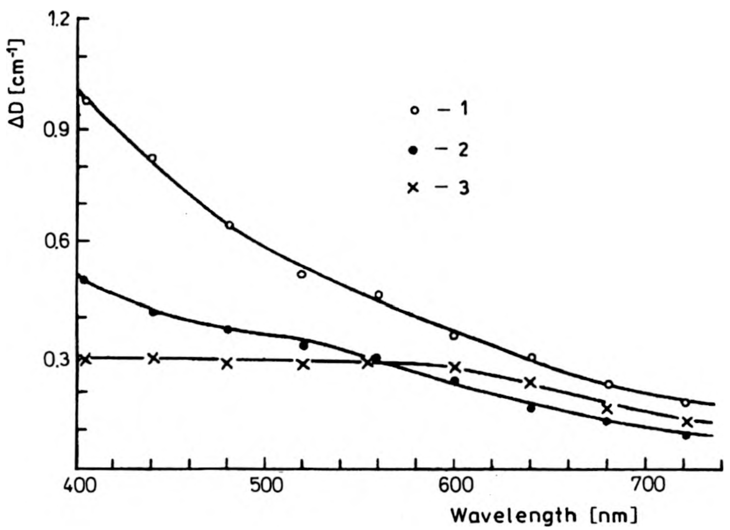

Fig. 2. Spectral dependence of the optical density difference for glasses after irradiation with γ-quanta of ^{60}Co (exposure dose $5 \cdot 10^5$ R): 1 — sodium-borate-silicate glass, 2 — quartz-like glass, 3 — melted quartz KU.

The data given in Figs. 1 and 2 confirm the significant resistance of porous glass to γ-radiation.

Physical basis of observed phenomena probably consists in the fact that sizes of γ-radiation induced defects are commensurable with those of molecular structural defects of porous glass formed during the leaching-out procedure [4]. These two kinds of defect get annihilated. One can assume that the defect stress fields induced by γ-radiation relax due to extreme heterogeneity of medium.

The phenomena like the ones described may occur in crystals, too. An example is the In_2Te_3 crystal which is known for its significant durability upon radiation as regards its electrical characteristics. Thus we may say that in friable crystals structural defects are dense. The radiation-induced defects are also annihilated during interaction with structural defects of crystal being present.

Another interpretation of high durability of porous optical elements may be given in the framework of the known conception of oxidating activity of hydroxyl groups [5]. The concentration of these groups in the porous silicate glass reaches about 10^{20} cm^{-3}.

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