

Formation of microoptical elements in the bulk of composition material on the basis of porous glass

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The possibilities of formation of microoptical elements in the bulk of composite material on the basis of porous glass have been investigated. It has been demonstrated that due to the local laser heating-up of composition material, the local desorption of adsorbate from porous matrix is initiated that causes formation of microlenses. Other possibilities of microoptical filters formation have been studied based on electrodiffusion immobilization of dye ions. Characteristics of such elements are studied and possible applications are discussed.

Formation of microoptical elements on the basis of porous glass demonstrates one of the many applications of this material to optical instrument-making. Earlier the optical and physical properties of porous glasses as well as compositions on the base of porous glasses have been studied [1].

Particularly, in paper [2] the optical characteristics of composition material "mesoporous glass–vapour of organic liquid" have been investigated. It was demonstrated that optical parameters of such a material are suitable for manufacturing optical components. By varying the amount of adsorbate in porous matrix and therefore the refractive index of composite material one can control the parameters of optical components made of the porous glass [3].

The amount of adsorbate in porous glass may be varied, among others, due to photothermal impact of laser radiation. At a certain value of radiation power density an active local desorption of adsorbate out of the pores occurs in the area irradiated by laser beam that causes the formation of a region with square-law distribution of refractive index.

The experiments have been carried out with the use of plates of 1–5 mm thickness made of porous glass DV-1M [4] with pore diameter of 8 nm. After immersion of organic liquids (benzene, isobutyl alcohol) the plate was placed into a sealed cuvette with optical windows. The desorption of adsorbate was stimulated by radiation of Ar laser ($\lambda = 514.5$ nm) with power density of ~ 10 W/cm². In order to provide the effective adsorption of laser radiation the plates were previously uniformly coloured with organic dye.

As a result of desorption the regions being equivalent to double-concave lens (Fig. 1) have been obtained. The diameter of the lenses formed ranges from 2 to 8 mm

depending on exposition time. The focal length of lenses calculated by formulae of thin lens varies in the range of 40–150 mm. The exposition time varies from tens of seconds to several minutes depending on the thickness of plate and the kind of adsorbate.

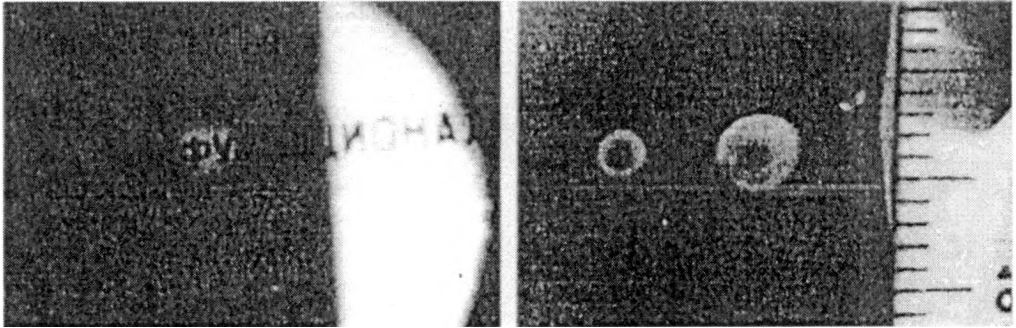


Fig. 1. Photo of microlens.

The fabricated lenses are stable under certain thermodynamic conditions due to the existence of two thermodynamically stable states on the hysteresis loop of isotherm curve for vapour adsorption in porous glass (Fig. 2). Optical parameters of the lenses remain stable for many days. The lens may be deleted by reimmersion of plate.

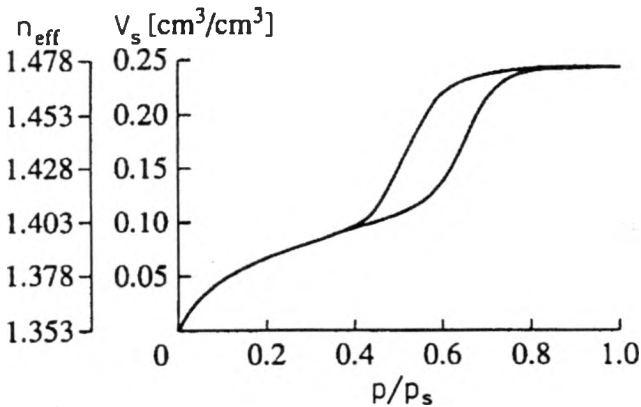
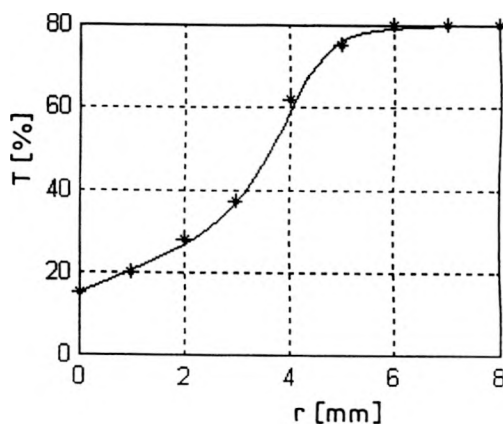
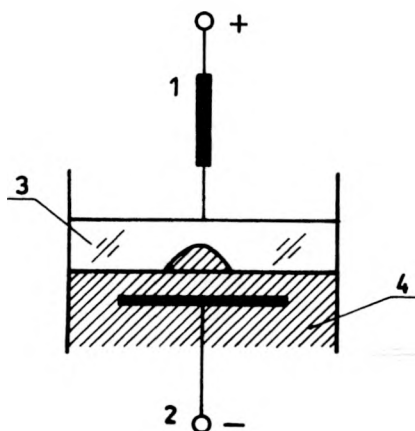


Fig. 2. Isothermal curve for benzene adsorption in the DV-1M porous glass at 25 °C [6].

Regions with local distribution of adsorbate concentration within the bulk of porous matrix and corresponding variation of optical properties may be formed by means of electrodiffusion of electrolyte into porous glass [5]. The method of electrodiffusion immobilization of dye ions into porous plate is shown in Fig. 3. In this way the regions with radial distribution of thionine concentration have been formed causing corresponding transmission distribution, as shown in Fig. 4. Practically, those regions are equivalent to microfilters and could be used for smoothing the power density of laser beam.



▲
Fig. 3. Scheme of dye electrodiffusion immobilization: 1 – needle electrode, 2 – plate electrode, 3 – porous plate immersed by ethanol, 4 – dye ethanol solution.

Fig. 4. Radial distribution of microfilter transmission at $\lambda = 600$ nm.

Thus, it is experimentally shown that various microoptical elements on the basis of porous glass can be produced with the use of methods being different from earlier ones of local laser fusing of porous glass or local surface leaching of non-porous preform.

References

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