ADAPTIVE OPTICAL SYSTEMS BASED ON STRONGLY SWELLING POLYELECTROLYTIC HYDROGELS

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Polyelectrolytic hydrogels are shown to be promising as a source material for adaptive optical systems.

The strongly swelling polyelectrolytic hydrogels[1] are a specific class of polymer meshes capable of absorbing water solutions up to 1 liter per 1 g of dry matter. Up to now only hygroscopic properties of the gels were used in medical and perfume industry. However as it is shown in this paper, the unique properties of polyelectrolytic gels make it possible to use them for creating optical systems as well. Among such properties is the possibility of obtaining the optical quality of surfaces due to scaling when changing the gel swelling degree (a gel can be synthesized in a vessel of a large volume following the shape of an optical element under production, and then to decrease the prototype homotetically to the size determined by thermodynamic quality of the medium[2]). Using this property, the optical quality of a surface can be achieved even with a rough mould. Other important property is the gel capability to change locally its shape due to the electric effect.[3] This capability is connected with the gel contraction when electric current traverses it. Then the hydrogel emits pure water and decreases its volume.[4] Contraction is inversable, and when finishing current effect, the swelling gel restores its initial shape. It is essential that nonuniform current distribution is capable of creating nonuniform deformations of the polymer mesh that makes it possible to create optical elements with the surface shape well reacting to an external signal.

The hydrogel swelling by at least 100 times practically does not differ from pure water because the polymer concentration is no more than 10^{-4} mol/liter.

For this reason, when changing the gel swelling degree by 50–500 times, the refractive index is kept practically constant, and the contraction leads only to the change of the optical element shape.

Thus, creating a nonuniform current distribution in the hydrogel–solution system, one can change the optical element shape by an external signal. The nonuniform current distribution can be provided, for example, by use of sectioned electrodes.

More simple method of the action on the hydrogel optical element shape is the mechanical deformation. It differs from the method of the electric field effect by essentially lower degree of spatial resolution relative to the variation of the shape of separate parts of the optical surface. However, this technique can be useful for simplest adaptive devices, such as, for example, the lens with transformable focal length. The hydrogel synthesized as a lens is deformed here by external ring made, for example, as an iris. Bending the lens surface at constant refraction index, it is possible to control its focal length.

Other technique for lens deformations is the mechanical tightening of the loop surrounding the lens, etc.

Thus, the polyelectrolytic hydrogels are the promising material for creation of adaptive optical systems.

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