BIO-INSPIRED OPTICS: LIQUID LENSES IMITATING EYE REFLEXES

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Biological vision systems such as animals or insects eye exhibit simplicity and multiplicity of operational characteristics that are not available to the traditional optical technologies. The distinctive features of the visual organs of living species allowing the adaptation for the environment using visual-motor reactions, inspired researchers to develop numerous biomimetic compact optical devices [1-4]. We demonstrate a laser controlled liquid-based tunable optical system replicating the eye behavior including the accommodation, the pupillary light response and the optokinetic response. A liquid droplet serving as a multifunctional lens consist of the mixture of tensioactive liquid and volatile liquid with low surface tension. The actuation principle is based on action of thermocapillary and solutocapillary forces generated by a thermal action of the laser beam. The laser heating lowers the fraction of volatile liquid resulting in an increase in surface tension. The increase in the laser power leads to a shrinkage of the droplet and consequently to the increase of the surface curvature. The decrease in the power results in a spreading of the droplet and hence to the decrease of the curvature. This behavior of the droplet is similar to the eye accommodation reflex and the pupillary light reflex in response to the intensity of light. To validate the proposed concept ethylene glycol/isopropyl alcohol mixture dyed with methyl violet for absorption of the laser radiation (532 nm) were used. The volume of mixture (2 microliter) was placed in a sealed optically transparent microcell. Fig. 1(a) shows variation of the focal length and the aperture (images) of the droplet in response to the laser power variation. Over the range of laser power from 2 to 30 mW the focal length changed from 40 to 15 mm. The droplet curvature changing with the supplied power is shown in Fig. 1(b). The focus adjustment time in response to the laser power changing layes from hundreds ms to a few seconds. Fig 1(c) shows an ability the droplet to move on the substrate toward a new position of the laser beam that replicates the optokinetic response of the eye. Speed of the droplet motion reaches 100 µm/s.

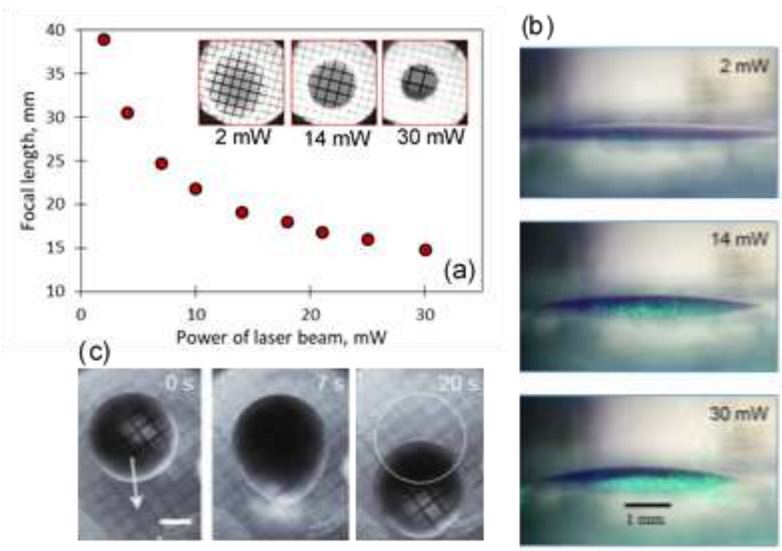

Figure 1 – (a) The droplet focal length variation vs. the laser power (images of a test-grid obtained with the droplet-lens); (b) the droplet reshaping vs. the laser power [5]; (c) The droplet motion to a new position of the laser beam [5]. Dashed circle shows the previous position of the droplet. Scale bar, 1 mm.

References

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