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ADAPTIVE MICRO-LENS ARRAYS CONTAINING CHALCOGENIDE MICRO-LENSES AND NEMATIC LIQUID CRYSTALS

M. Manevich[a], M. Klebanov[b], V. Lyubin[b], J.Varshal[a], J. Broder[a], N. P. Eisenberg[a]
[a]*Department of Electro–optics, Lev Institute-JCT, Jerusalem 91160, Israel*
[b]*Department of Physics, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel*

New adaptive micro-lens arrays based on $1As_2S_3 \cdot 1As_2Se_3$ chalcogenide photoresist micro-lenses immersed in nematic liquid crystals (NLC) with an electrically controllable focal length have been developed. Parameters of new micro-optical devices are discussed.

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Micro-lens arrays are important elements of modern electro-optics, used for a number of purposes such as optical computing, optical communications, beam coupling and also for integrated planar optical interconnections etc [1, 2]. However, most of these devices do not possess the property of adaptability of their optical parameters, primarily, focal length although in many cases it is necessary to use adaptive micro-optical devices in modern electro-optics. Several variants of adaptive miro-optical devices, particularly, adaptive micro-lens arrays were proposed recently, most of them are based on the effect of reorientation of NLC in an external electrical field [3-7].

A very promising approach has been proposed recently in [8]. In this approach, a hole-patterned electrode structure was filled with a NLC material. Unfortunately, the lens quality in this case was not very good, as shown by increased aberrations and distortion of focal spots, caused primarily by the fact that the gradient of the effective index is controlled exclusively by the director distortions in a flat cell with a patterned electrode.

In the present letter, new micro-lenses are considered, fabricated from inorganic chalcogenide photoresists, combined with NLC. Construction of the proposed micro-lens array is shown schematically in Fig.1. Application of an electrical field leads to the director reorientation and to changes in the focusing properties of chalcogenide micro-lenses. This new design of adaptive micro-optical devices is based on the use of inorganic chalcogenide photoresist micro-lenses immersed in a NLC, E90, to form an electrically controllable focal length.

The inorganic chalcogenide photoresist micro-lenses are characterized by high optical quality as shown recently [9]. The high optical quality is due to application of a very precise gap micro-lithography method in their fabrication [10]. The gap micro-lithography method is performed with a gap between substrate and mask surfaces. The binary mask layout contains an array of 70 − 100 μm diameter holes in a chromium layer. Changing the distance between the illuminated mask and substrate surfaces modifies the profile of the light distribution from a step to a rounded one, and the optimum shape according to the desired specification (diameter and sag of the micro-lens) can be realized.

*Corresponding author: michaelm@jct.ac.il

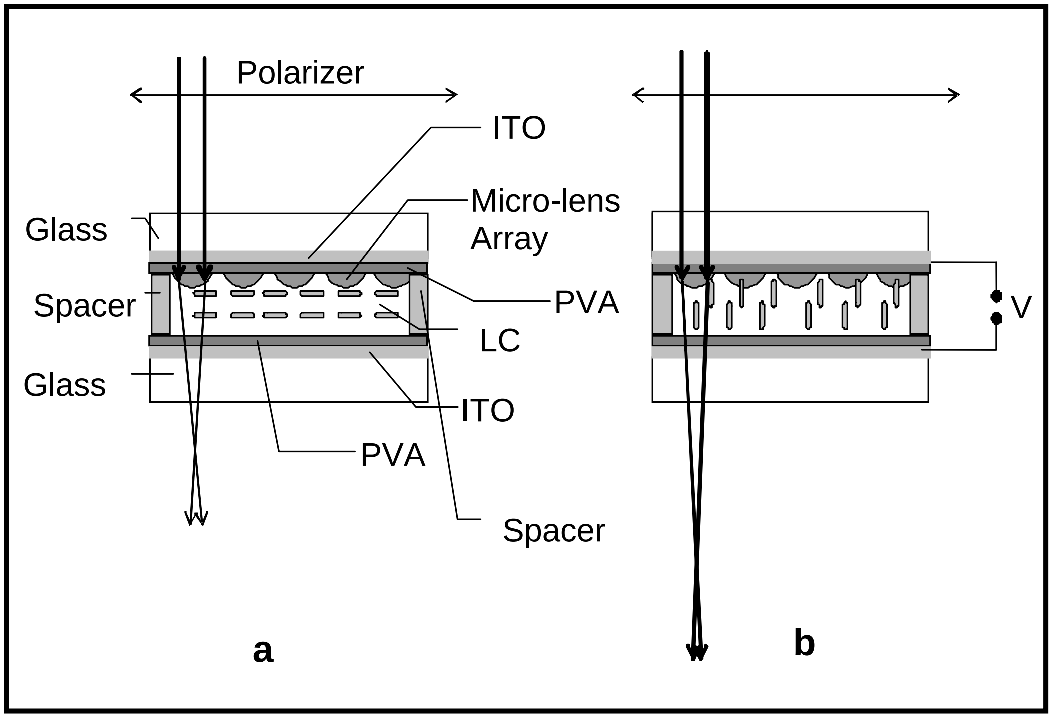

Fig. 1. A proposed design for an adaptive micro-lens array: electric field "off" (a); electric field "on" (b). 1 – glass substrate; 2 – spacer; 3 – indium–tin oxide electrodes; 4 – polyvinyl alcohol; 5 – $1As_2S_3{\cdot}1As_2Se_3$ chalcogenide micro-lens array; 6 - liquid crystal E90; 7 – polarizer.

In this technique, the three-component $1As_2S_3{\cdot}1As_2Se_3$ chalcogenide photoresist was used [11, 12]. An approximate 550 µm gap from mask to substrate surfaces and 1 minute exposure of a Xe- light source were used.

The primary parameters of an adaptive micro-lens array are shown in the table:

Micro-lens diameter, µm	114.8
Micro-lens sag, µm	0.85
Micro-lens array pitch, µm	300
Micro-lens array size, mm	12 x 12
Type of chalcogenide	$1As_2S_3{\cdot}1As_2Se_3$
Type of liquid crystal	E 90
Liquid crystal refractive index range	1.523 – 1.7313
Focal length range, µm	1,938 – 2,521

A single plano-convex micro-lens with diameter of 114.8 mm and sag of 0.85 mm is shown in Fig.2. The micro-lens focal length is changed by approximately 30% from 1,938µm to 2,521 µm by changing the applied voltage from 0 V to 6 V.

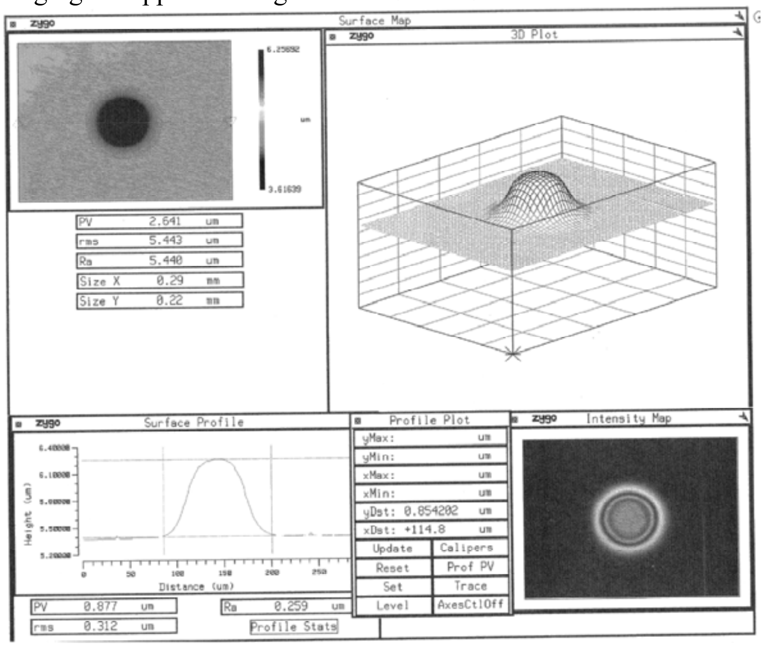

Fig. 2. Plano-convex micro-lens with a diameter of 114.8 µm and a sag of 0.85 µm.

Conclusion

New adaptive micro-lens arrays have been developed. The focal length of adaptive micro-optical devices is changed by approximately 30% from 1,938 µm to 2,521 µm by changing the applied voltage.

References

[1] T. J. Suleskiand, R. D. TeKolste, J. Lightwave Technol. **23**, 633 (2005).
[2] S. Sinzinger, J. Jahns, "Refractive micro-optics", in Micro-optics (2^{nd} Edition), 93-131 (2005), Willey-VCH Verlag.
[3] S. Sato, Opt.Rev. **6**, 471 (1999).
[4] L. G. Commander, S. E. Day, D. R. Selviah, Opt. Commun. **177**, 157 (2000).
[5] H. Ren, S. T. Wu, Appl.Phys.Lett **82**, 22 (2003).
[6] H. Ren, Y. H. Fan, S. Gauza, S. T. Wu, Jpn. J. Appl. Phys. Part 1, **43**, 652 (2004).
[7] H. Ren, Y. H. Fan, Y. H. Lin, S. T. Wu, Opt. Commun. **247**, 101 (2005).
[8] O. Pishnyak, S. Sato, O. D. Lavrentovich, Applied Optics, **45**, 4576 (2006).
[9] N. P. Eisenberg, M. Manevich, A. Arsh, M. Klebanov, V. Lyubin, J. Non-Cryst. Sol. **352**, (2006).
[10] M. Manevich, M. Klebanov, V. Lyubin, J. Varshal, J. Broder, N.P.Eisenberg, Chalcogenide Letters (in press).
[11] N. P. Eisenberg, M. Manevich, A. Arsh, M. Klebanov, V. Lyubin, J. Optoelectron. Adv. Mater. **7**, 2275 (2005).
[12] A. Arsh, M. Klebanov, V. Lyubin, L. Shapiro, A. Feigel, M. Veinger, B. Sfez, Optical Materials **26**, 301 (2004).