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on Fundamental and Applied Aspects of
Physical Chemistry

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FAST FABRICATION OF LARGE AREA CONCAVE MICROLENS ARRAYS

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ABSTRACT

A single-step process for rapid fabrication of large-area concave microlens arrays using a diode-pumped solid state (DPSS) laser operating at 473 nm is developed. Using tartrazine sensitized gelatin layer treated with tot'hema - mixture of iron (II)-, manganese (II)- and copper(II)gluconate- (denoted short as tSTG) and a direct laser writing device developed in our laboratory, we could produce 10 000 uniform microlens arrays within 30 min. Uniform microlenses with different diameters and depth can be produced by varying the laser power, exposure time and dye concentration.

INTRODUCTION

Two dimensional (2D) microlens arrays, consisting of small lenses ranging in diameter from several micrometers to nearly 1 mm, find their applications in micro-optical devices, displays, biochemical systems, and artificial compound eyes [1-3]. Various methods are used for the microlens arrays fabrication: hot embossing, thermal reflow, droplet process and gray scale photolithography [4-6].

In this paper, we present a fast, single-step process for fabrication of large-area concave microlens arrays using a direct laser writing method. Within 30 min, 10 000 microlenses with a diameter of 50 μm and depth of 3 μm, were produced on a thin tSTG layer using blue laser light (473 nm). The layer is easy to prepare, cost-effective, elastic, biocompatible, thermally stable and nontoxic [7-9]. The produced microlens array can be used as a concave large-area microlens array, or as a mold for replication onto polydimethylsiloxane (PDMS) that is suitable for different applications [10].

RESULTS AND DISCUSSION

Thin tSTG layer was prepared on a glass microscope slide following the procedure described in our previous papers [7-9], using tartrazine, a lemonyellow, water soluble food dye (E 102) with maximum absorbance at (427 ± 2) nm, instead off eosin to modify the spectral properties of the material. The absorption spectrum of the tSTG layer was analyzed using a fiber-type spectrometer (Ocean Optics) equipped with a tungsten-halogen lamp. The absorption spectrum of the tSTG layer is shown in Figure 1.

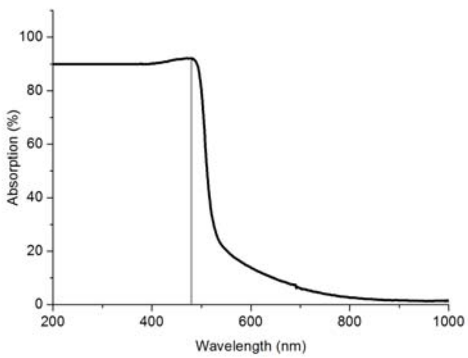


Figure 1. Absorption spectrum of tSTG layer

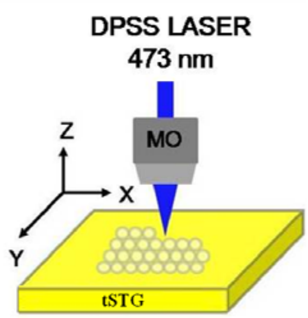


Figure 2. Scheme of the microlens array fabrication on the tSTG layer

The large-area microlens array was produced using the diode pumped solid state (DPSS) laser operating at 473 nm wavelength and output power of 50 mW to illuminate the tSTG layer, as shown in Figure 2.

The laser beam was focused with a microscope objective (50× 0,55NA) on the sample mounted on a precise *xy*- linear translation stage used for positioning the tSTG layer with step resolution of up to 25 nm and position repeatability of 2 μm. Software (developed in Microsoft Visual Studio) reads an image file and sends control data to the programmable controllers which coordinate the translation stage and the shutter. The microlens array is recorded lens by lens using the program which determines the microlens array parameters from the image file.

By controlling the laser power, exposure time and distance among neighbour microlenses we were able to create closely packed microlens arrays.

Also, we can change the microlens parameters such as: depth, diameter, focal length. Influence of exposure time on the lens depth, for the laser power of 20 mW, is shown in Fig. 3. As can be seen the lens depth rapidly grows, and increases with exposure time. After a few seconds, depending on the laser power the depth stops growing, reaching its final value (the lens is completely formed).

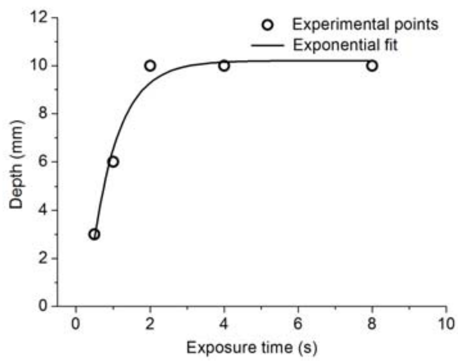
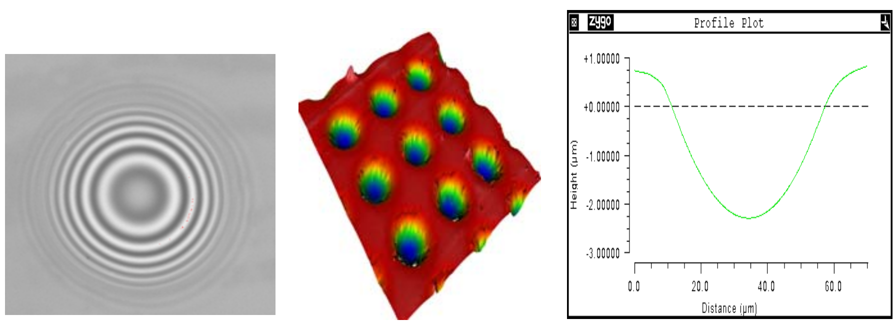


Figure 3. Variation of depth tSTG microlens with exposure

Array of 100 x100 microlenses was produced on the 100 µm thick tSTG layer irradiated by a DPSS laser operating at a 473 nm wavelength. The exposure time was 200 ms and laser power of 20 mW. The microlens array is produced on 1cm×1cm of tSTG layer. Profilometry was used to obtain three– and two–dimensional profiles of tSTG microlenses, shown in Figure 4.



a) b) c)

Figure 4. Surface profile of tSTG microlens array: a) Interference fringe pattern of a single microlens; b) 3D profile of the array; c) 2D surface profile of a single microlens; Morphology of the microlenses array was analyzied using non–contact profilometry (3D optical surface profiler - Zygo New View 7100).

The microlenses with diameter of 50 µm and depth of 3 µm are obtained with good repeatability. An image of the number “5” taken by a digital camera through the optical microscope and tSTG microlens array is shown in Fig. 5, and representing the image quality. Also, hexagonal closely packed microlens arrays were made, and can be used to imitate biological compound eyes structure.

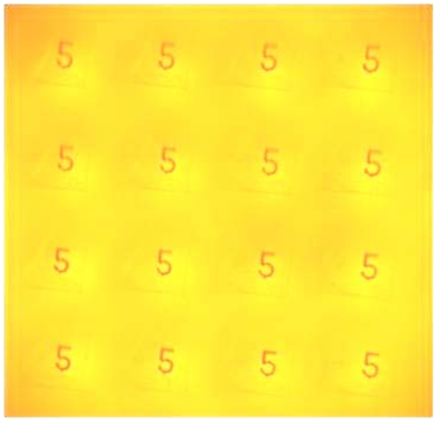


Figure 5. Image of number "5" taken through the microscope and tSTG microlenses array

CONCLUSION

In summary, a fast, single step fabrication process of 2D concave microlens arrays is described. 10 000 (array of 100x100) microlenses are produced on tartrazine sensitized tot'hema gelatin layer (short tSTG) by DPSS laser operating at 473 nm. Convex microlenses can be also mass replicated using the concave as molding templates.

The closely packed tSTG microlenses show good optical and imaging properties, and can be used for various applications such as: medical laser, optical sensors, light-field cameras, biological structure...

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REFERENCES

[1] A Tripathi, N. Chronis, J Micromech Microeng. 2011, 21, 105024.
[2] V. Lin, H. C. Wei, H. T. Hsieh, G. D. J. Su, Sensors 2011, 11, 10293−10307.
[3] H. Zhang, L. Li, D. L. McCray, S. Scheiding, N. J. Naples, A. Gebhardt, S. Risse, R. Eberhardt, A. Y. Yi, Opt. Expr., 2013, 21, 22232-22245.
[4] F. Xiqiu, Z. Honghai, Sensor Letters 2008, 6, 266-271.
[5] J. M. Pavia, M. Wolf, E. Charbon Opt. Express 2014, 22, 4202-4213.
[6] S. J. Hwang, Y.X. Liu, G.A. Porter, Opt. Express 2013, 21, 30731-30738.
[7] B. Murić, D. Pantelić, D. Vasiljević, B. Panić, Opt. Mater. 2008, 30, 1217-1220.
[8] B. D. Murić, D. V. Pantelić, D. M. Vasiljević, B. M. Panić, Appl. Opt. 2007, 46 8527-8532.
[9] A. J. Krmpot, G. J. Tserevelakis, B. D. Murić, G. Filippidis, D. V. Pantelić, J. Phys. D: Appl. Phys. 2013, 46, 195101.
[10] Yi-S. Cherng, Guo-D. J. Su, J. Micromech. Microeng. 2014, 24, 015016.