Microlenses array made with AZ4562 photoresist for stereoscopic acquisition

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Summary

This paper presents a fabrication process for obtaining refractive microlenses arrays with high reproducibility and low cost. This process was specifically optimized for the AZ4562 photoresist. Functional prototypes of microlenses arrays with dimensions in the range of 30 μm and spaced apart between them by 5 μm were fabricated and tested.

Motivation and results

Refractive microlenses arrays have been extensively used in a broad range of applications where focusing or imaging are an appealing alternative for applications where miniaturization and alignment simplicity are requirements [1]. Such microlenses can enhance the light on image sensors (by increasing their sensitivity), on biomedical instruments, on Lab-On-a-Chip systems, in optical communications and for stereoscopic image formation on image sensors. As illustrated in the Figure 1, this fabrication process was developed for mounting the microlenses on top of microdevices composed by CMOS image sensors and optical filters. As illustrated by the FEM simulation in the Figure 2, this feature allows stereoscopic image formation with a single image sensor. These simulations were done to steer the impinging light from the right channel image and having an angle of 7.6º with the normal due to the assumption made, that the light was previously focused by a converging lens. The left channel image behavior can be simulated considering a symmetrical angle of -7.6º. The volume of the AZ4562 before and after the reflow must be equal.

As illustrated in the Figure 3, the microlenses arrays can be fabricated as follows: arrays of rectangular strips with high aspect-ratios (strips with high length/width ratios) are patterned using lithography. Then, a reflow process is applied to the AZ4562 strips. The reflow consists in heating the lens material (with a squared shape) until it becomes viscous and forms a surface with a desired shape due to the surface tension. Different sized arrays were designed and printed into a chromium mask. The AZ4562 photoresist was selected due to the fabrication requirements. This positive photoresist is ideal for coating thicknesses above 3-5 μm without having to increase the exposure energy considerably and still providing enough energy down to the substrate of the AZ. The Figure 4 shows few functional prototypes, whereas the Table I lists their geometric parameters. The subjective evaluation of the optical quality of microlenses was done by impinging a laser beam (generated from a neon source) into the array and observing the diffraction pattern into a white plane. As showed in the Figure 5, the subjective quality of the microlenses array is very good. It can also be observed in the Figure 5 that each lens in the array spreads the laser beam into a specific direction. Moreover, it is possible to observe the interaction between the spreaded beams. The structural and optical quality that were observed during the process optimization and during the characterization of the microlenses arrays open good perspectives for fabricating stereoscopic image sensors at low cost.

References

[1] Caijun Ke, Xinjian Yi, Zhimou Xu, Jianjun Lai, *Monolithic integration technology between microlens arrays and infrared charge coupled devices.* Optics & Laser Technology, (2005), 239-243.

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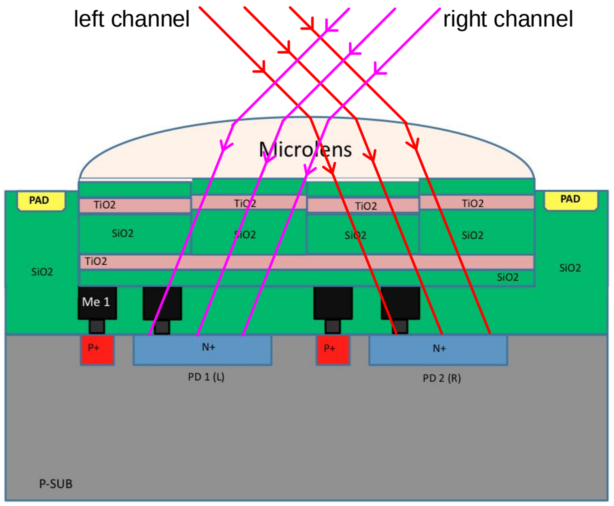


Fig. 1: Illustration of the concept associated to the microlenses array for stereoscopic acquisition with a single polychromatic CMOS image sensor (example with only 1 microlens and 2 photodiodes).

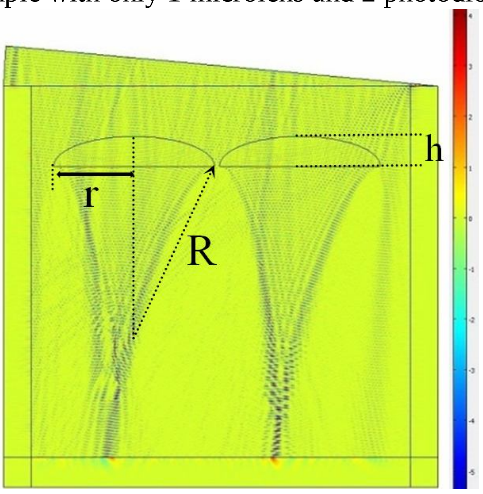


Fig. 2: FEM simulations showing the light concentration for microlenses with a width of W=32 μm and a sag of h=5 μm.

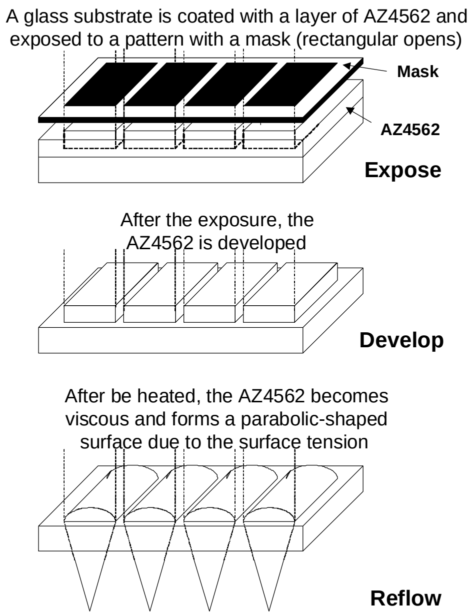


Fig. 3: Microlenses fabrication steps.

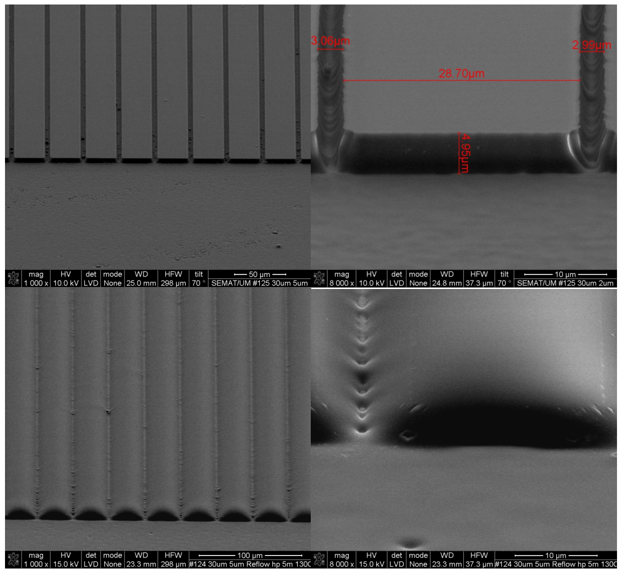
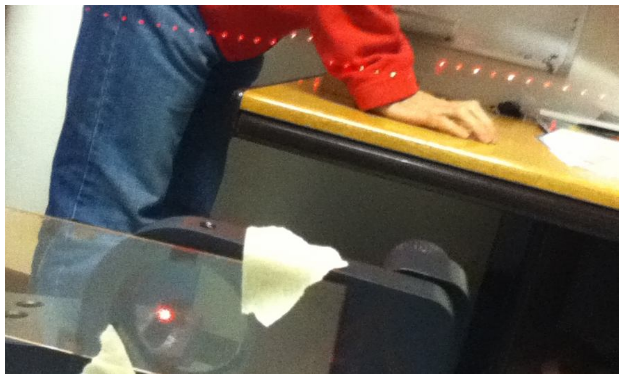
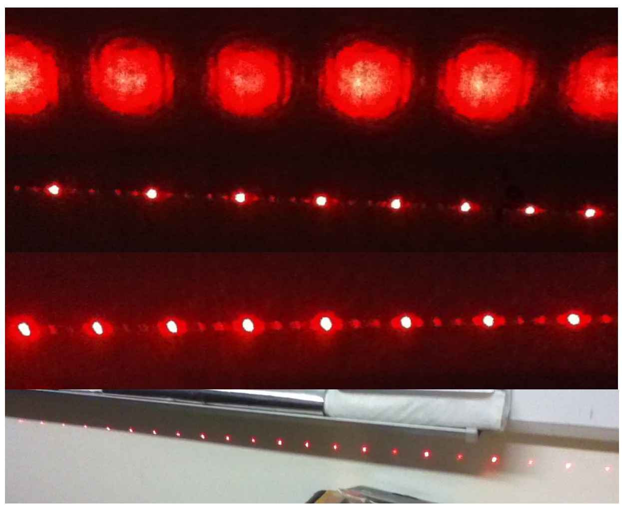


Fig. 4: SEMs of few microlenses arrays before (on top) and after (on bottom) doing the reflow.



(a)



(b)

Fig. 5: (a) Optical setup used for the quality evaluation of multibeams. This setup is composed by a selected array of microlenses, by a laser source for and by a flat surface to project the spreaded beams. (b) Fotographs with projections of few laser beams after being spreaded from the impinging one by the array of microlenses. It is possible to note interference patterns between the spreaded beams.