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SHORT COMMUNICATION

As_2S_3 BASED ARRAYS OF LARGE-SIZE IR MICROLENSES

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An increase of microlens dimensions in IR microlens arrays, based on chalcogenide glassy films, was achieved using thermal reflow method with a new selective developer for thick As_2S_3 films.

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In [1] IR cylindrical microlens arrays fabricated using chalcogenide glassy (ChG) $AsSeI_{0.1}$ films, photolithography, and thermal reflow were described. The microlenses in these arrays had optical parameters suitable for practical applications and very good convex surface quality. But a maximum sag of ~1.9 μm and a maximum width of ~14 μm were obtained for the microlenses while microlenses of much larger dimensions are required for application in many modern optoelectronic systems. The microlens dimensions are limited by the strong absorption of light (especially taking into consideration the strong photodarkening of the ChG film upon exposure [2,3]). If the film thickness is increased, the ChG film at the substrate is irradiated so weakly that it is etched in the next photolithographic process practically at the same rate as the non-irradiated parts of the film. Therefore very thick ChG films cannot be used in the fabrication.

In the present communication, the IR microlens arrays of larger size based on As_2S_3 thick films fabricated using the same thermal reflow technique are described. The fabrication of larger microlenses was due to the development of a new very effective selective developer. With this developer, having a larger contrast value (contrast is the ratio of etching rates for non-irradiated and irradiated areas of the film), even in the case of very thick As_2S_3 films, the sections of the film at the substrate are etched much slower than the non-irradiated As_2S_3 areas of the film.

Glassy As_2S_3 films of 4.5-5.5 μm thickness were fabricated by vacuum evaporation using a resistive evaporator and increased amounts of starting crushed glassy As_2S_3 material. The values of refractive index of the films (n~2.4 at λ = 0.9 μm and n~2.3 at λ = 1.5 μm) were calculated by the Swanepol method [4]. On effective selective developer based on isoamylamine was prepared. Using this new developer, As_2S_3 films of 1.0 μm thickness with a very high etching contrast value γ = 100-250 were obtained. Below are given some results of a detailed study regarding the application of the new developer to thick As_2S_3 films.

The efficiency of the new developer for thick As_2S_3 films is characterized in Table 1 and 2, which show the dependence of the etching contrast γ on light intensity and irradiation time, using as illumination source the Ar+ - laser (λ = 488 nm). From the Tabulated data, it can be concluded that the new developer is capable of ensuring large etching contrast values for thick As_2S_3 films even for small times of irradiation (4 sec.).

In order to fabricate the microlens arrays, a 5μm As_2S_3 photoresist layer was deposited by vacuum thermal evaporation onto an oxide glass substrate. Contact binary photomasks containing a set of transparent circles on a non-transparent background for spherical microlenses, and a set of transparent rectangles on a non-transparent background for cylindrical microlenses, were used. The samples were exposed using a 1000W xenon lamp and then developed in the negative photoresist mode in the isoamylamine based developer for 8 minutes. This process resulted in a negative (relative to the photomask) image in form of As_2S_3 islands having 3D shapes. The thermal reflow procedure consisted of heating the 3D shapes at 290 ^oC for 5 minutes. This procedure transformed the As_2S_3 islands into plano-convex refractive spherical and cylindrical microlenses.

Table 1. Etching contrast as a function of the Ar + laser intensity for a 5μm thick As_2S_3 film.

Intensity, W/cm^2	γ
0.14	25
0.3	60
0.7	100
2.75	>150

Table 2. Etching contrast as a function of the time of Ar + laser irradiation for a 3 μm thick As_2S_3 film.

Irradiation time, s.	γ
4	36
8	120
11	140
22	190
32	240

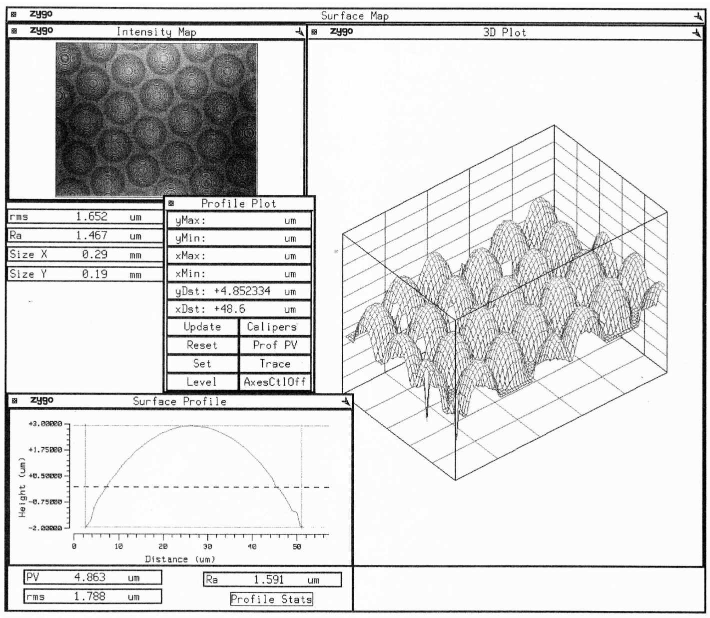

Fig. 1. Spherical microlens array.

Measurement of the microlens arrays was fulfilled using a microinterferometer from "Zygo Corporation" (USA). These results are plotted in Figs. 1, 2. The quality of the convex surface of the microlenses (shape, roughness) was very good and reproducibility of the parameters of the microlenses was also fully satisfactory. Some parameters of the microlens arrays are shown in Table 3.

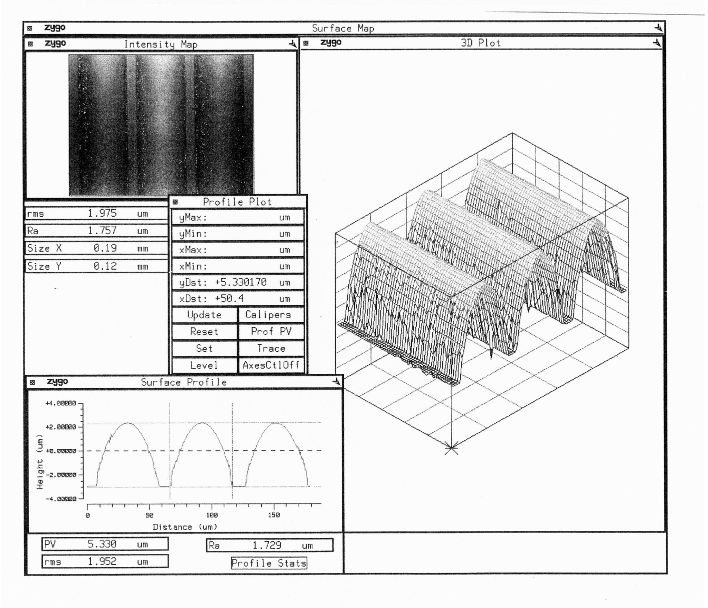

Fig. 2. Cylindrical microlens array.

Table 3. Parameters of IR arrays containing spherical and cylindrical microlenses.

Type of microlenses Parameters	Spherical	Cylindrical
Sag	4.83 μm	5.34 μm
Dimensions of single microlens	Diameter: 48.7 μm	Width: 50.4 μm Length: 2500 μm
Pitch	55 μm	Horizontal axes: 60 μm Vertical axes: 2550 μm
Focal length (λ= 0.55 μm)	47 μm	46 μm
Array size	100 × 100 (100 rows with 100 microlenses)	50 ×2 (2 rows with 50 microlenses)

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