Chalcogenide Letters Vol. 2, No. 4, April 2005, p. 35 – 37

MICRO-PRISM ARRAYS FOR INFRA-RED LIGHT BASED ON AS_2S_3-AS_2SE_3 PHOTORESISTS

N. P. Eisenberg, M. Manevich, A. Arsh[a], M. Klebanov[a], V. Lyubin[a]

Department of Electro–optics, Jerusalem College of Technology, Jerusalem 91160, Israel
[a]Department of Physics, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel

Using three-component As-S-Se chalcogenide photoresists and new efficient amine-based selective developers, arrays of microprisms are fabricated. Parameters of several microprism arrays obtained are demonstrated.

Microprisms and microprism arrays are interesting and important elements for a number of purposes such as beam coupling or combination, for integrated planar optical interconnections where they are capable of realizing large coupling angles at sufficiently high efficiencies.

In the fabrication of microprisms and microprism arrays the specialists usually apply analog photolithography using gray scale photomasks designed specifically for microprisms or microprism arrays and thick photoresist films. The photoresist prisms, which are unstable and have very poor optical parameters, are then transferred by anisotropic reactive ion etching into robust optical material, transparent in the spectral range for which the microprism arrays are intended, for example, into SiO_2 or GaAs [1,2]. Anisotropic ion etching is not a very simple process, therefore its elimination would be very desirable in microprisms fabrication.

In this letter we propose a new technology for fabrication of microprism arrays for infra-red light, which has the potential to eliminate the ion etching process.
This technology is based on the use of chalcogenide glasses that are simultaneously effective photoresists and very good I.R. optical materials.

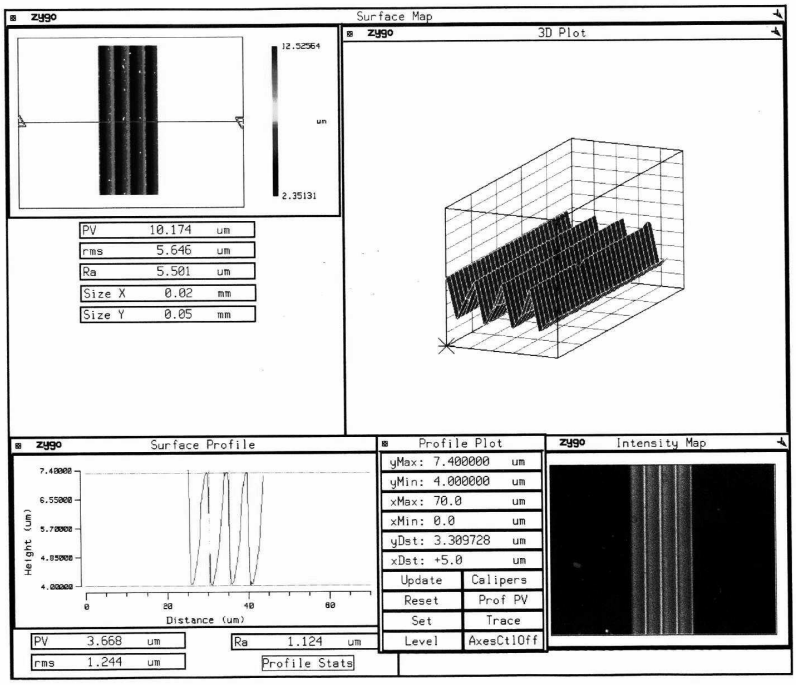

Fig.1. Microprism array with microprism base width 5μm.

The method proposed is essentially the direct one-step formation of a 3D microprism array using the dependence of the etching rate of chalcogenide photoresists on the illumination intensity. Previously such technology was used in fabrication of I.R. microlens arrays [3-5]. Circular and cylindrical I.R. microlens arrays were successfully fabricated using the above discussed technique and binary As-S and As-Se photoresists. In the case of microprism fabrication it is very important to have very soft contrast characteristics (dependence of remaining photoresist thickness on the dose of irradiation) of the photolithographic process, which are characterized by a long quasi-linear section. In the developed technology, we used three-component As-S-Se chalcogenide photoresists and new efficient amine-based selective developers, which together allowed to realize the necessary soft contrast characteristics of the photolithographic process using Xe- source of light.

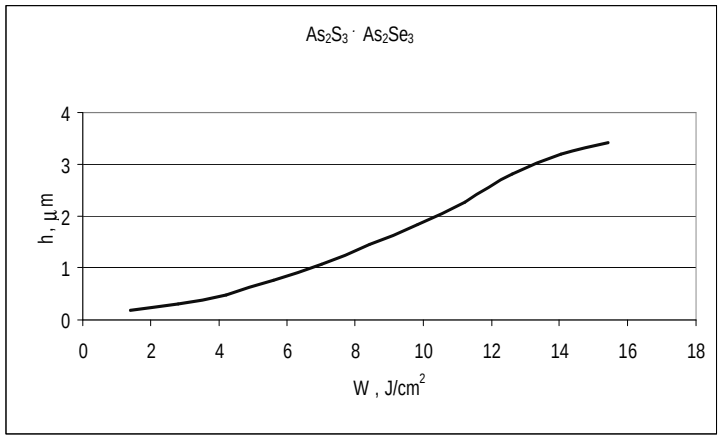

Fig.2. Contrast characteristic of the photolithographic process used.

The microprisms arrays obtained were measured using "Zygo Corporation" (USA) microinterferometer. Using different gray scale photomasks microprisms with wide variation of their geometric parameters were obtained. Parameters of several microprism arrays are shown in the Table and one of such arrays with microprism base width 5μm is represented in Fig.1. The quality of the microprism surface (form, roughness) was very high and the reproducibility of the parameters of the microprisms was also good. In fabrication of these microprism arrays, $1As_2S_3 \cdot 1As_2Se_3$ photoresist films with thickness ~ 4 μm and a selective developer based on ethylenediamine were used. Contrast characteristic of the photolithographic process is demonstrated in Fig. 2. Chalcogenide glasses are characterized by high values of refractive index in the range of 2.3 – 3.2 and therefore the chalcogenide microprisms can be used for coupling of I.R. light beams into optical wave-guides with high refractive index, particularly, into wave-guides produced from chalcogenide glasses [6].

Table. Parameters of the right-angled microprism arrays in $1As_2S_3 \cdot 1As_2Se_3$ chalcogenide film.

Parameter	Microprism array number		
	1	2	3
Microprism height	3.31 μm	3.49 μm	3.47 μm
Microprism base width	5 μm	50.4 μm	203 μm
Microprism base length	1000 μm	1000 μm	1000 μm
Roughness	0.5 nm	0.5 nm	0.5 nm
Microprism array size	32 x 1	32 x 1	32 x 1
Fill-factor	100 %	100 %	100 %

In conclusion, in this letter the development of new simple photolithographic technology for fabrication of microprisms and microprisms arrays for infra-red light based on chalcogenide photoresists is reported.

References

[1] E. B. Kley, F. Thoma, U. D. Zeitner, L. Witting, H. Aagedal. Proc.SPIE **3276**, 254 (1968).
[2] C.Gimkiewicz, D.Hagedorn, J. Jahns, E.B.Kley, F.Thoma. Applied Optics **38**, 2986 (1999).
[3] N.P. Eisenberg, M. Manevich, M. Klebanov, V. Lyubin, S. Shtutina.
J. Non-Cryst. Sol. **198-200** (1996).
[4] V. Lyubin, M. Klebanov, I. Bar, S. Rosenwaks, N.P. Eisenberg, M.Manevich
J. Vacuum Science and Technology B **15**, 823 (1997).
[5] N. P. Eisenberg, M. Manevich, A. Arsh, M. Klebanov, V. Lyubin,
J. Optoelectron. Adv. Mater. **4**, 405 (2002).
[6] I. D. Aggarwal, J. S. Sangera. J. Optoelectron. Adv. Mater. **4**, 405 (2002).