Computer Optics Vol. 2, No. 2, pp. 155–156, 1990
Printed in Great Britain

0955-355X/90 $10.00 + 0.00
Copyright © 1990 Pergamon Press plc

RECORDING TECHNOLOGIES FOR RELIEF IMAGERY WITH CONTINUOUS PROFILE

S. V. KARPEYEV and V. S. SOLOVYOV

Abstract—Novel technologies developed to produce relief patterns with continuous profile are reviewed. The best results have been reported for X-ray photoresist subjected to exposure in a precision image generating setup. The applicability of liquid photopolymers is discussed.

Popov [1] has considered various materials and methods involved in the fabrication of relief images of plane focusing elements. However, all these methods, except the multiple-step lithographic technique, fail to ensure the desired resolution, linearity and true shape of the relief. Moreover, they produce only a rough surface and owing to the intrinsic multi-stage chemical treatment are liable to technological instability and poor repeatability.

In this paper we review other materials and technologies suitable for relief imagery. In particular, the suitability of photopolymers for this purpose is covered.

Belousov and Yatskova [2] have reported a relief with continuously variable profile in relatively thick Cellofot plates on a cellulose acetosuccinate base. Thin films of this material may be also used. The relief image was obtained by exposing a half-tone mask to ultraviolet irradiation followed by development in an alkaline solution. This process resulted in 250-μm zones without a marked fall-off at the margins. One advantage of this method is its ease of producing reliefs in thick plates, although the resolution of Cellofot plates is about equal to that of bichromic gelatin.

Solovyov *et al.* [3] have tested negative photoresists as potential materials for laser beam focusers, so-called "focusators", in the infrared [3]. The study revealed two drawbacks typical of these photoresists—evolution of gas during exposure and swelling during development. These phenomena result in micropores in the surface layer which scatter light and lead to high diffraction losses from the surface of the focusator.

Kolnimov *et al.* [4] have described photosensitive materials based on carbazol polymers; in particular, grade Luvican M-170 polyvinylcarbazole and grade Olaine polyepoxypropylcarbazole (PEPC) poured in layers of 10-μm thickness onto glass substrates. These materials were used to obtain 5-μm deep profiles of 40-μm zone size.

The resolving ability of these materials and the dimensions of roughnesses on the surface depend substantially on the regimes of the processing, Appropriately selected processing regimes result in a mirror surface. The optimum selection is under investigation.

Aristov *et al.* [5] have used an X-ray resist based on polymethylmetacrilate to prepare relief elements. Kinoform elements with zone size of about 1 μm were obtained by direct exposure of the photoresist to a power-controlled electron beam. This technology should be recognized as giving the best results in the preparation of elements for the visible and X-ray ranges. Its implementation, however, requires precision image generators.

Relief patterns with continuous profile can be produced by direct etching of some polymers exposed to vacuum ultraviolet and X-rays in an oxygen environment [6]. The difficulties of this technology are associated primarily with the materials for half-tone masks in this range of wavelengths.

The LITMO institute have come up with a promising technology of burning kinoform elements by a CO_2 laser in microporous glass [7]. Melting and settling of the micropores at the zone of heating produces a mirror-like relief surface. The minimal dimension of zones under this technology is limited by the wavelength of the laser, being lower at shorter wavelengths.

Research efforts are underway to obtain relief patterns on photopolymers. Advantages of this method will include manufacturability—the layer of optical quality is formed by a simple flow of liquid polymer between the glasses—and elimination of the development process which is apt to produce micropores comparable with the wavelength of visible light.

REFERENCES

1. V. V. Popov. *Kompyuternaya Optika* No. 1, 160 (1987).
2. B. I. Belousov and G. I. Yatskova. *Zh. Nauchn. Prikl. Fotogr. Kinematogr.* No. 4, 241 (1987).
3. V. S. Solovyov *et al.* In *Opticheskaya zapis i obrabotka informatsii* [*Optical Recording and Processing of Information*]. KuAI Press, Kuibyshev (1988).
4. O. V. Kolnimov, V. V. Kolesnikova, V. K. Mikhnichuk *et al. Zh. Nauchn. Prikl. Fotogr. Kinematogr.* No. 5, 345 (1986).
5. V. V. Aristov, S. V. Gaponov, V. M. Genkin *et al. Pis'ma Zh. Tekh. Fiz.* **44** (4), 207 (1986).
6. T. M. Makhviladze, Ye. G. Panteleyev and M. Ye. Sarychev. *Trudy IOFAN* (Transactions of the Institute of General Physics of the USSR Academy of Sciences, Moscow), Vol. 8, p. 40. Nauka, Moscow (1987).
7. V. A. Goncharov. *Priroda* No. 3, 32 (1988).
8. V. K. Grishchenko, A. F. Maslyuk and S. S. Guldzera. *Zhidkiye fotopolymerizuyushchiesya kompositsii* [*Liquid Photopolymeric Compositions*]. Naukova Dumka, Kiev (1985).