Laser Engraving of Relief in Nanostructural Amorphous Films

V.I. Nalivaiko, G.S. Yuryev*, A.R. Sametov**

Institute of Automation and Electrometry SB RAS, pr. ak. Koptuga 1, Novosibirsk, RF,
Phone: +7(383)3307978, Fax: +7(383)3330863, nalivaiko@iae.nsk.su
** Nikolaev Institute of Inorganic Chemistry SB RAS, pr. ak. Lavrenteva 11, Novosibirsk, RF*
*** Technological Design Institute of Scientific Instrument Engineering SB RAS, Russkaya str. 41, Novosibirsk, RF*

Abstract – The new functional property of amorphous semiconductor chalcogenide films is presented. We put task of recording material choice for production of deep kinoform optic relief on a film surface by means of evaporation with a laser focused beam of diffraction element photoplotters. The method of direct laser writing was investigated with As_2S_3 nanostructural molecular films.

Studying of molecular formations in As-S, As-Se and Ge-S semi-conductor amorphous compounds were developed. X-ray diffraction researches were carried out by means high resolution synchrotron radiation diffractometer (INP SB RAS, Novosibirsk). It was shown, that the strongest molecular structurization of materials was peculiar to As-S system which thin films were most widely applied to optical record of the information, diffraction optics [1], and also its were a perspective material for photon crystal production [2]. The computer modelling of structure carried out for As_2S_3 films and massive samples had allowed to define nanodimention molecular formations and coordination of atoms so that theoretical and experimental pictures of X-ray diffraction had coincided.

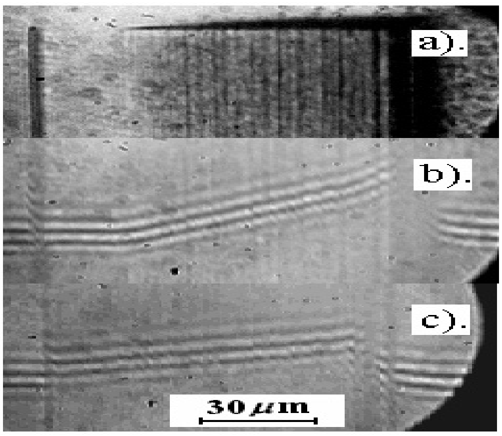

Fig. 1. Optical images in reflected light (λ=5500 A) surfaces of As_2S_3 molecular film with the deep triangular test structure received by a method of engraving before polishing etching: a) surface of a film; b) surface film interferogramm before correction; c) surface film interferogramm after correction

The basic results of structural researches can be formulated briefly as:

1. The molecular structure is present at As_2S_3 massive glasses;
2. The structure of As_2S_3 massive glass has molecular structure which is expressed less brightly in comparison with molecular structure of films received by thermal vacuum evaporation;
3. At a chemical bond uniform grid of films and massive vitreous chalcogenides there are inclusions in the form of molecular formations that distinguishes them from oxidation glasses.

An opportunity of relief engraving by the focused optical beam on a laser photoplotter [3] with reception of a smooth optical quality surface is revealed as a new functional property for nanostructured films. For crystal materials laser engraving usually provides a rough surface. Nanoscale structure of As_2S_3 films qualitatively changes conditions of material evaporation by laser beam.

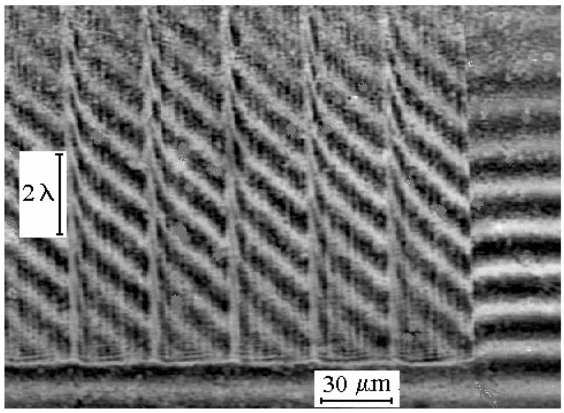

Fig. 2. Surface film interferogramm in passing light (λ=6328 A) of a phase waveguide input/output grid fragment with triangular structure of stripes and depth 2λ after polishing etching

It is established two modes of engraving. The smooth optical surface of a relief is formed by depth up to 0.2 microns. The recording of a deep relief up to 27λ in a passing light (λ=6328 A) it is accompanied with explosive emission of a film material and creation of "borders" on boundary of zones which for formation of a smooth relief of a surface leave the subsequent "damp" polishing etching of films. Engraving of a fine relief by laser photoplotter in As_2S_3 films had been synthesized in real time linear diffractive grids for a vacuum ultraviolet with step 1.2 microns and width of a stroke 0.6 microns.

Engraving of a deep relief had been received circular optical elements of type fresnel zone plates with a triangular phase structure. The image of a surface and interferogramm a geometrical relief on a surface of a film are presented after test recording of sequence of arches (the step is equal 0,5 microns) by means of linearly accrueing intensity of a laser beam from 0 up to 180 mW at reception of characteristic curve of a registering material for various radiuses of substrate (Fig. 1).

After correction of the energy level corresponding the beginning of zone and threshold intensity of record (50 mW, λ=4880 A), the triangular structure of zone by depth 6λ in reflected light has been received.

A focusing element fragment for input/output of an optical beam in a waveguide executed on As_2S_3 film surface in the form of a grid by size 2×2 mm with radial strokes and depth 2λ is represented on fig. 2. Experimentally measured diffractive efficiency of such element for a laser beam (λ=6328 A) made 90 %. The offered technology is represented perspective for synthesis of deep phase structures kinoform optical elements.

References

[1] V. Vedernikov, V. Vjuhin, V. Kiryanov, V. Nalivaiko, etc., Optoelectronics, Instrumentations and Data processing 3, 3 (1981).

[2] Y. Ono, M. Shinzo, *in Proc. European Optical Society Topical Meetings "Diffractive Optics 2003", Oxford, UK*, 2003, pp. 20–21.

[3] V. Kiryanov, *in Proc. SPIE 3091*, 1997, pp. 66–70.