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Short Communiation

Technology of Creation Periodic Structure on Surface Crystal of Paratellurite

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In this paper presents the artificial periodic structures, first obtained by method of anisotropic etching the surface of single-crystal of paratellurite. The technology of this method is in detail presented in relation to paratellurite. The geometry of the structures was analyzed with an optical interferometric profiler NanoMap 1000 WLI.

Keywords: Periodic structure, Paratellurite, Diffractive optical elements.

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1. INTRODUCTION

Creating of optical elements with a periodic structure on the surface of the crystals is not new [1-2]. One of the methods of obtaining complex microrelief is etching. In the [3] were studied processes of anisotropic etching of single-crystal silicon to obtain various periodic microprofiles, particulary a sawtooth profile.

For the visible range of the spectrum used birefringent crystals of Iceland spar (calcite). Mechanical properties of calcite are low (softness, brittleness) and create difficulties during mechanical processing. However, this problem is successfully solved by anisotropic chemical etching, which allows to develop new types of polarizing and diffractive optical elements [4, 5].

In the [6-8] studied the possibility of alignment of the diffraction efficiency in diffractive optical elements by creating a two or three-layer relief-phase structures from materials with different refractive indices and dispersions.

Single crystals of paratellurite are material for optical elements modern acousto-optical devices which working in the wavelength range of 0,35-5,5 μm. Paratellurite is a birefringent material with a refractive index $n_{\underline{o}} = 2{,}293$ and $n_{\underline{e}} = 2{,}452$ at the wavelength of 546 nm. The aim of this paper is the creation of a periodic structure on the surface of the wafer from paratellurite by the method of anisotropic etching and to assess the possibility of creating of diffractive optical elements on the basis of paratellurite.

2. PARATELLURITE WET ETCHING

For the experiment to create a periodic structure was prepared wafer from crystal of paratellurite (grown by Czochralski method in the direction [110]) with the linear dimensions 16 × 10 × 4 mm.

The surface of the wafer was covered with a compound of nitrocellulose lacquer (chemically resistant to alkalis) with a solvent (7 % acetone, 50 % toluene, 15 % ethanol, 10 % n-butyl acetate, 10 % butanol; 8 % ethylcellulose) in the ratio 1 : 2. The thickness of the compound layer was 100 microns. The next step was the removal of a part of the layer by using a diamond needle with different intervals (150, 250, 500 micron) for the access of the etchant to the wafer surface. The etching was performed with a 9 molar solution of KOH during 6 minutes. Dissolution of paratellurite happen according (1)

$$TeO_2 + 2KOH = K_2TeO_3 + H_2O \quad (1)$$

After the sample was removed from the solution, it was washed with distilled water and treated with acetone to delete the products of chemical reactions. As a result, the wafer surface was obtained in the form of micro-relief gratings with different periods (Fig. 1).

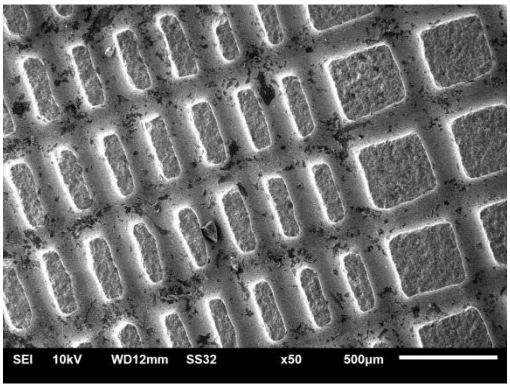

Fig. 1 – The image of the periodic structure on the surface of the wafer paratellurite (scanning electron microscope JEOL JSM-6610 LV)

Study of the chemical composition of the obtained structures on paratellurite on scanning electron microscope JEOL JSM-6610LV and energy dispersive spectrometer Oxford INCA X Energy350-Max 20 showed the absence products of chemical reactions and residues of the protective layer on the surface of the wafle.

3. ANALYSIS OF PERIODIC STRUCTURES

The obtained periodic structures were investigated by the optical profilometer NanoMap 1000 WLI and analyzed using specialized software SPIP. The results are

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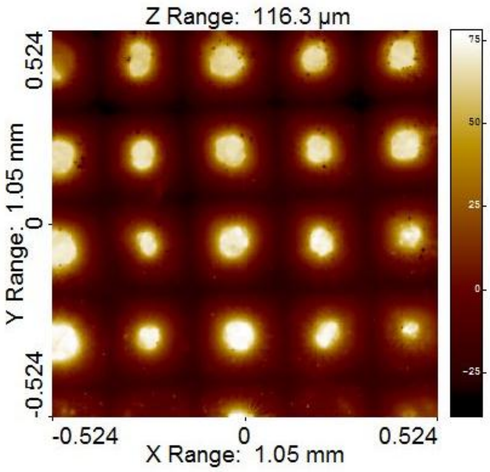
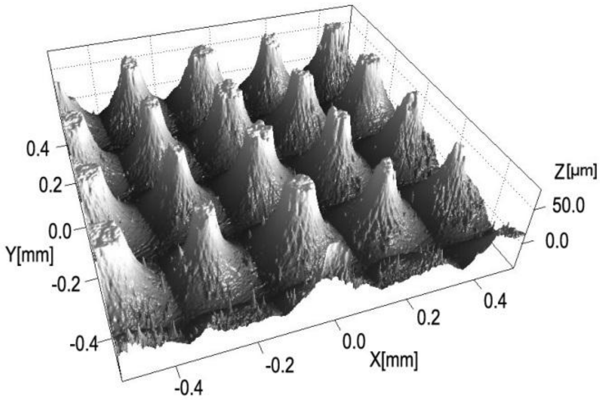
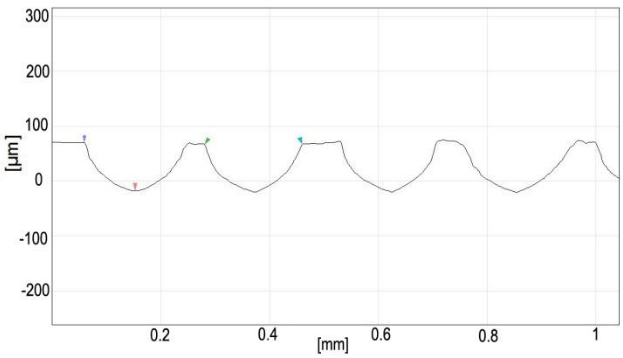


a

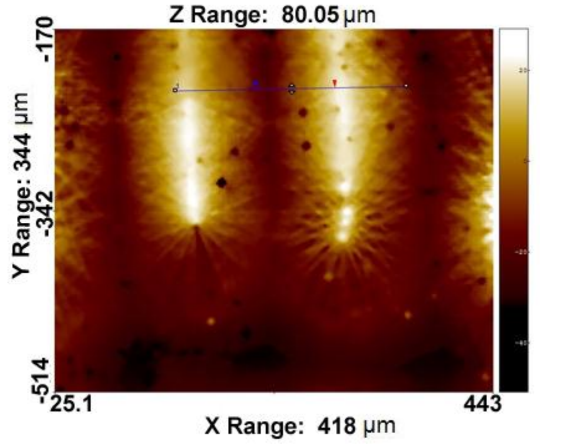


b

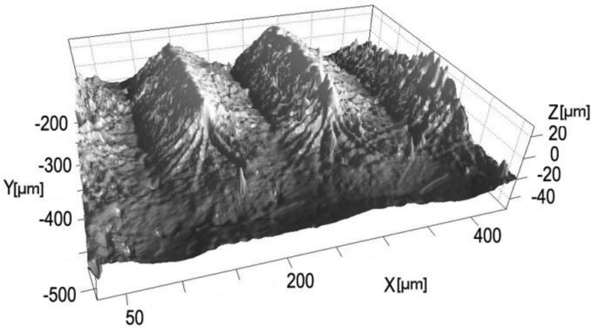


c

Fig. 2 – Image of the surface with a periodic structure 250 × 250 micron formed by dissolving (a) its 3D profile (b) and 2D profile taken over the peaks centers (c)



a



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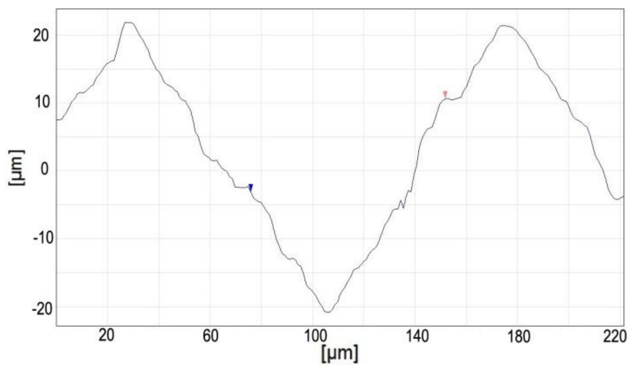

c

Fig. 3 – Image of the surface with a periodic structure 150 micron formed by dissolving (a) its 3D profile (b) and 2D profile taken over the peaks centers (c)

presented in Fig 2-3 in the form of images, as well as 3D and 2D profiles.

Experimental data allow to conclude that the profiles are formed in the process of chemical dissolution, have a high degree of periodicity and the type of grooves (the angle at the top of cavity, the surface smoothness) in many respects depends on the technology of preparation and the etching time. The structural perfection of the material to a minor extent affects the appearance of the resulting surface. Distortion of the profile of the structure associated with a yield dislocations is minor, due to the duration of staying of the sample in the etchant.

4. CONCLUSSION

According to the results, we can conclude that the creation of periodic profiles on the surface of the crystals paratellurite by the method of anisotropic etching has the perspective in the field of diffractive optics, in particular, in the development of new diffractive optical elements for range of 0.35-5.5 microns.

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