

# Plasma technologies application for building materials surface modification

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**Abstract.** Low-temperature plasma modification of  $\text{LiYF}_4$  crystal surface in Helium atmosphere caused microhardness decreasing and increasing of roughness of crystal surface. The change of microhardness and morphology is a possible result of Fluorine outgoing from material structure due to heating of surface and plasma chemical reactions and ingoing of Oxygen. As a result of exchange and diffusion processes crystal surface structure become more crumbly, its morphology and mechanical properties change.

## 1. Introduction

Low-temperature has wide application in different kinds of industry [1-4], including optics, where it is used for surface cleaning, deposition and assisting with deposition of thin functional coatings [5]. Ion's low energy allows using low-temperature plasma also for modification of some crystals surface, i.e.  $\text{LiYF}_4$ . That crystal is used in laser systems [6], it has relatively high surface microhardness, that prevents its high quality finishing.

The aim of this article is low-temperature plasma modification of  $\text{LiYF}_4$  crystal surface for increasing of quality of this crystal finishing. To achieve this goal crystal surface was processed by Helium low-temperature RF plasma at atmosphere pressure in the presence of water vapour.

## 2. Experiments

Experimental unit consists of chamber, RF power supply, gas supply system. Functional scheme of experimental unit is shown on Fig. 1. The upper and bottom electrodes are situated in chamber vertically and coaxially. The upper electrode is RF power supplied (frequency 13.56 MHz, power up to 50 W) and bottom electrode is grounded. Distance between electrodes was 5 mm. Both electrodes are made from stainless steel and have cylinder form for evenly plasma processing of crystal. The crystal  $\text{LiYF}_4$  (Fig. 2) was put on the bottom electrode. There was a barrier layer between crystal and bottom electrode. Passive Aluminum radiators was used for electrode cooling and situated outside the chamber. Between RF power supply ("Magniterm LCL", Russia) and upper electrode there was a matcher. Helium with maximum humidity was supplied through gas inlet.



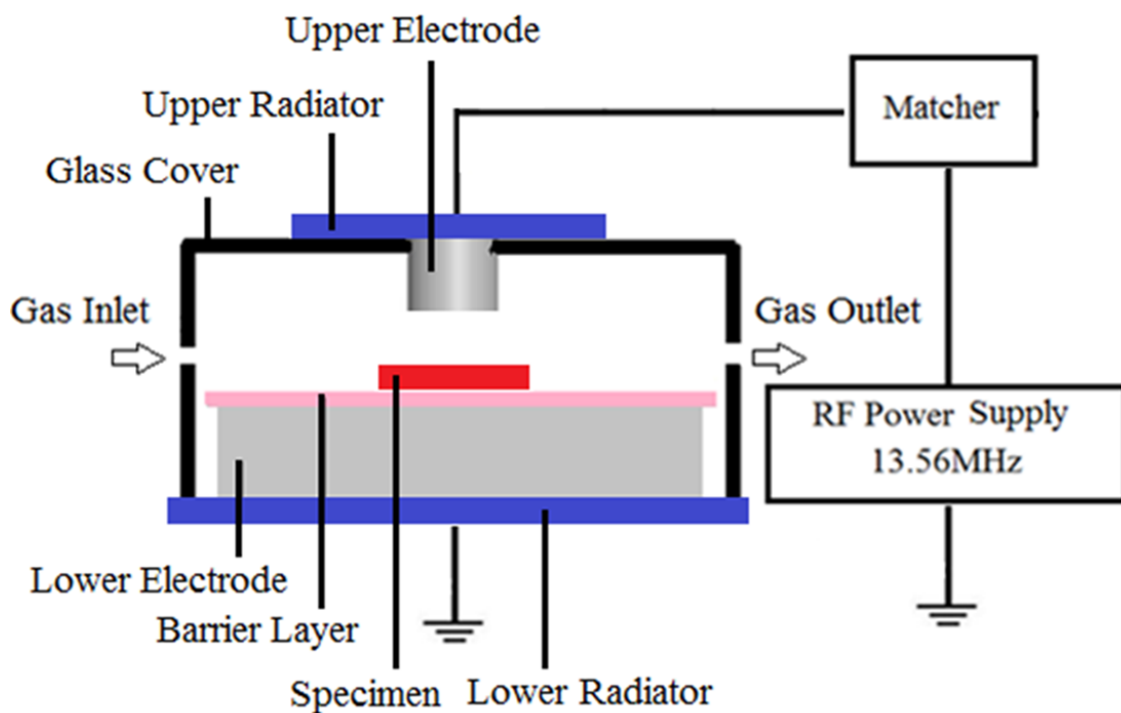


Figure 1. Functional scheme of experimental unit.

Atom force microscope NT-MDT Solver P47H was used for measurements of morphology. Microhardness was measured by hardness measuring unit PMT-3. Parameters of experiments of low-temperature plasma processing of  $\text{LiYF}_4$  crystals are shown in Table 1.

Table 1. Experiment parameters

Parameter	Value
Sample Material Diameter Thickness	monocrystalline $\text{LiYF}_4$ 6 mm 2 mm
Gas Composition Humidity Rate	Helium 100% 1% 1 l/min
Supply Type Discharge power Frequency	RF 20 W 13.56 MHz
Current density (upper electrode)	$7.5 \text{ mA/mm}^2$
Processing time	15 min, 30 min, 60 min
Chamber pressure	atmospheric

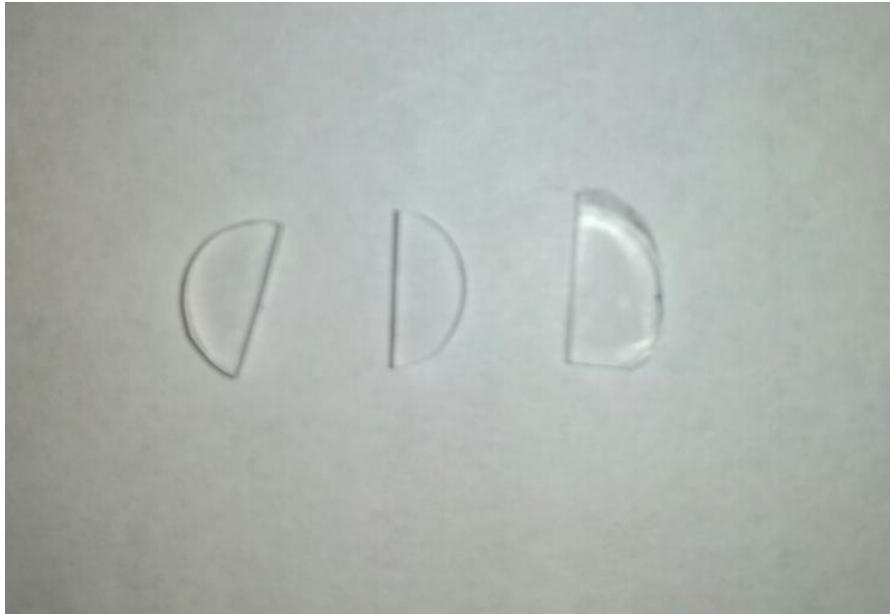


Figure 2. LiYF<sub>4</sub> crystals

### 3. Results and discussions

The view of low-temperature plasma within crystal processing is shown in Fig. 3. Wide part of plasma zone is near bottom electrode and sample. Results of AFM measuring is shown in Fig. 4 and 5. Changes of microhardness and roughness of crystal surface are shown in Fig. 6. The microhardness of sample surface decreases with increasing of processing time. The surface roughness increases with increasing of processing time. It could be caused by surface structure changes. Fluorine from crystal material under influence of low-temperature plasma diffuses to the surface and desorbs from it. As a result the stoichiometry of crystal is broken.

Also there is Oxygen in water vapor in Helium and the possibility of plasma chemical treatment of crystal surface is not small. As result in crystal appear Yttrium and Lithium oxides, not only stoichiometry is broken, but chemical composition is changed.



Figure 3. The view of low-temperature plasma.

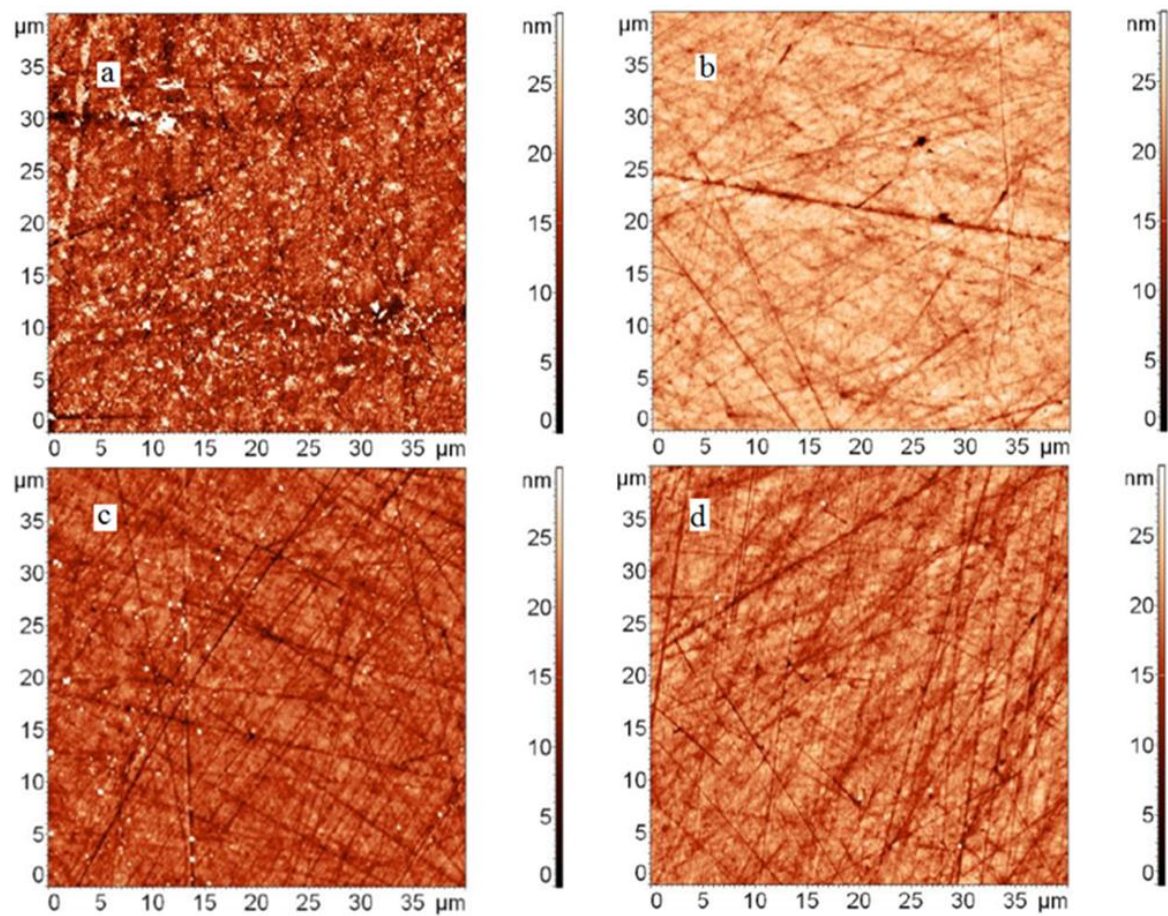
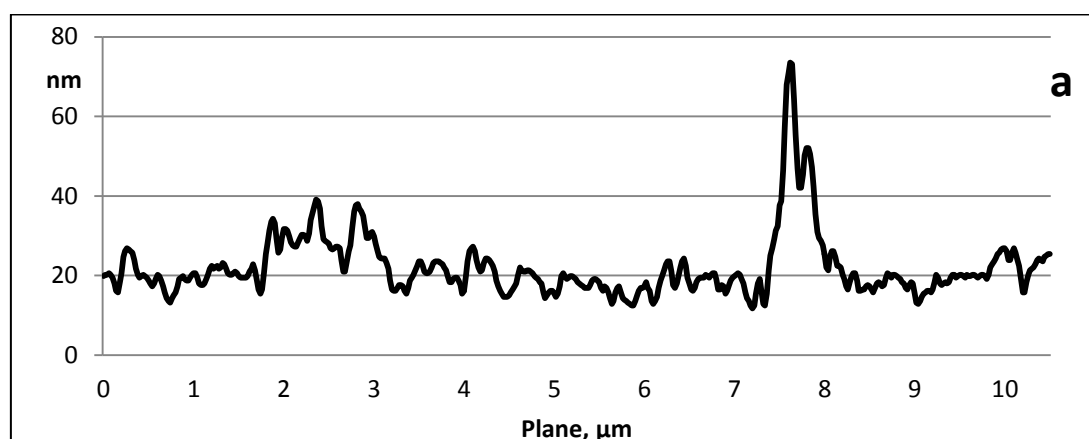


Figure 4. AFM images of the surfaces treated by the helium plasma (a) exposition times 60 min, (b) 30 min, (c) 15 min; (d) is the typical AFM image of the reference virgin sample's surface



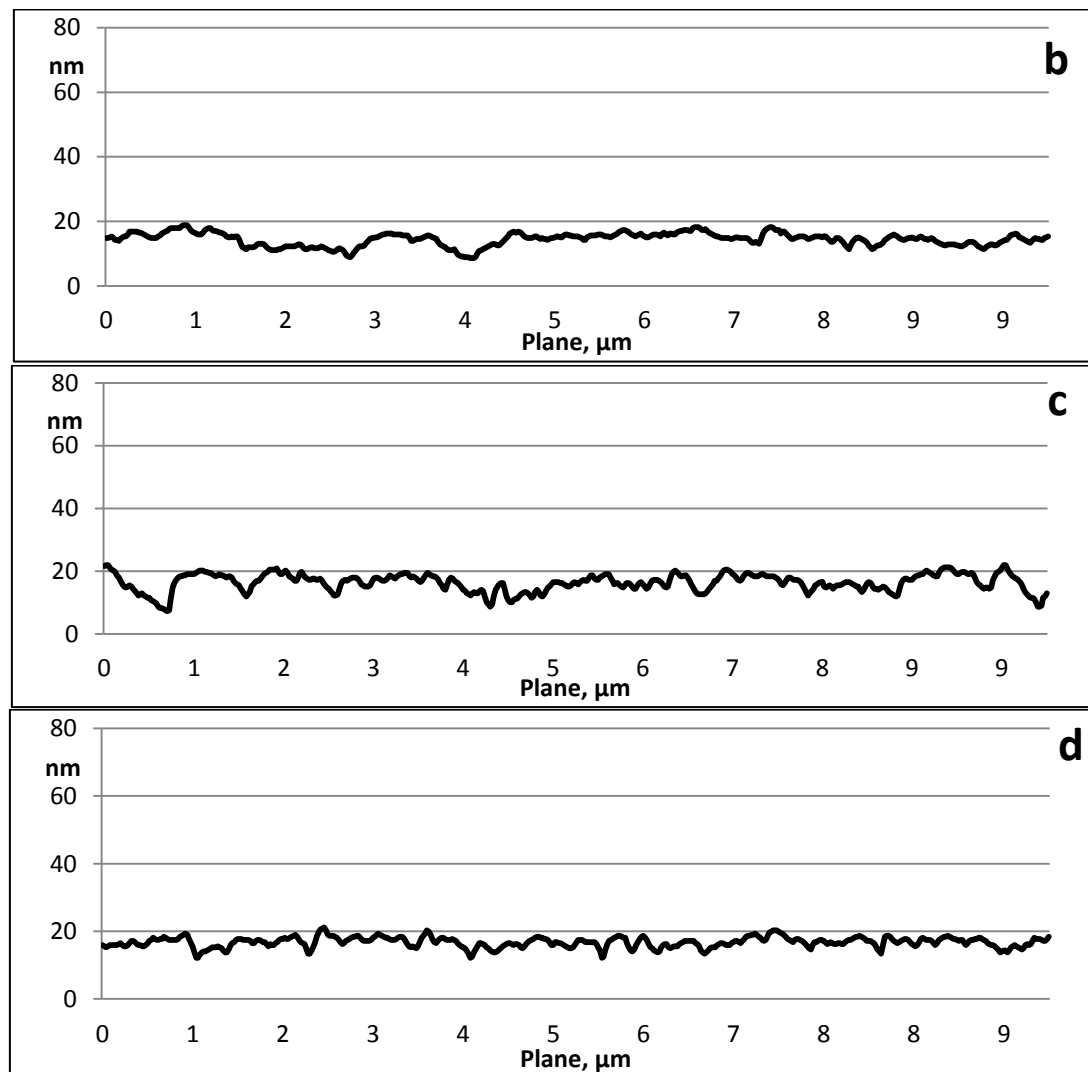


Figure 5. The roughness of the surfaces processed by helium plasma. AFM image: (a) 60 min, (b) 30 min, (c) 15 min, (d) non-treated.

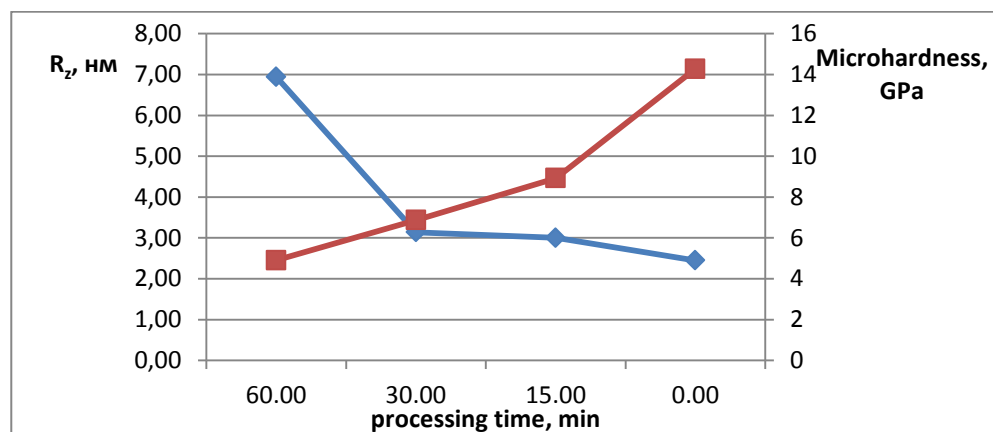


Figure 6. Dependence of microhardness (■) and roughness (◆) of crystal surface from processing duration.

The difference of crystal surface microhardness from crystal bulk microhardness gives opportunity for next mechanical, chemical or mechanic-chemical polishing of crystal surface and for increasing of finishing quality.

#### 4. Conclusion

The microhardness of  $\text{LiYF}_4$  crystal surface decreased in more than 2 times due to low-temperature Helium plasma modification within 1 hour. This result gives an opportunity for increasing of crystal surface finishing quality. Increasing of surface roughness could be caused by fact that crystal surface structure become more crumbly.

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# **Corrigendum: Plasma technologies application for building materials surface modification**

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The article title:

**“Plasma technologies application for building materials surface modification”**

is incorrect and the correct article title is:

**“Low-temperature plasma modification of LiYF<sub>4</sub> crystal surface.”**