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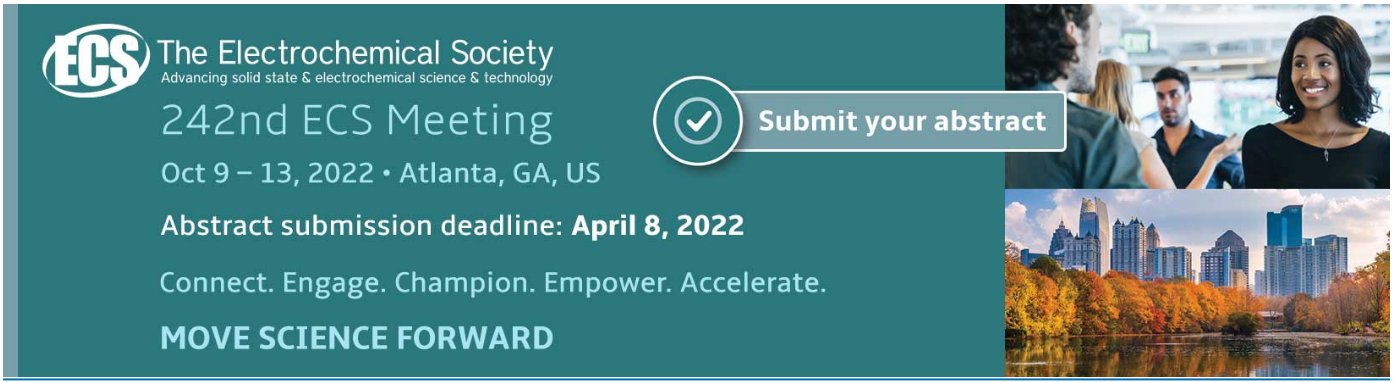

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Formation of SiO_2 buffer layer for $LiNbO_3$ thin films growth

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Abstract. This paper shows the results of study of the effect of SiO_2 buffer layer thickness on the morphological parameters of nanocrystalline $LiNbO_3$ films formed by pulsed laser deposition. It has been established that with increasing in the thickness of SiO_2 buffer layer from 10 nm to 50 nm, the roughness of $LiNbO_3$ films decreases from 5.1 nm to 4.4 nm. The minimum value of the grain diameter (118 nm) corresponds to the thickness of the buffer layer equal to 50 nm. The results obtained can be used in the design and manufacture of integrated acousto-optic and piezoelectric devices, as well as sensitive elements of sensors using various effects of surface acoustic waves.

1. Introduction

Modern electronics faced with necessity of creation new principles of power elements formation, since the capabilities of electrochemical power sources cannot fully meet its growing demands [1-4]. Moreover, there are certain difficulties associated with the disposal of waste batteries. In this regard, active research on the modernization of existing structures and technologies of formation, as well as the development of fundamentally new energy sources based on nanomaterials that meet the requirements of efficiency, versatility and environmental safety are being conducted [5-7].

A promising direction in the field of battery development is the development of piezoelectric transducers using mechanical energy of the environment as a source of power supply for wearable electronics (smart watches, mobile phones, pacemakers) [8-13]. Using of such piezoelectric transducers can expand the capabilities of wearable electronics devices, significantly increasing the time of their autonomous operation and reducing the weight and dimensions of the power supply elements.

The creation of devices based on ferroelectric and piezoelectric films at the present stage of technology development is difficult due to the problems associated with the insufficient development of the technology for their production, as well as the need to use additional buffer layers. Most ferroelectric and piezoelectric materials ($BaTiO_3$, $PbTiO_3$, $LiNbO_3$) are multicomponent oxides, which significantly complicates the technological process of their production and their integration with silicon technology of micro- and nanoelectronics [14-18]. Pulsed laser deposition is one of the promising method for the formation of multicomponent oxides films, due to a large number of technological parameters, which allows control the composition of the formed films, as well as their morphological and electrical parameters [19].

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The purpose of this work is determination of influence regularities of SiO_2 buffer layer thickness on the morphological parameters of $LiNbO_3$ nanocrystlline films fabricated by pulsed laser deposition.

2. Materials and Methods

For fabrication of naocrystalline $LiNbO_3$ films we used nanotechnological cluster complex NANOFAB NTK-9 (NT-MDT, Russia), comprising PLD module Pioneer 180 (Neocera Co., USA). $LiNbO_3$ target were ablated by excimer KrF laser (λ=248 nm). Energy density on target surface was maintained at 2.0 J/cm^2. The quantity and frequency of laser pulses were 50 000 and 10 Hz respectively. Target-substrate distance was 115 mm.

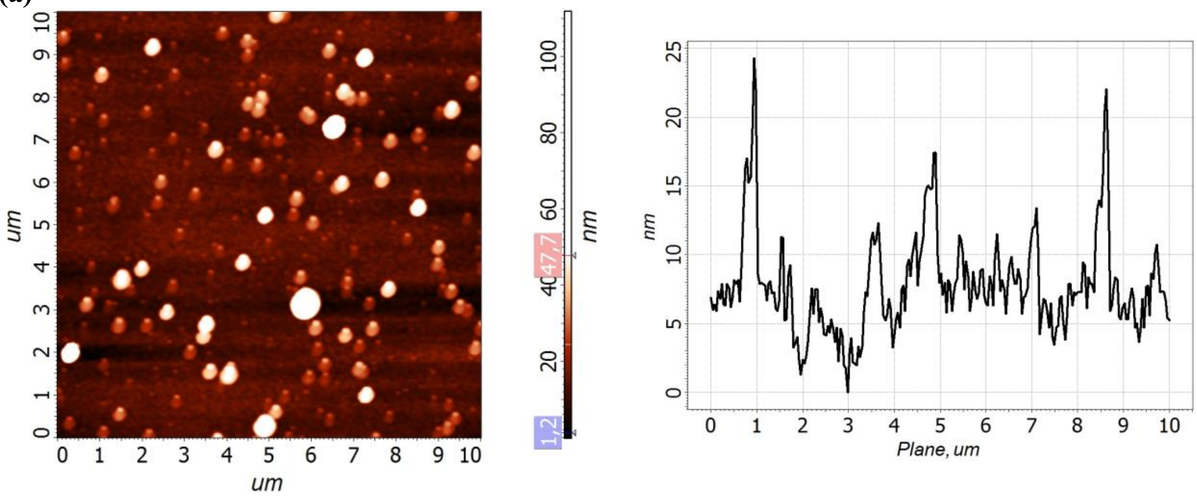
$LiNbO_3$ films were deposited on Si substrates (1 cm x 1 cm) with buffer layer of SiO_2. All substrates were subjected to preliminary purification in inorganic solvents to remove surface contamination. The morphology of the obtained film was researched by Ntegra probe nanolab (NT - MDT, Russia) and scanning electron microscop NOVA Nanolab 600 (FEI Co., Netherlands).

The formation of Si and SiO_2 films was carried out by plasma chemical deposition in a combined discharge plasma. The combined capacitive and inductively coupled plasma discharge allows controlling the granularity and roughness of the resulting dielectric surface. Film growth modes P_R = 2 Pa, gas flows N_{SiH4} = 5 cm^3/min, N_{N2O} = 60 cm^3/min, power of the capacitive plasma source was W_{RIE} = 10 V, power of the source inductively coupled plasma W_{ICP} = 400 V, deposition time 54 minutes.

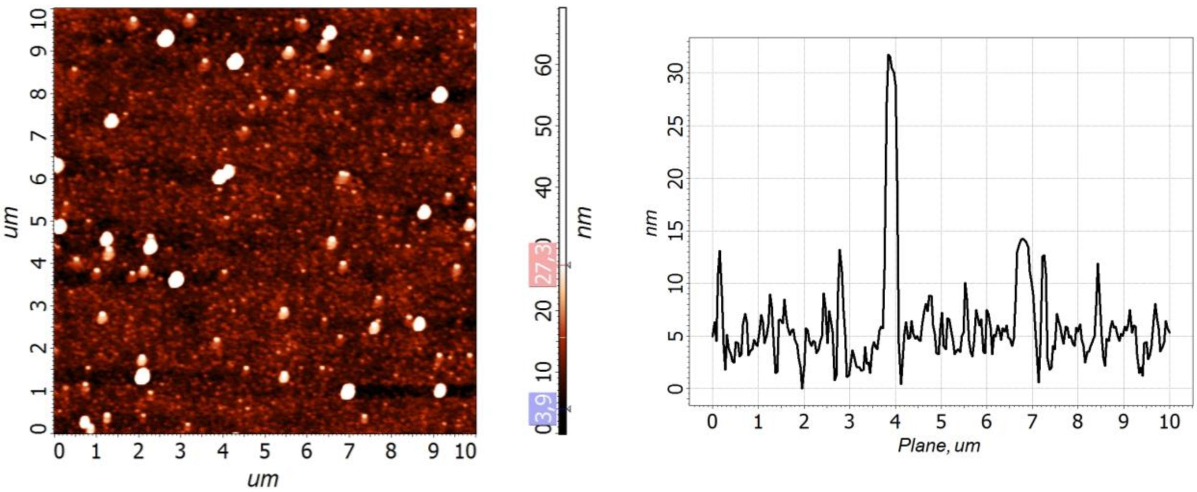
3. Results

Figure 1 shows the results of AFM images of $LiNbO_3$ films obtained on SiO_2 buffer layer with different thickness.

(a)



(b)



(c)

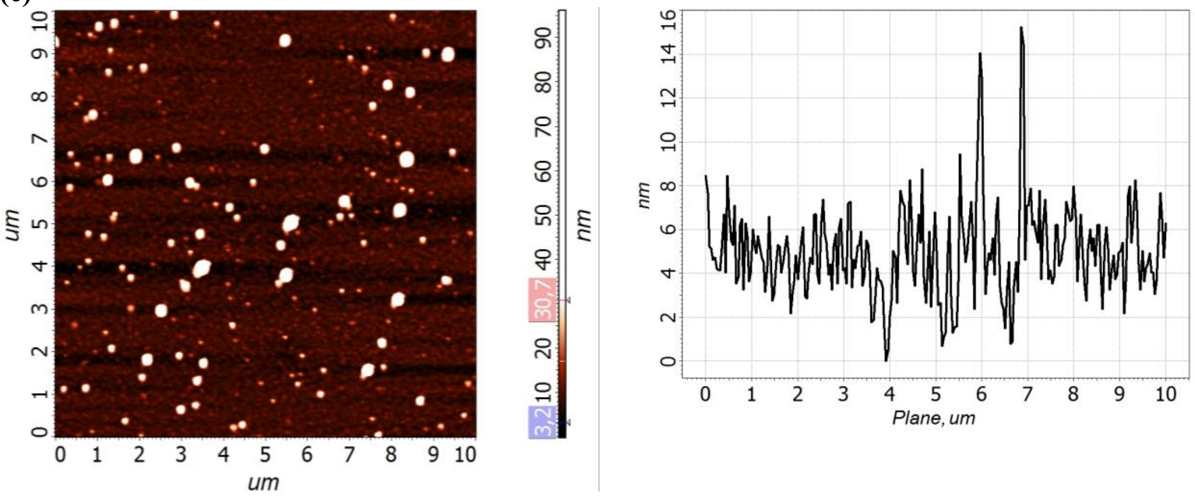
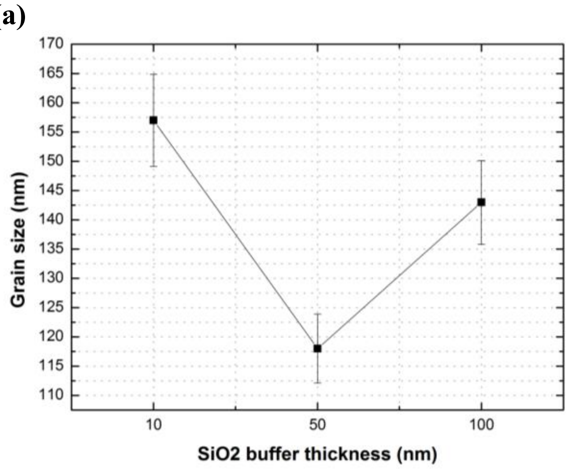


Figure 1 (a, b, c) AFM images and profilograms of $LiNbO_3$ nanocrystalline films obtained on SiO_2 buffer layer with different thickness: 10 nm **(a)**, 50 nm **(b)**, 100nm **(c)**

Figure 2 shows the values of surface roughness and grain diameter of nanocrystalline $LiNbO_3$ films obtained on SiO_2 buffer layer with different thickness.

(a)



(b)

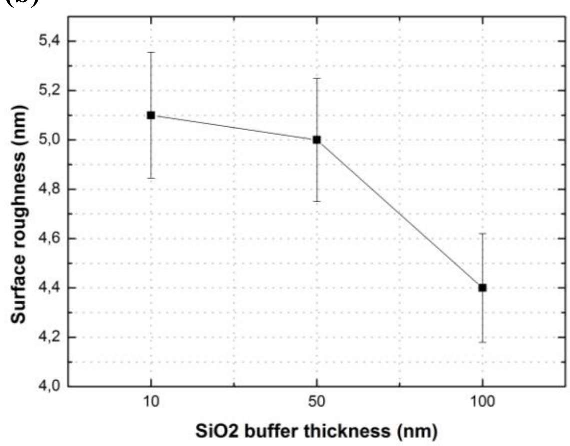


Figure 2 (a, b) Dependences of the morphological parameters of $LiNbO_3$ nanocrystalline films on the thickness of the SiO_2 buffer layer: grain size **(a)** and surface roughness **(b)**

As the thickness of the buffer layer increases from 10 to 100 nm, the roughness of the nanocrystalline $LiNbO_3$ films decreases due to the activation of the process of interatomic interaction of the materials of the formed film. Increasing in the grain size of $LiNbO_3$ films with an increase in the thickness of the buffer layer may be associated with an increase in the grain diameter of the SiO_2 layer and the effect of "inheriting" the morphology of the buffer layer. Figure 3 shows SEM images of $LiNbO_3$ nanocrystalline films obtained on SiO_2 buffer layer with different thickness.

(a) **(b)** **(c)**

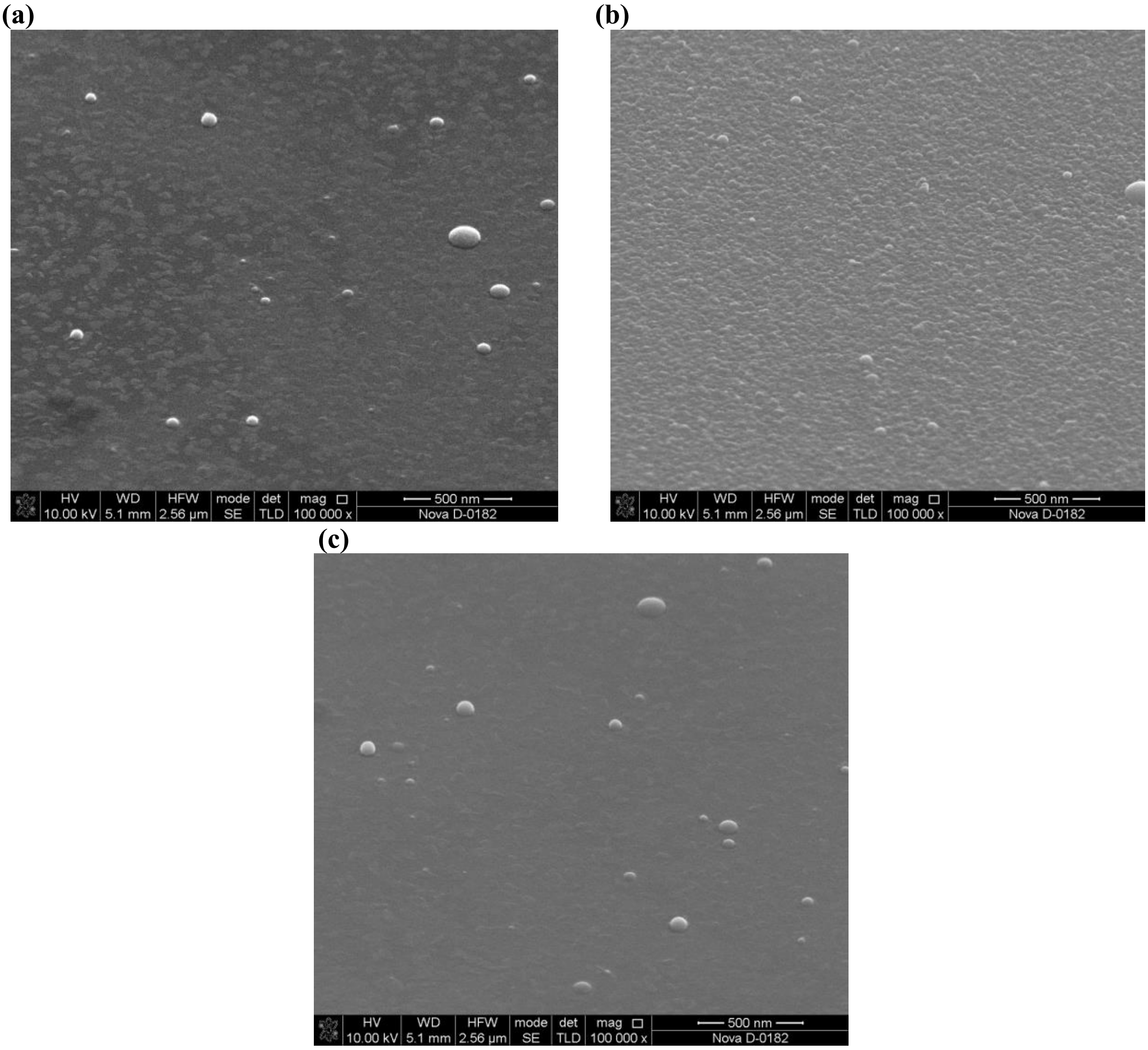


Figure 3 (a, b, c) SEM images of $LiNbO_3$ nanocrystalline films obtained on SiO_2 buffer layer with different thickness: 10 nm (a), 50 nm (b), and 100 nm (c)

4. Discussion and Conclusions

In this work, experimental studies were carried out on the deposition of a buffer layer of SiO_2 by plasma chemical deposition. $LiNbO_3$ films were obtained by pulsed laser deposition. It has been established that with an increase in the thickness of the buffer layer of SiO_2 from 10 nm to 50 nm, the roughness of $LiNbO_3$ films decreases from 5.1 nm to 4.4 nm. The effect of the thickness of the buffer layer of SiO_2 on the morphological parameters of $LiNbO_3$ nanocrystalline films formed by pulsed laser deposition was studied. The obtained films with these roughness indicators can be used in the formation of solar cells, as well as elements of nanophotonic devices.

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