

Piezoelectric properties of $\text{SrBi}_2(\text{Ta}_x\text{Nb}_{1-x})_2\text{O}_9$ thin films synthesized by the sol-gel method

A.V. Semchenko¹, V.V. Sidsky¹, A.Yu. Shepelina², D.A. Kiselev², V.A. Pilipenko³

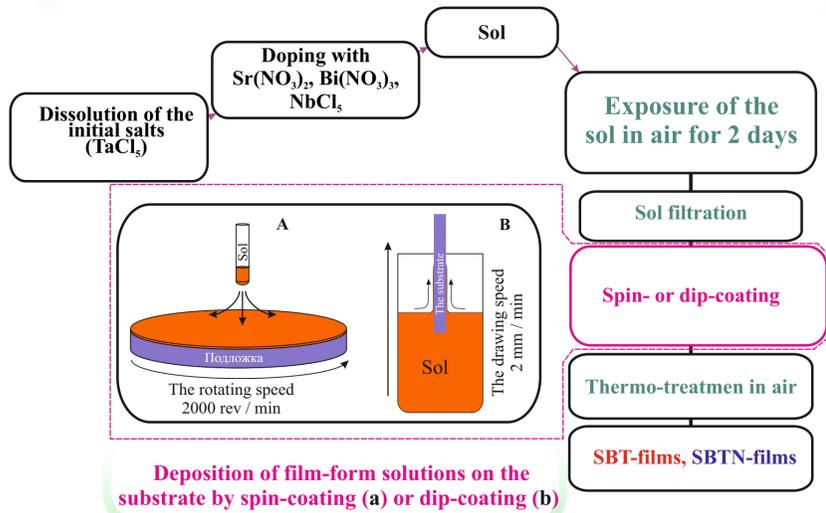
¹F. Skorina Gomel State University, Sovetskaya 104, Gomel, 246019, Belarus

²National University of Science and Technology "MISIS", Leninskiy Prospekt 4, 119049 Moscow Russia

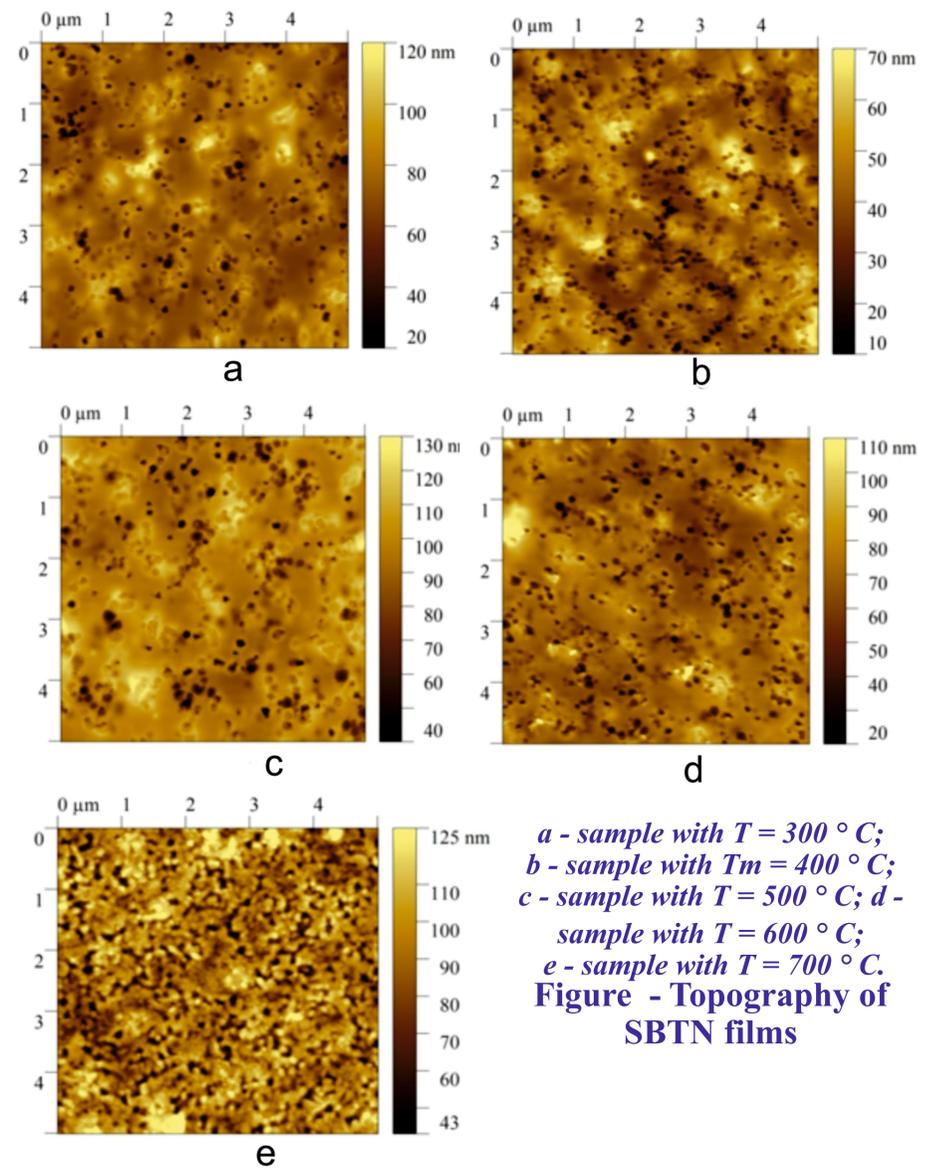
³JSC "INTEGRAL", Korjnevsky str., 12, Minsk, 220108, Belarus



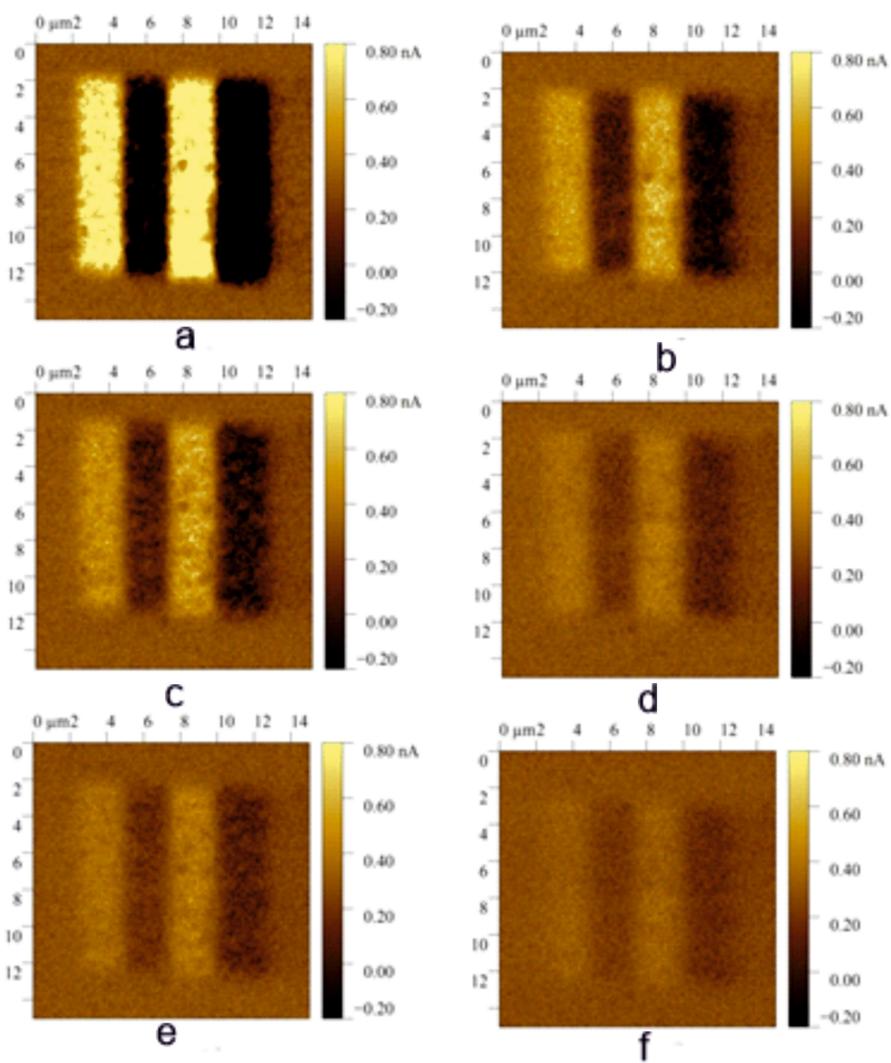
The main stages of sol-gel process



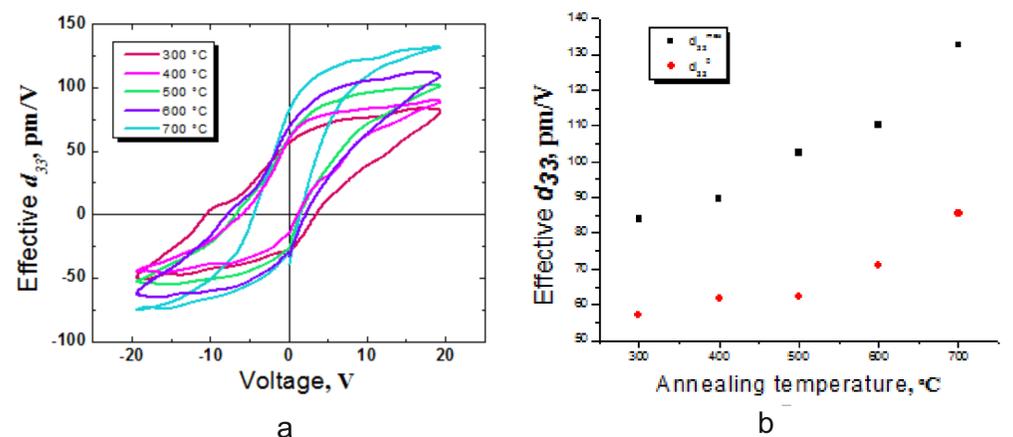
Deposition of film-form solutions on the substrate by spin-coating (a) or dip-coating (b)



a - sample with $T = 300^\circ\text{C}$;
b - sample with $T_m = 400^\circ\text{C}$;
c - sample with $T = 500^\circ\text{C}$;
d - sample with $T = 600^\circ\text{C}$;
e - sample with $T = 700^\circ\text{C}$.
Figure - Topography of SBTN films



a - residual piezoelectric hysteresis loops ;
b - values of quantities d_{33}^0, d_{33}^{\max} as a function of temperature
Local switching effect in SBTN films with different annealing temperatures



Polarization of SBTN film with annealing temperature 300°C after polarization with voltage $\pm 15\text{ V}$ and $\pm 20\text{ V}$ (in contact mode): a - immediately after polarization; c - 20 minutes after polarization; e - 40 minutes after polarization; b - 10 minutes after polarization; d - 30 minutes after polarization; e - 50 minutes after polarization

Visualization of the induced domain state is possible after polarization of the film by applying a constant voltage to the "cantilever - film - substrate" system. For this, the surface of the film, measuring $(2.5 \times 10) \mu\text{m}^2$, was first polarized with a constant voltage of $\pm 15\text{ V}$ and $\pm 20\text{ V}$, and then a larger area of the film was scanned in the piezoresponse mode $(15 \times 15) \mu\text{m}^2$. The results are shown in Figures 1. It can be seen that the induced areas repeat the profile set by the probe during scanning.

"Dark" and "light" areas indicate the opposite direction of the polarization vector. Analysis of the phase of the piezoresponse showed that "dark" regions correspond to domains with a polarization vector directed to the probe (hereinafter referred to as "negative" domains), "light" correspond to domains directed from the probe to the film (hereinafter referred to as "positive" domains).

Polycrystalline $\text{SrBi}_2(\text{Ta}_x\text{Nb}_{2-x})\text{O}_9$ (SBTN) films (700°C annealing temperature) with different Nb content from 10 % to 50 %, with a step of 10 %, as well as 5 samples of SBTN films (20 % content Nb). Polarized areas are unstable and quickly relax. Figures 1 show scans showing the relaxation of the polarized state over time for samples annealed at different temperatures.

This work was funding from the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie grant agreement № 78070.

This work was carried out with the partial support of the Belarusian Republican Foundation for Fundamental Research (grant №T20P-359).

