Project name: IRN AP 14972981 "Development of technology for obtaining an effective piezoelectric material for creating competitive piezoelectric generators"

Abstract: It is known that piezoelectric generators (PEG) are able to generate electricity by converting the mechanical vibrations of the environment. Every year, the demand for competitive PEGs is growing, due to their environmental friendliness and the simplicity of the way to generate electricity. The main transducer element in PEG, which converts the energy of mechanical vibrations into electrical energy, is piezoelectric ceramics. But the existing PEGs are not capable of generating high energy powers due to the lack of efficient piezoceramics. Therefore, first of all, it is necessary to develop efficient piezoelectric ceramics capable of significantly increasing the output energy parameters of existing PEGs.

Purpose: Develop a technology for obtaining efficient piezoelectric ceramics, including piezoelectric nanoceramics, capable of significantly increasing the energy parameters of existing PEGs.

Expected and achieved results:

During the implementation of the project, all the tasks of the project will be solved:

- theoretical and technological approaches for obtaining effective piezoelectric ceramics capable of significantly increasing the energy parameters of existing PEGS will be developed and substantiated.
- technologies have been developed for producing effective piezoelectric ceramics for PEG by methods of solid-phase synthesis and hot pressing.
- technologies have been developed for the production of effective piezoelectric ceramics for PEG by methods of exposure to optical and microwave radiation.
- the technology of obtaining effective for PEG by doping has been developed.
- nanostructuring technology of piezoelectric nanoceramics has been developed to produce homogeneously mixed nanomaterials with specified particle sizes.
- the structures of synthesized piezoelectric ceramics have been studied (by X-ray phase and X-ray diffraction analysis, scanning electron microscopy).
- piezoelectric, electrophysical parameters and characteristics of synthesized piezoelectric ceramics are investigated.
- a physico-chemical analysis of the structure and properties of synthesized samples was carried out in order to establish criteria for identifying optimal compositions of piezoelectric ceramics capable of providing an efficiency of PEG composition higher than that of existing generators.

- a laboratory model of PEG was made and tests of synthesized piezoelectric ceramics in the composition of PEG were carried out to assess their generating capacity (determination of efficiency).

- in the course of the research, a scientific and technological reserve for the production of piezoelectric ceramics for PEG will be developed.

- according to the results obtained during the implementation of the project, at least 2 (two) will be published articles in journals from the first three quartiles by impact factor in the Web of Science database or having a CiteScore percentile in the Scopus database of at least 50. It is planned to submit an application for an invention to the Kazakhstan or Eurasian Patent Office on this topic. The results of the work will also be reported at International conferences.

Achieved results in 2022:

- Promising compositions have been identified and technologies for obtaining effective piezoelectric ceramics by solid-phase synthesis have been developed.

- Solid solutions of piezoelectric ceramics for a triple system (1-2x)$BiScO_3$·(2-y)x$PbTiO_3$·yx$PbMg_{1/3}Nb_{2/3}O_3$ were obtained by solid-phase synthesis for the section of the system with y=0.5.

- The structural parameters of synthesized solid solutions of the triple system are investigated: (1-2x)$BiScO_3$·(2-y)x$PbTiO_3$·yx$PbMg_{1/3}Nb_{2/3}O_3$, the symmetry types and parameters of the elementary cells are determined, the phase diagram is determined.

- Dielectric parameters for synthesized solid solutions of a triple system are investigated: (1-2x)$BiScO_3$·(2-y)x$PbTiO_3$·yx$PbMg_{1/3}Nb_{2/3}O_3$, the temperature–frequency dependences of the dielectric constant ε and the tangent of the loss angle tgδ in the temperature range T = 295 – 700 K and the frequency range f = 25 Hz – 1 MHz were studied.

- The temperatures of the phase transitions T_c of ferroelectrics and the temperatures of the phase transitions T_m of ferroelectrics-relaxors for solid solutions of the triple system are determined: (1-2x)$BiScO_3$·(2-y)x$PbTiO_3$·yx$PbMg_{1/3}Nb_{2/3}O_3$.

- Data of temperature dependences of thermally stimulated depolarization currents of samples of solid solutions in the range of 300-700 K of different compositions were obtained.

Research group members:

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Information for potential users: An efficient piezoelectric material will be obtained for use in piezoelectric generators.