

- **Organization:**
Physical-Chemical Institute at the
Vasyl Stefanyk PreCarpathian National University
- **Legal status legal entity – University**
- **FP's experience -**

FP7 Research Area
Energy, NMP

Keywords
IV-VI Semiconductor Materials, Impurities, Thermoelectricity, Technology,
Material Science, Optimization.

Title of the proposed project
IV-VI-Based Semiconductor Materials for Thermoelectricity Energy
Transformers

Project description

- **Concept and objectives**

We planned to develop effective technology receipt lead telluride n- and p-type of conductivity, set influence technological factors growing on thermo-electric properties material, find out the most optimum alloying the admixtures lead telluride from the point view thermo-electricity. The technological aspects of project include the choice of modes synthesis material from components and alloying admixtures for the receipt of alloys n- and p-type of conductivity, next terms homogenizing annealing (temperature, time), milling and selection factions of certain size, realization hot-pressed in the preforms the proper size (depending on technolo factors).

The research side of work foresees determination complex of thermo-electric parameters of material, got at different technological factors, and also them temperature dependence. In addition a necessary task is establishment conformities to the law in these dependences and explanation of them physical and chemical nature.

The next stage is an increase efficiency of the probed materials by a way them the directed alloying. Most perspective is alloying the probed materials by the admixtures of elements by V group of the Periodic table (Bi, Sb) of Chemical Elements. On this stage the complex of researches, related to theoretical description and engineering imperfect subsystem, development technology alloying materials of PbTe:Bi(Sb), is planned.

From other side, promoting thermo-electric good quality is possible the management of growing material by technological modes. The study of transport phenomena allows to forecast the temperature and concentration limits prevailing certain mechanisms dispersion of transmitters charge. Therefore, on the basis analysis of the phenomena transfer it is possible to set the technological modes for creation materials with the beforehand set properties, in particular, to develop technologies materials with dominant carrier scattering on phonons.

Thus, the association all of the higher resulted tasks enables to optimize technological processes for the receipt of materials with high thermo-electric descriptions.

S&T objectives of project in detail

The project purpose is development of technology receipt a new semiconductor materials on the basis of unalloyed and alloyed IV-VI semiconductors for creation of middle range temperature modules (500-700 K).

The followings tasks will be executed thus:

- development technologies synthesis and receipt of laboratory samples of IV-VI of the n- and p-type of conductivity;
- development technologies of directed alloying of semiconductors by the admixtures elements of the V group of the Periodic system of chemical elements (Bi, Sb);
- research physical and chemical properties, engineering of point defects and analysis of transport phenomena of the receive thermo-electric materials;
- technology optimization of new semiconductor materials with high thermo-electric parameters.

The project results are receipt of pre-production models semiconductor materials on the basis of lead telluride with high thermo-electric parameters for their subsequent use in the devices for transformation thermal energy in electric.

Basic parameters which characterize thermo-electric descriptions of material and which will be by us determined is:

Coefficient of thermo-electromotive force (α), specific conductivity (σ), coefficient of heat-conducting (χ). Except for basic, will be probed by us: concentration carriers of charge (n) and type conductivity, mobility carriers of charge (P), Hall coefficient (RH), thermo-electric good quality (Z, ZT), specific thermo-electric power ($\alpha^2\sigma$). The indicated coefficients will be determined experimentally a compensative method in the permanent electric and magnetic fields, depending on chemical composition, technological factors, change of temperature.

- a synthesis is a iso- and two-thermal synthesis;
 - research of defect subsystem in complex application of thermodynamics, crystal-chemistry and crystal-quasi-chemistry analysis;
 - a study of transport phenomena is a method of relaxation time, variation approach (with consider band structure);
- optimization of technology material receipt is technologies of orientation hot-pressed.

▪ **Expected progress beyond the state-of-the-art**

Today in wide practical application, mainly, there are classic thermo-electric materials, tested sometimes and by experience of the industrial use. Therefore the special interest is presented by achievements in the increase efficiency of classic materials which are utilized in industry.

Thus researches, directed on the increase efficiency of thermo-electric transformation energies, based not on growth of good quality, but on the use technological factors which reduce in a price the cost of termomaterial which is instrumental in the economy of thermo-electric devices considerably, acquire the special attractiveness. Therefore at the really attained values of good quality a primary concern is become by the improvement of technological processes with comparatively low expenses.

Today technology and production of low temperature material is adjusted on the basis of telluride Bi and furnace (Bi_2Te_3 , Sb_2Te_3) for room temperatures (~ 300 K) the production of medium-temperature material (500-700 K) which is needed as to domestic so oversea producers of the cascade modules the thermo-electric generating of power absents in Ukraine.

In the last years into first place questions which touch power safety goes out in the world. Therefore researches, directed on development of methods conservation energy, transformation them from one kind in other, accumulation of energy carry priority character both on national and on international levels. EU's countries, as well as Ukraine strongly depends on production of electric energy volumes. In addition, swift development the newest high-fidelity technologies compel to develop the thermo-electric devices of generation and transformation energy for all more frequent cases,

when no other devices can be utilized. It, in particular, is expressly traced in medicine, space industry, way of life, when it is necessary actively to search the methods economy energy a population in the days of economic crisis.

▪ **Added value for European Research Area**

One of the most essential and priority directions of scientific researches in Ukraine and in other states became development of new energy saving technologies, creation effective repaireding energy sources, utilization of thermal wastes, autonomous energy sources, and others like that. Thus researches, related to the direct converting of thermal energy into electric, go out on one of the first places.

For the industrial production of new thermo-electric transformers energies are needed, above all things, to probe fundamental laws and develop technological bases of forming of high-efficiency materials for creation on their basis active elements of thermo-electric devices. Thus, self thermo-electric materials technology goes out on the first plan.

[Budget estimation (EUR)] 350 000 EUR

Key partners already involved

Gazi University (Ankara, Turkey)
Lublin Technical University (Lublin, Poland)
Institute of Physics NAS of Belarusj (Minsk, Belarusj)
V.E.Lashkarev Institute of Semiconductor Physics NAS of Ukraine (Kyiv, Ukraine)
Institute of Thermoelectricity NAS of Ukraine (Chernivtsy, Ukraine)

Profile of a partner

Type of organization

- + **[Research organization]**
- + **[University (High School)]**
- [Industry]
- + **[SME]**
- [Regional authority]
- [Other]

Partner's role in the project

- 1) **[Administrative Coordinator]** or
[Scientific Coordinator] or
[Partner]

- 2) **[Research]**
 [Technology development]
 [Training]
 [Demonstration]
 [Dissemination]
 [Other]

[Country preferred]
EU (MS or AS)

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