Vasyl Stefanyk Precarpathian National University
(Ivano-Frankivsk, Ukraine)

Thermoelectric Materials and Devices for Energy Saving and Security Increase (G4536)

Thermoelectric: Cheap and Safe Energy

October 05, 2017
Ivano-Frankivsk - Krasnoillya, Ukraine

This project is supported by: The NATO Science for Peace and Security Programme

Project title:
Thermoelectric Materials and Devices for Energy Saving and Security Increase [ref. no G4536]

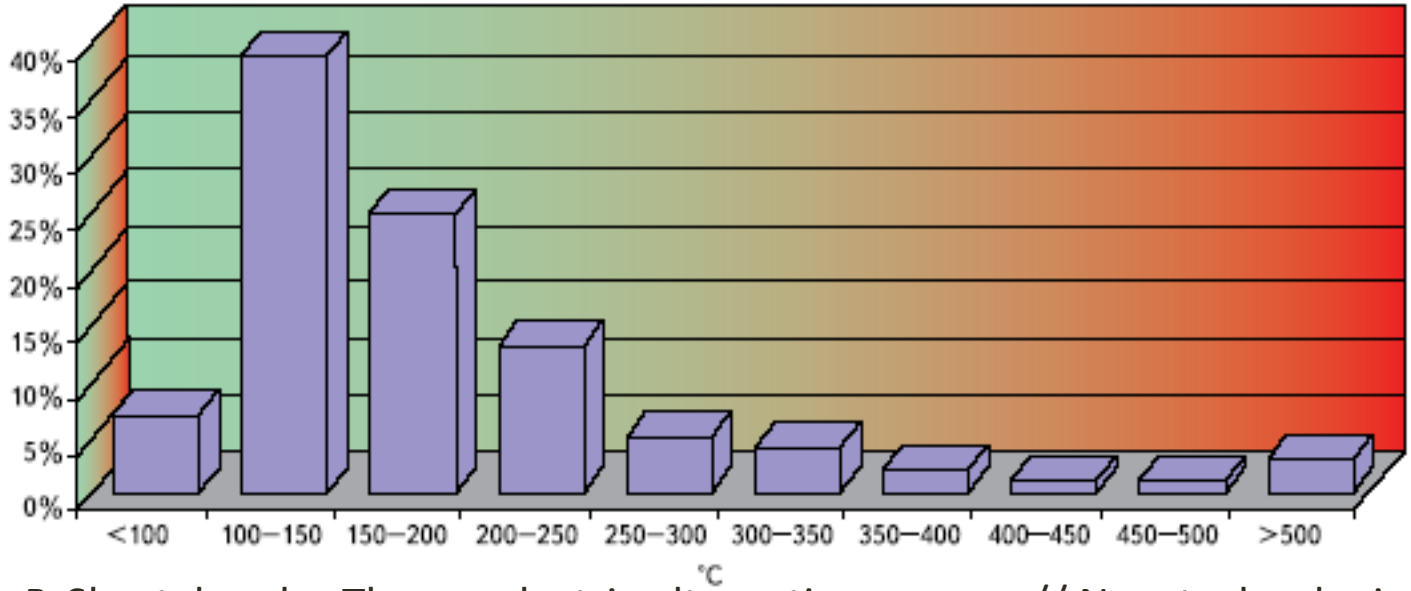
Duration: **24 month**

Project participants:

NATO country - Gazi University (Ankara, **Turkey**);
NATO partner country – Vasyl Stefanyk Precarpathian National University (Ivano-Frankivsk, **Ukraine**)

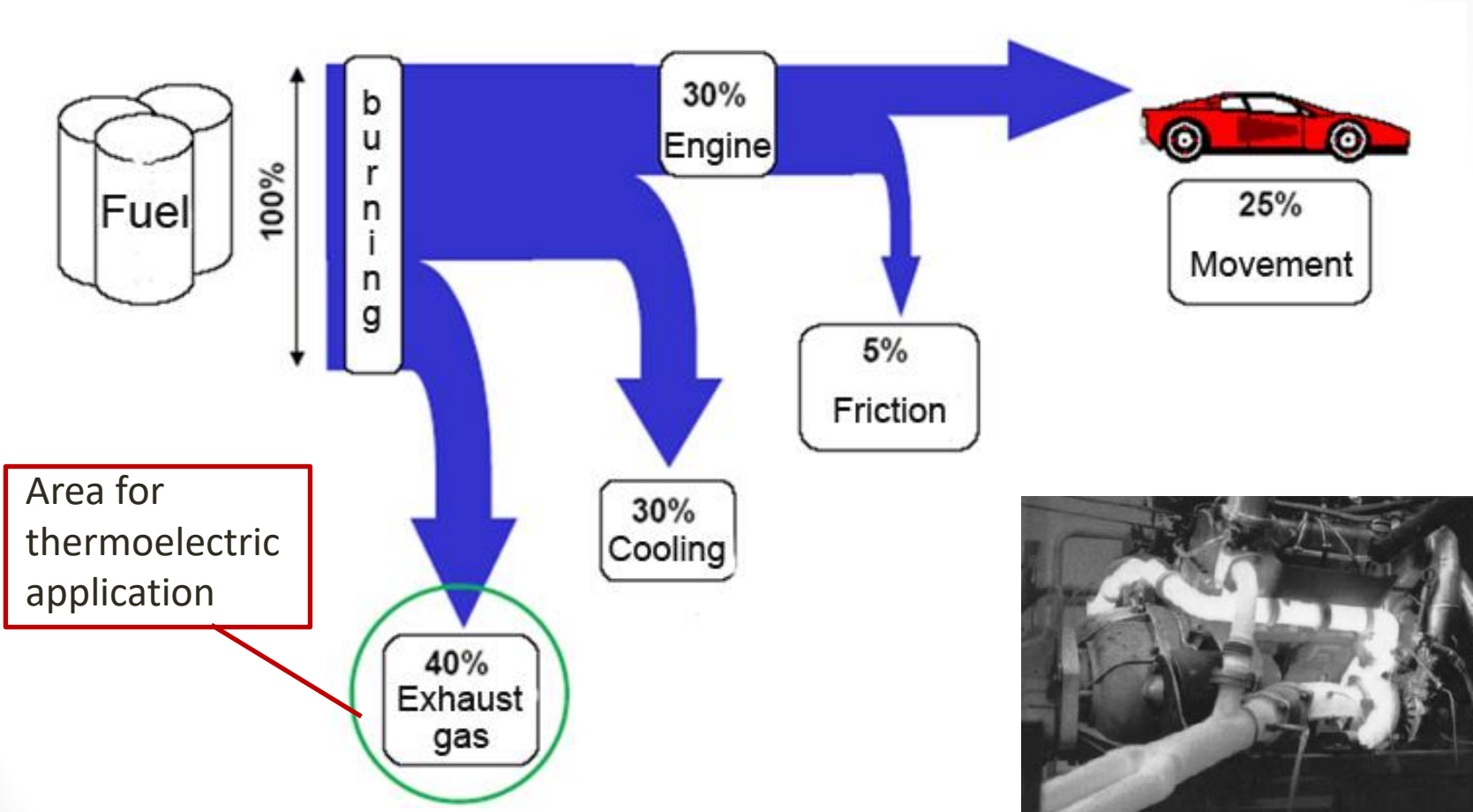
Budget			
By participants		By Category (**Ukraine**)	
Turkey	€ 80 000	Equipment	€ 105 000 (65%)
Ukraine	**€ 159 000**	Training/Stipends	€ 22 000 (13.5%)
		Implementation	€ 32 000 (20%)
NATO Total Funding			**€ 239 000**
Non-NATO Funding			€ 80 000

State of art.
Loss of heat around us



P. Shestakovsky. Thermoelectric alternative sources // New technologies. No 12. 131 (2010).

State of art.
Loss of heat around us



Francis Stabler, Future Tech, (GM Powertrain, Ret.)

State of art.
Vehicles with TE-generators

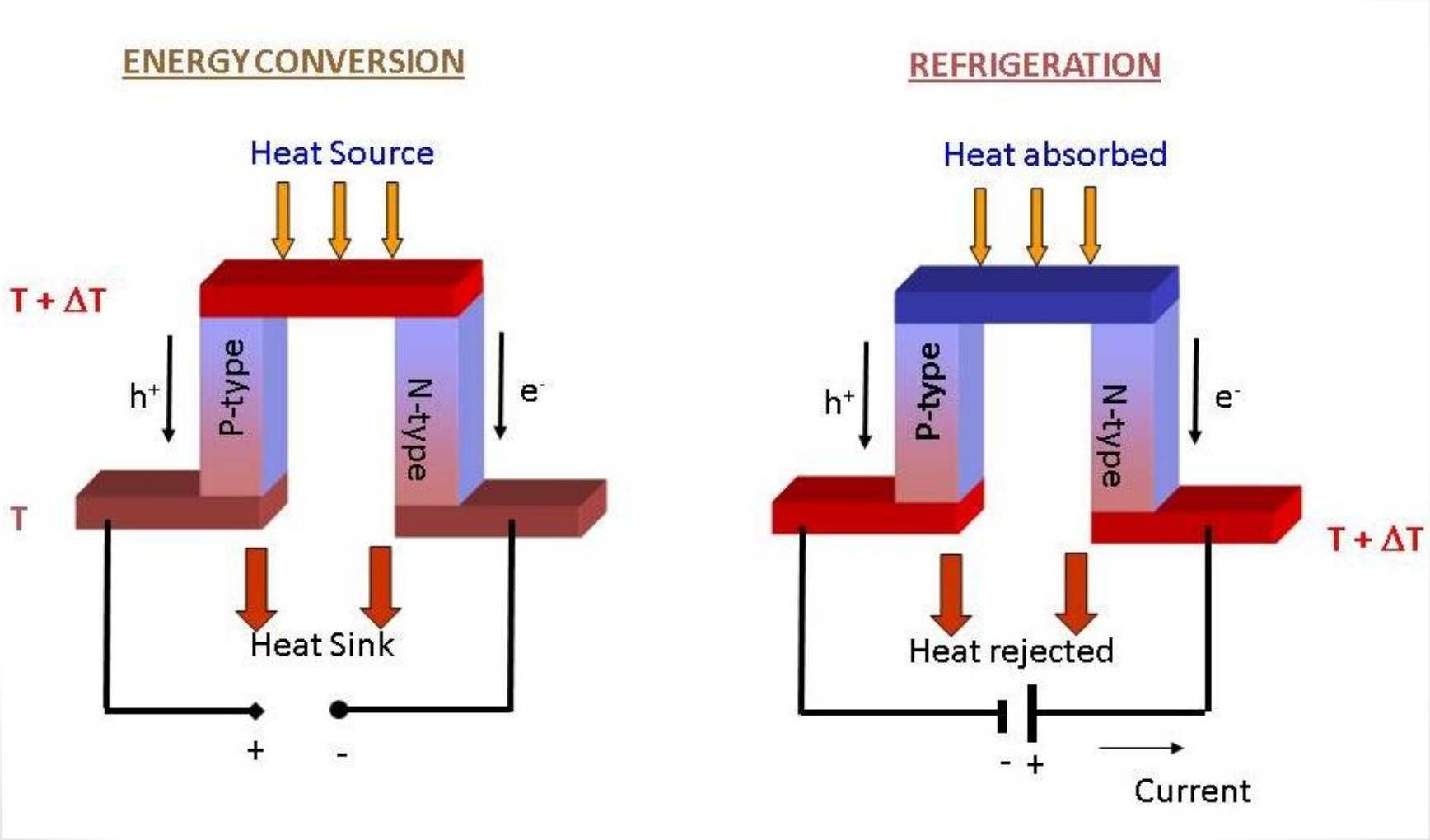
Chevrolet Suburban

BMW X6

The using of thermoelectric devices decreases up to 10% in fuel consumption, and also, emissions of CO_2!

Non-thermoelectric air-conditions contains a coolant, whose influence on environmental pollution is in 1300 times dangerous than CO_2 emissions!

Basic of thermoelectric



http://maeweb.ucsd.edu/node/29

Application of TE

Laptop charging is 3-5 hours
www.waldeneffect.org

TEGs for convert of solar heat energy

TEGs for exhaust gas

TEGs in military vehicles (USA, Abrams Tank)

TEGs for geothermal energy

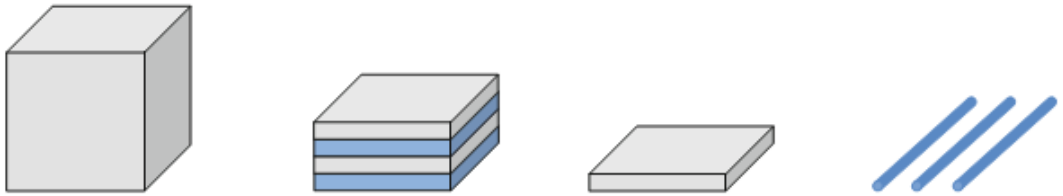
TE-cooling for medicine; mini-refrigerators

State of Art: Materials

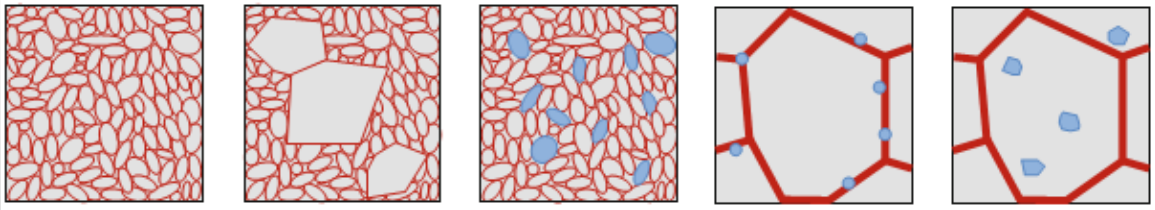
$$ZT = S^2\sigma/\chi$$ - Figure of merit of TE-mterials

Z – figure of merit of TE-material, T – temperature, ZT – dimensionless figure of merit; S – Seebeck efficient, σ – specific electrical conductivity, χ – efficient of thermal conductivity.

Modern main task in thermoelectricity is creation of specific type of material ***«electronic crystal – phonon glass»***.



1 – from macro- to nano-



2 – insertion of nanoinclusions

Novelty of the project : Material Science

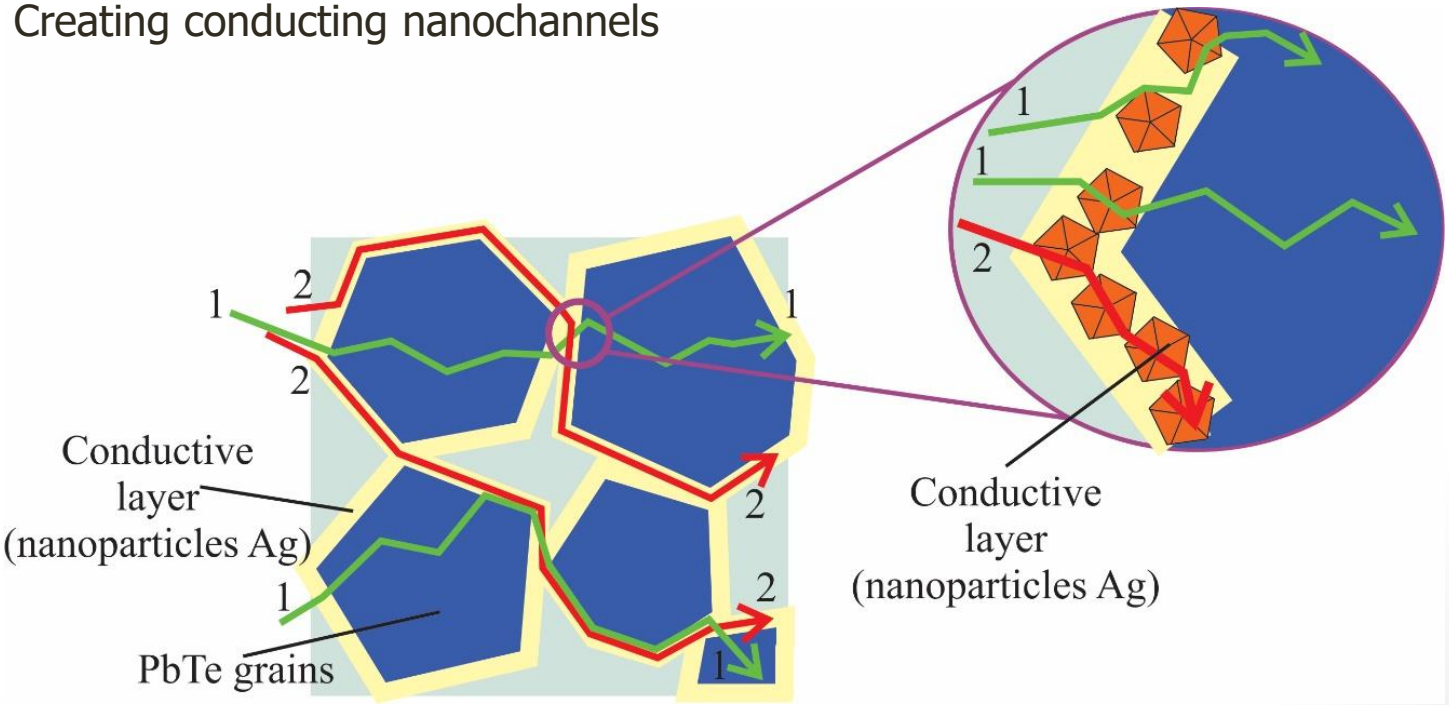
Theoretical approaches

1. Application of recent methods to test materials:

- The inclusion of a large number of nanoinclusions;
- Ordering nanoinclusions (placement nanoinclusions, alternating nanoinclusions and macro-grains);
- Modulation doping (creation of composites doped and non-doped phases)

Development of new approach:

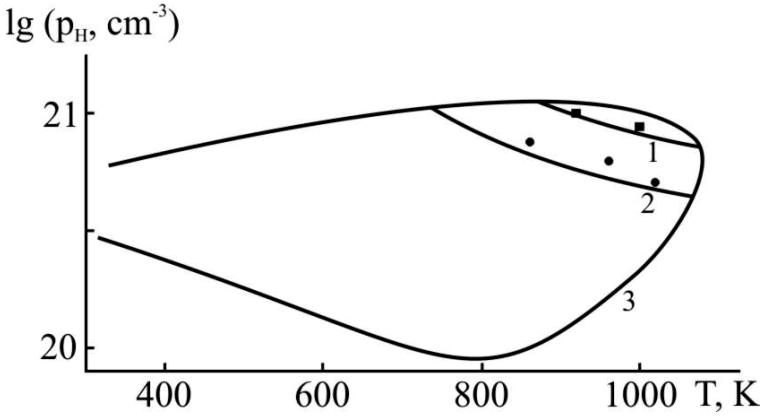
- Creating conducting nanochannels

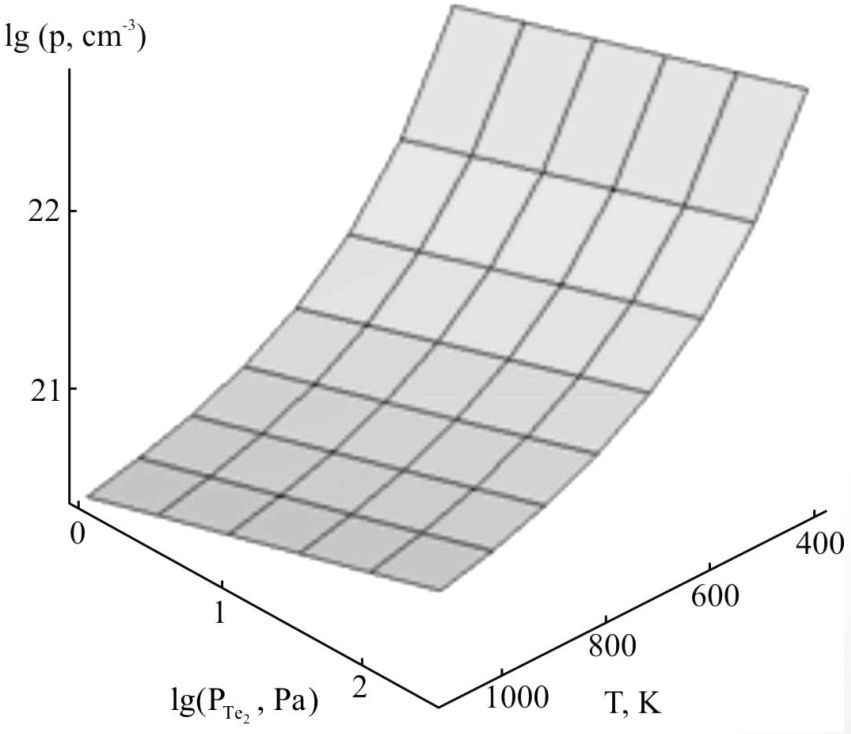


Novelty of the project : Material Science

Theoretical approaches

2. New complex of theoretical methods in material research that developed by project authors: crystal-chemical, thermodynamics, quasi-chemical, and crystal-quasi-chemical.

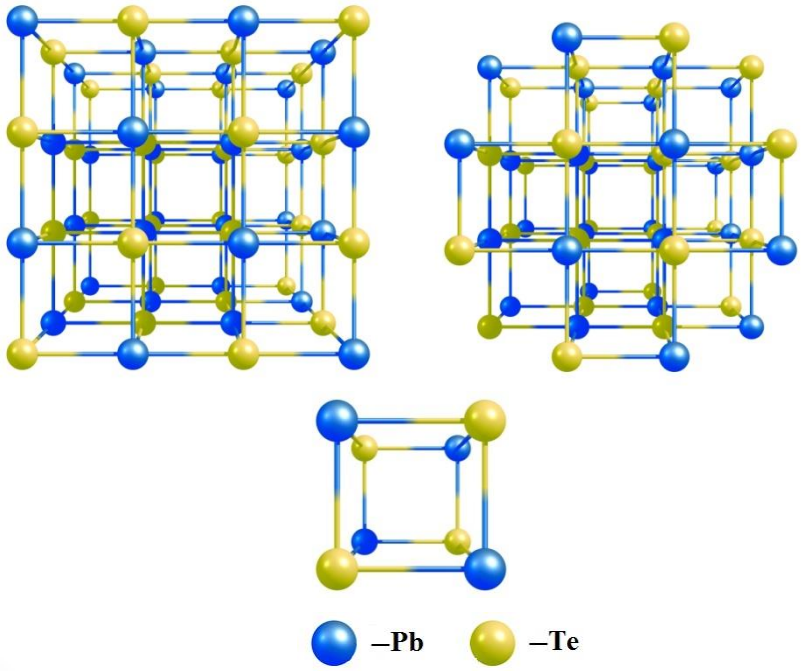


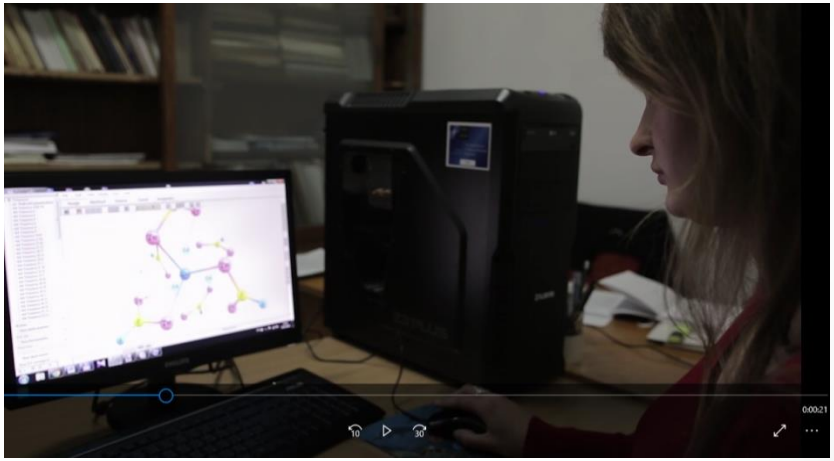


Novelty of the project : Material Science

Theoretical approaches

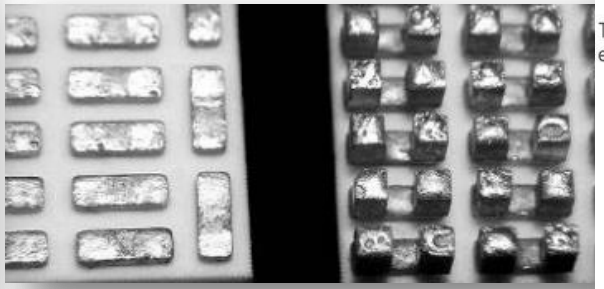
3. Development of DFT-calculation (*ab initio* or quasi-chemical calculation) to obtain of thermodynamics and crystal properties.

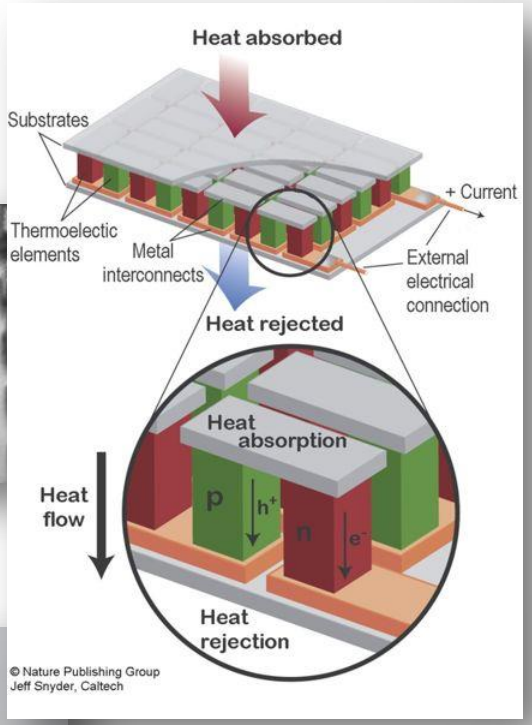


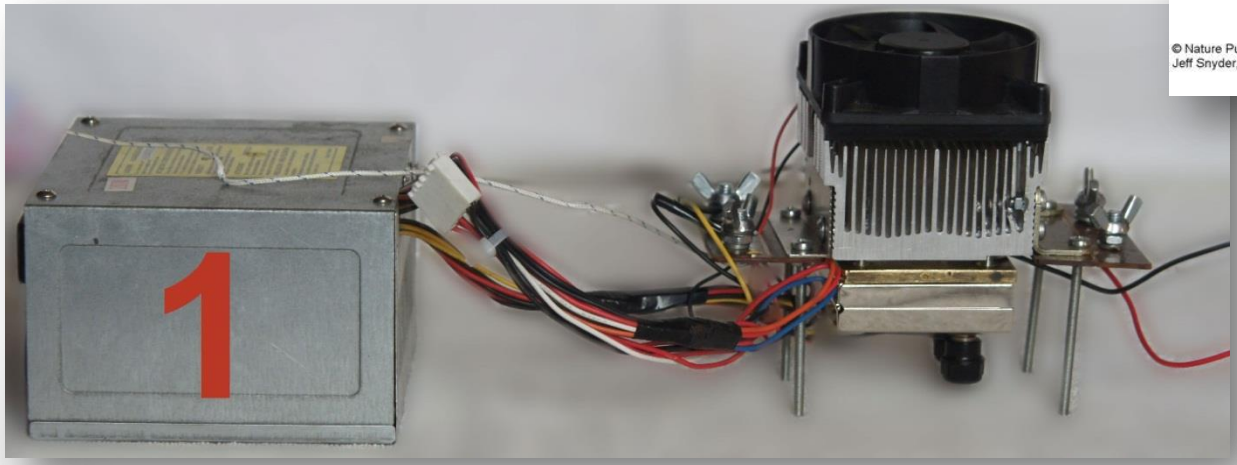


comp_dft_young.mp4

Material – TEM - TEG







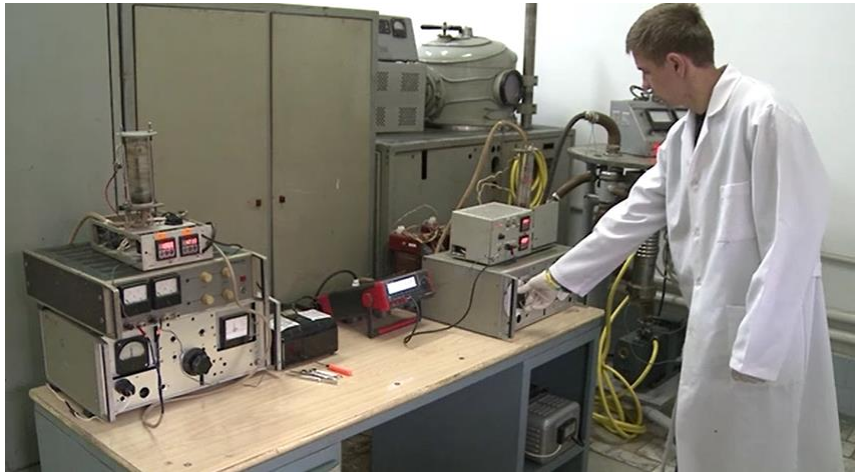
Material – TEM - TEG

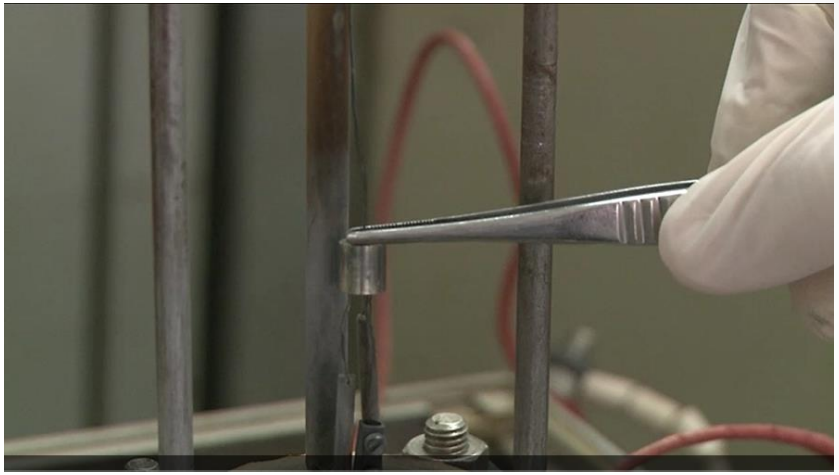
Synthesis of thermoelectric materials

Mill and pressing of thermoelectric materials

Material – TEM - TEG

Measurement of thermoelectric parameters (materials & thermocouples)





Material – TEM - TEG

Measurement of thermoelectric parameters (modules)

Material – TEM - TEG

Application of end thermoelectric device (generator)

NATO OTAN
This project is supported by: The NATO Science for Peace and Security Programme

End-users

TES Thermoelectric Systems Ltd. (Turkey)

Production Company ‘Karpaty’ (Ukraine)

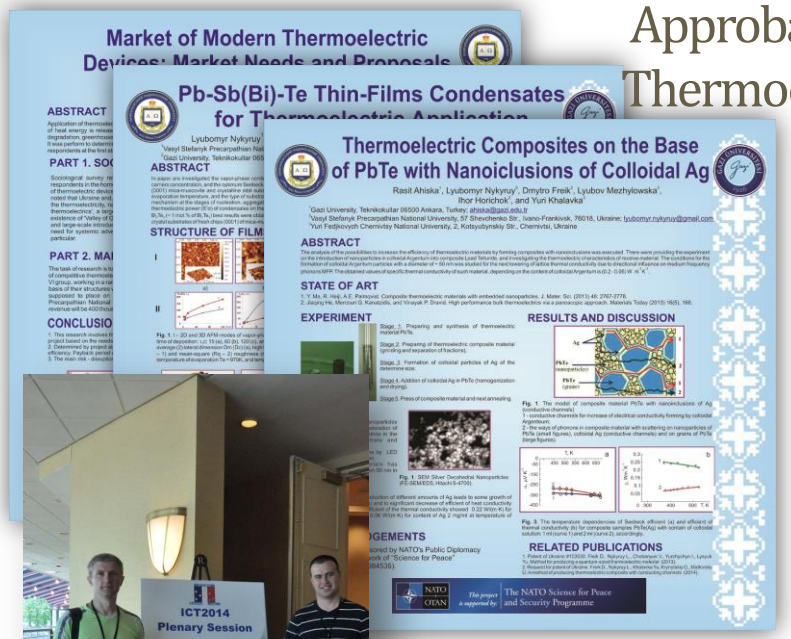
NATO OTAN
This project is supported by: The NATO Science for Peace and Security Programme

End-users and life after project

Science Park
Precarpathian University

teknopark ankara
"Teknolojinin Başkenti"

Dessimination



Approbation: International Conference on Thermoelectric ICT2014, Nashville, TN, USA

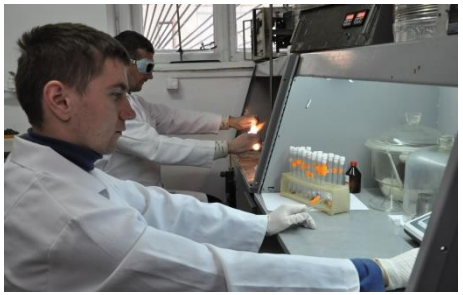
International Conference on Thermoelectric ICT2015, Drezden, Germany

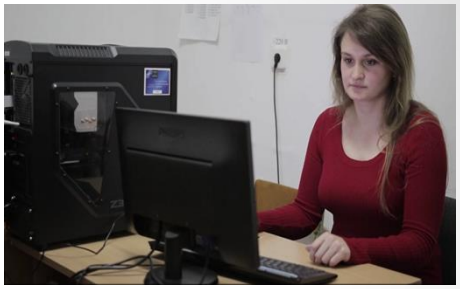
Training of young scientists :

Rzeszow, Poland (2014, 2015)

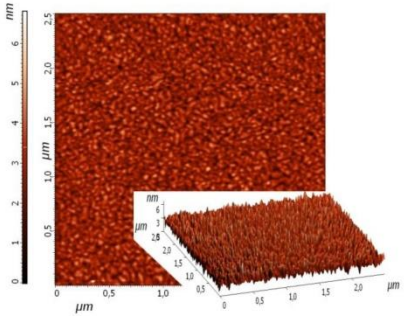
Ankara, Turkey

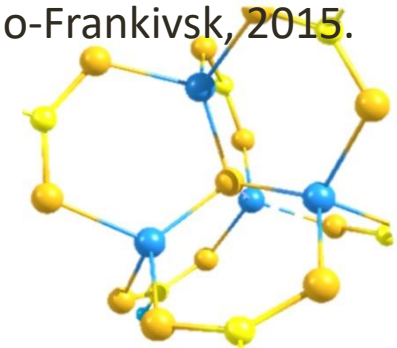
Young scientists





Statistics:
9 students, 11 PhD-students
2 PhD theses:
- Chaviyak I.I. Growth processes, structure and transport phenomena in Tin Telluride vapor-phase nanocondensates. Ivano-Frankivsk, 2015.





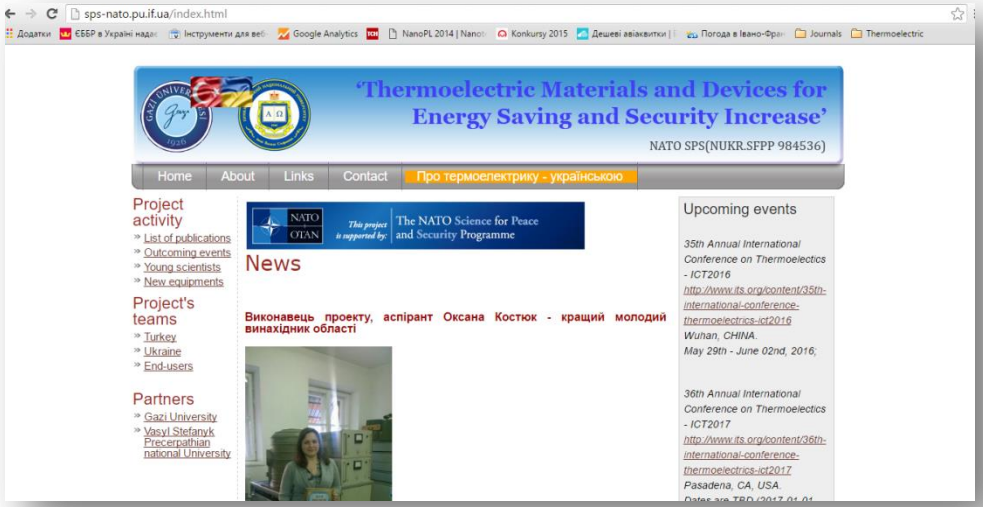
- Parashchuk T.O. Thermodynamic properties of II-VI chalcogenide crystals: modeling and calculation. Chernivtsi, 2015.

CNM-4'2015 (Uzhgorod, 2015)

PNU first start-up call (Ivano-Frankivsk, 2015)

Oksana Kostyuk – best young inventor in Ivano-Frankivsk region, 2016

Visibility & Devices



NATO SPS (G4536)

http://sps-nato.pu.if.ua/

Muffle furnace Nabertherm, L 15, (Germany, 4 784 EURO)

Vacuum post HiCube (Austria, 7 004 EURO)

Approbation : patents and papers

- **Patent of Ukraine N**103530. **The method of receiving of the quantum-sized thermoelectric material**. Freik D.M., Nykyruy L.I., Chobanyuk V.M., Yurchyshyn I.K., Lysyuk Yu.V. Appl.#a201114629. Date: 25.10.2013. Bul. №20/2013.

- Appl. on the patent of Ukraine. **The method of receiving of the thermoelectric composite material PbTe with nanoinclusions of Ag.** Freik D.M., Nykyruy L.I., Horitchok I.V., Khalavka Yu.B. (under revision).

I. Horichok, R. Ahiska, D. Freik, L. Nykyruy, S. Mudry, O. Matkivskiy, T. Semko, ***Journal of Electronic Materials***, 2015, Doi: 10.1007/s11664-015-4122-9
http://link.springer.com/article/10.1007%2Fs11664-015-4122-9#/page-1
Gorichok I.V., Fochuk P.M., Verzhak Ye.V., Parashchuk T.O., Freik D.M., Panchuk O.E., Bolotnikov A.E., James R.B.. Compensation mechanism of bromine dopants in cadmium telluride single crystals / ***Journal of Crystal Growth***. – 2015. –V. 415. pp. 146–151.
http://www.sciencedirect.com/science/article/pii/S0022024814007647
Freik D., Parashchuk T., Volochanska B. Thermodynamic parameters of CdTe crystals in the cubic phase., ***Journal of Crystal Growth***, 2014, 402, 90-93
http://www.sciencedirect.com/science/article/pii/S002202481400339X.
Ahiska R., Freik D., Parashchuk T., Gorichok I. Quantum chemical calculations of the polymorphic phase transition temperatures of ZnS, ZnSe, and ZnTe crystals // ***Turkish Journal of Physics***, 2014, 38, 125-129
http://journals.tubitak.gov.tr/physics/issues/fiz-14-38-1/fiz-38-1-15-1301-7.pdf.
Freik D.M., Mudryi S.I., Gorichok I.V., Dzumedzey R.O., Krunutcky O.S., Lyuba T.S. Charge carrier scattering mechanisms in thermoelectric PbTe:Sb // ***Ukr. Journ. of Phys.***, 2014, 59(7), 706-711
D. Freik, M. Galushchak, L. Nykyruy, I. Horichok, O. Matkivsky, Y. Khalavka. Thermoelectric Composites on the Base of PbTe with Nanoiclusions of Colloidal Silver. ***Journal of Nano- and Electronic Physics***, 2015, 7(4), 004-1-04004-5
http://jnep.sumdu.edu.ua/

Approbation : testing in critical weather

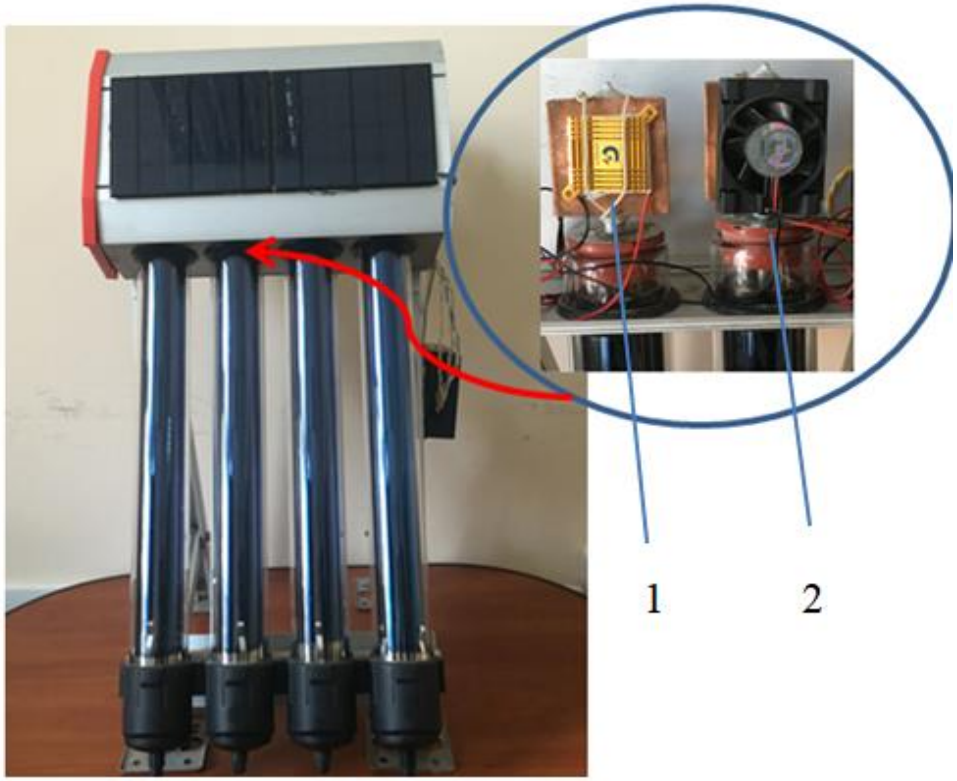


Рис. 1. Фотографія сонячного термо-електричного генератора. На вкладці зображено фото вмонтованого модуля (1) та системи охолодження (2).

Thank you for attention!

Dr. Lyubomyr Nykyruy,
Project director from Ukraine,
PhD in Physics, Docent,
Vasyl Stefanyk
Precarpathian National University,
Shevchenko Str. 57, Ivano-Frankivsk,
76018, Ukraine

+38(095)6991785
lyubomyr.nykyruy@gmail.com

Dr. Rasit Ahiska,
Project director from Turkey,
Dr. Sci. in Physics, Prof.,
Gazi University,
Ankara, Turkey

ahiska@gazi.edu.tr

http://sps-nato.pu.if.ua/