SPS INFORMATION DAY

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

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

Thermoelectric: Cheap and Safe Energy

May 27, 2016,
Kyiv, Ukraine

Project teams

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]

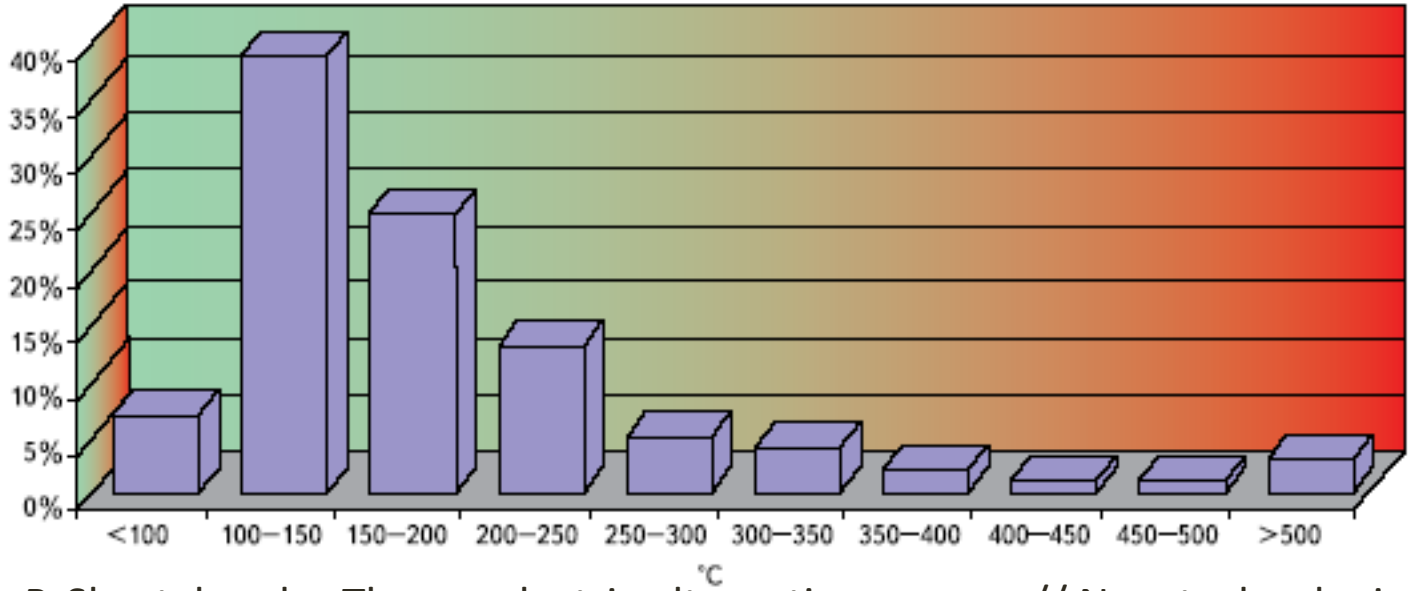
Duration: **24 month**

Project participants:

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

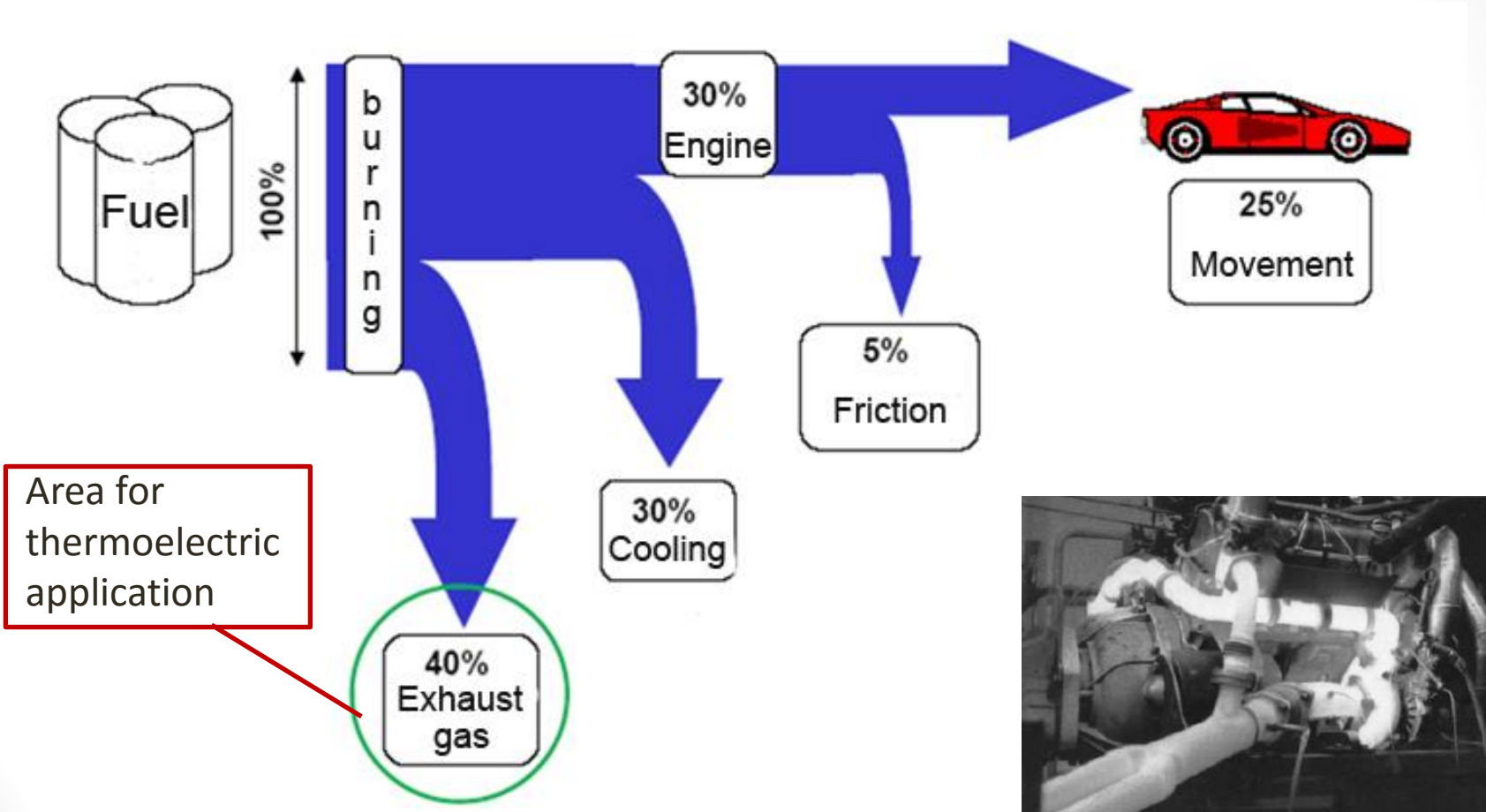
Budget			
By participants		By Category (**Ukraine**)	
Turkey	€ 80 000	Equipment	€ 105 000 (65%)
Ukraine	**€ 159 000**	Training/Stipends	€ 22 000 (13.5%)
		Implementation	€ 32 000 (20%)
NATO Total Funding			**€ 239 000**
Non-NATO Funding			€ 80 000

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

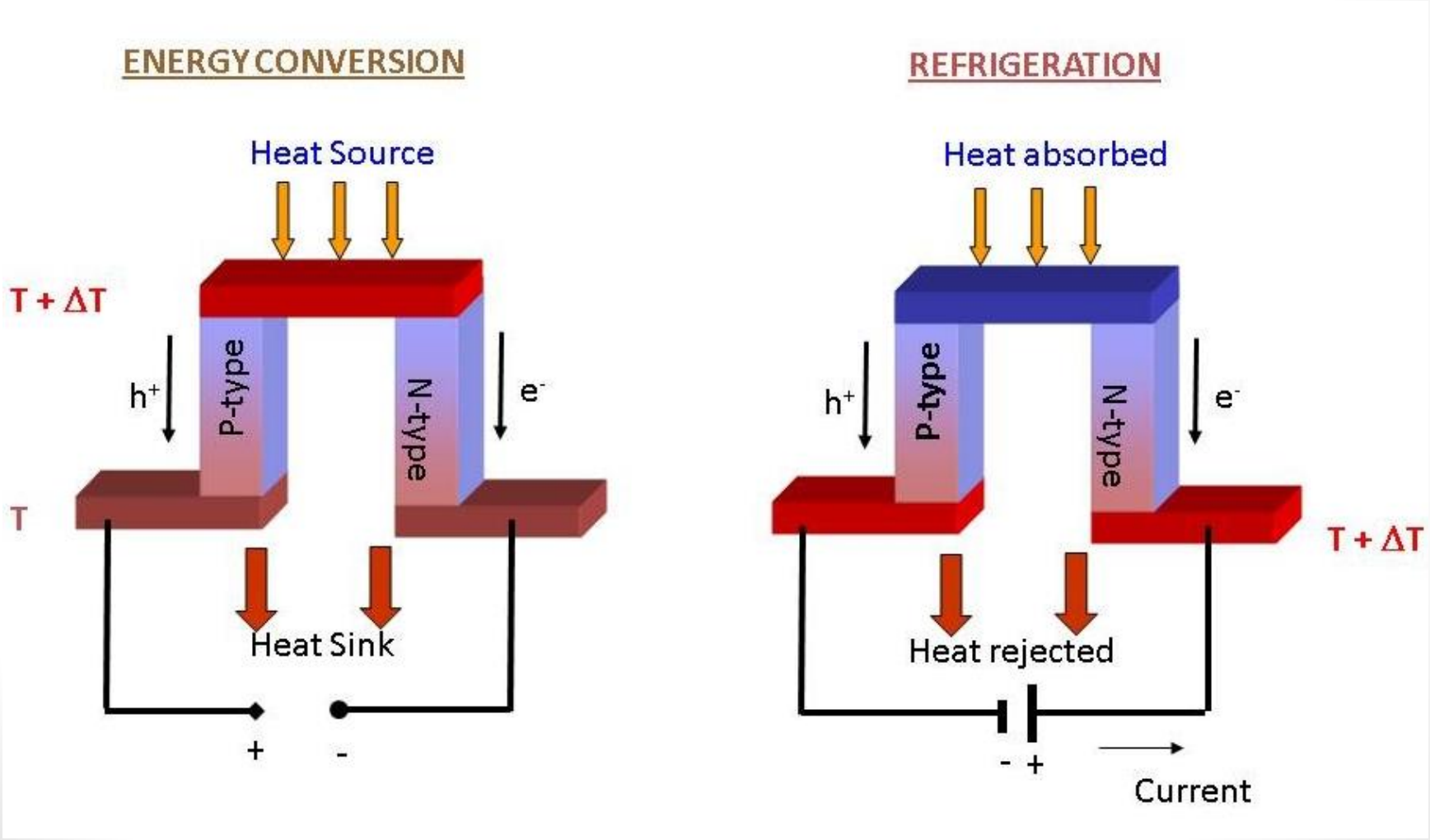
Chevrolet Suburban

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

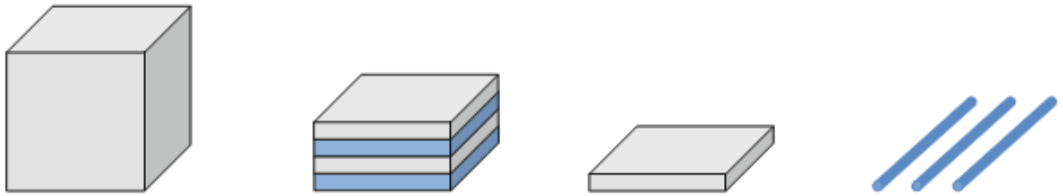
TE-cooling for medicine; mini-refrigerators

State of Art: Materials

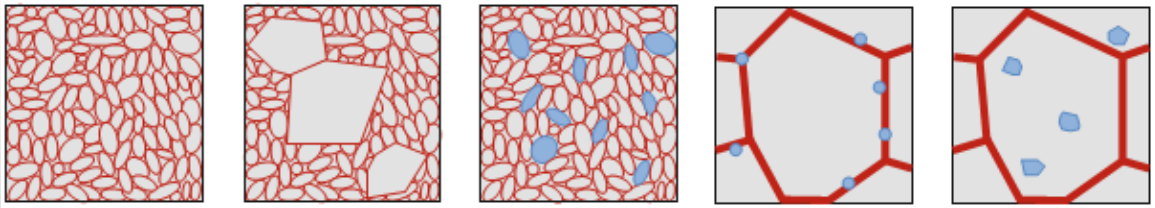
$$ZT = S^2\sigma/\chi$$ - Figure of merit of TE-mterials

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

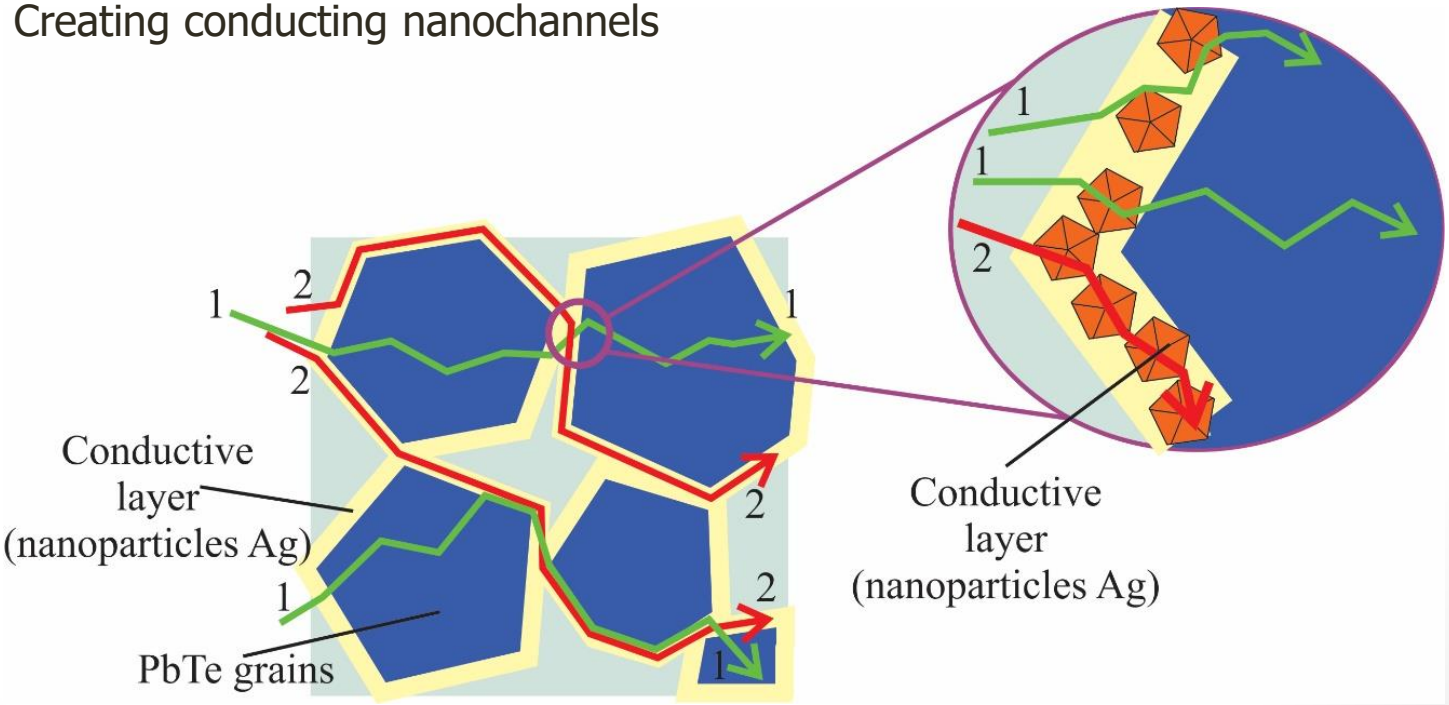
Theoretical approaches

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:

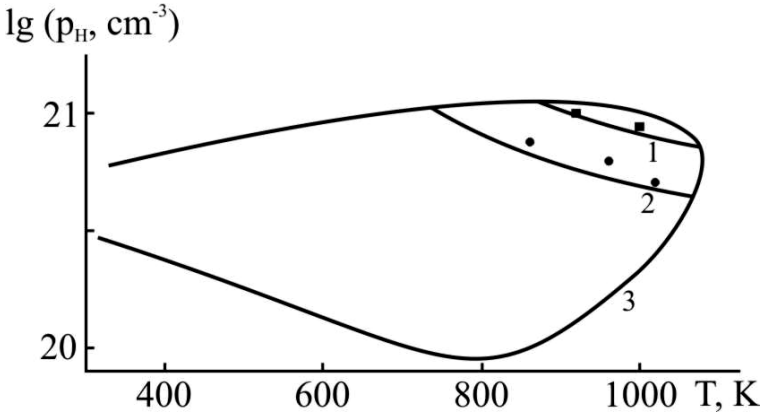
- Creating conducting nanochannels

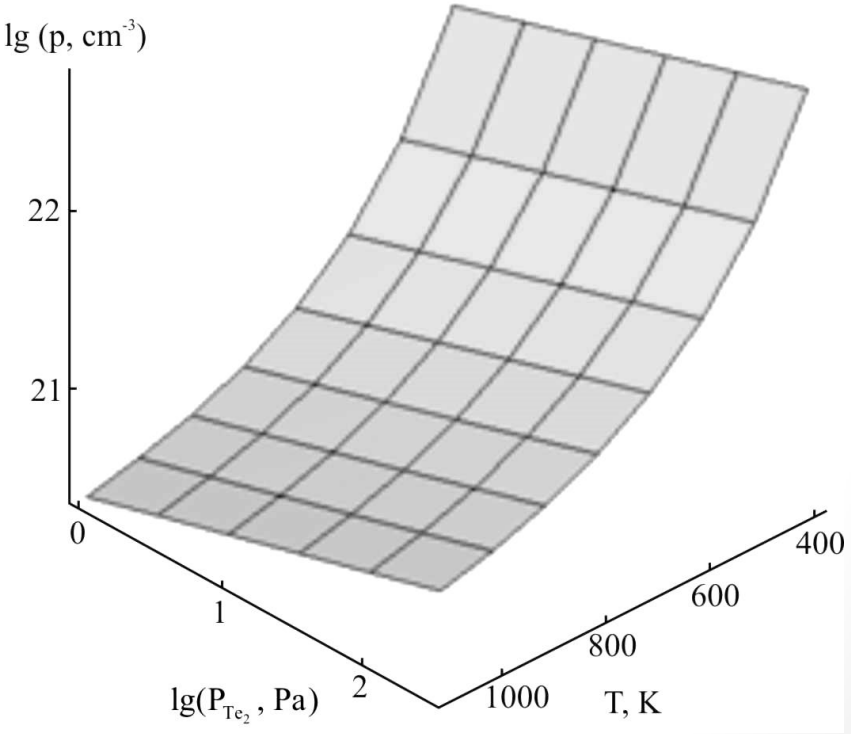


Novelty of the project : Material Science

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.

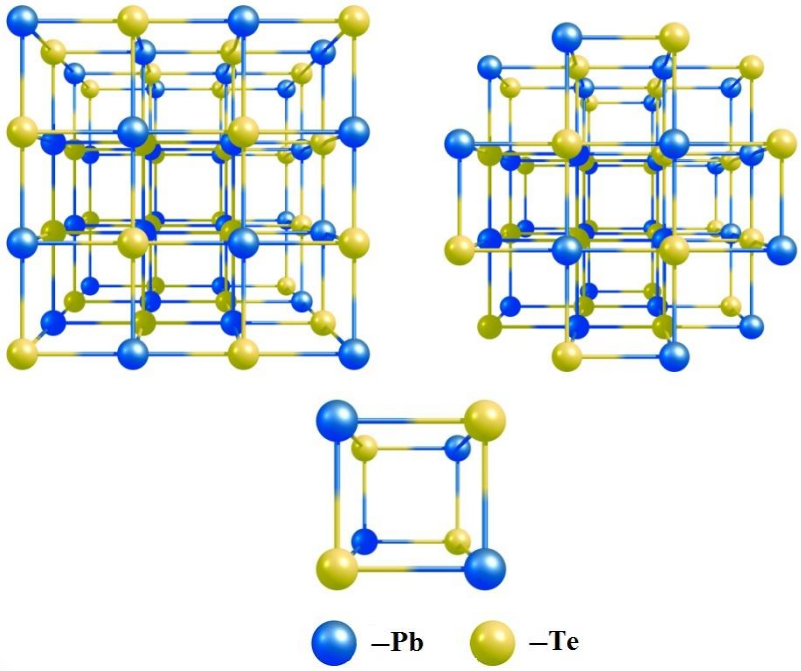


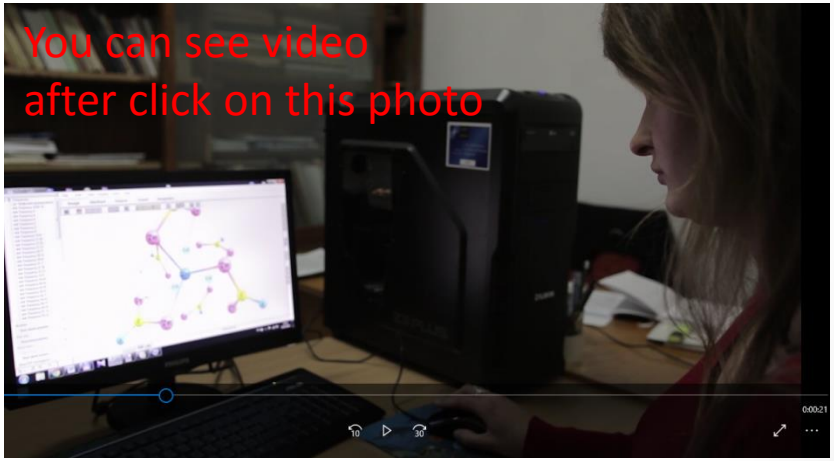


Novelty of the project : Material Science

Theoretical approaches

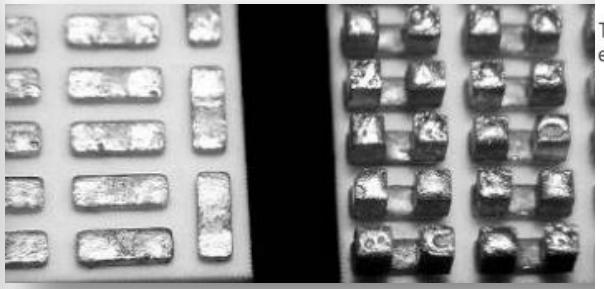
3. Development of DFT-calculation (*ab initio* or quasi-chemical calculation) to obtain of thermodynamics and crystal properties.

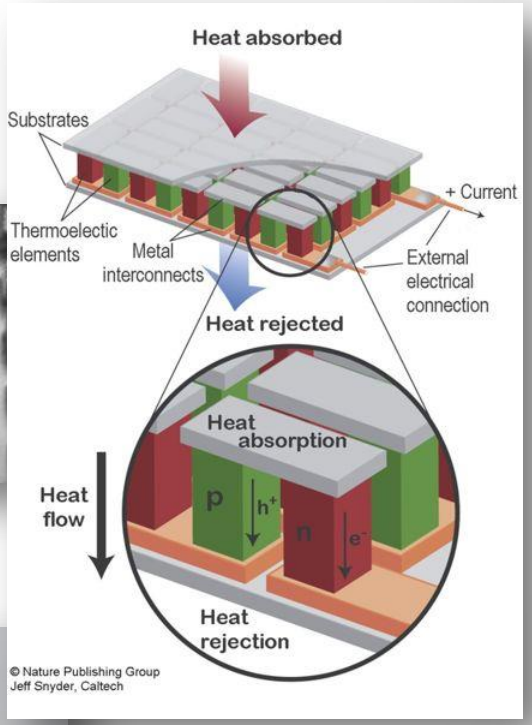


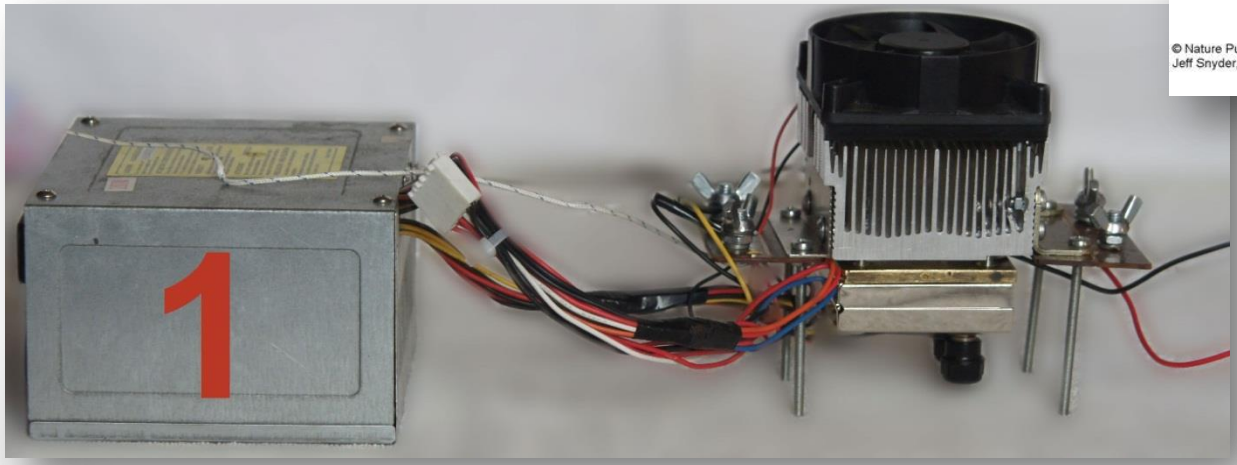


Modeling by young scientists
(DFT-calculation)

Material – TEM - TEG







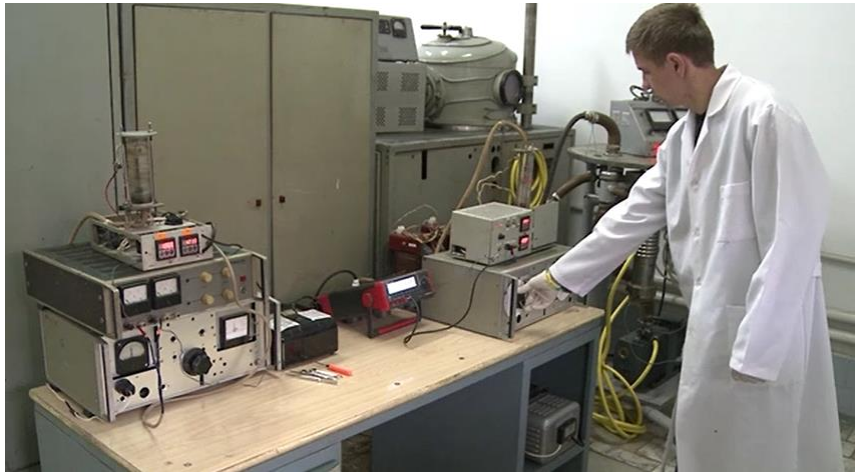
Material – TEM - TEG

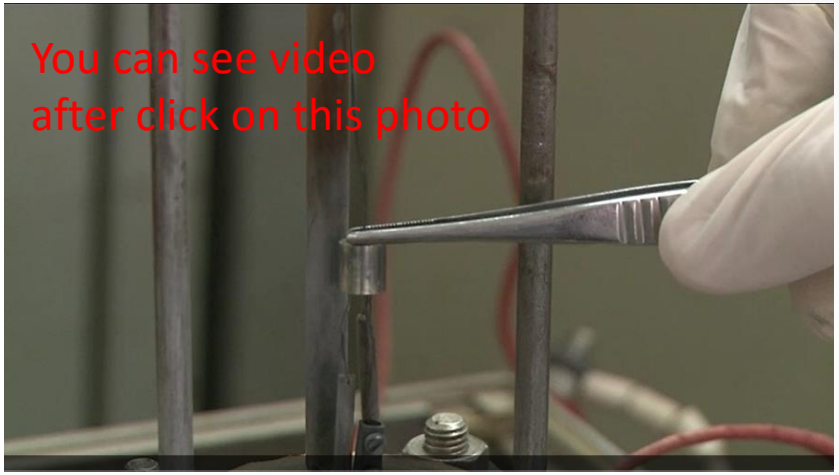
Synthesis of thermoelectric materials

Mill and pressing of thermoelectric materials

Material – TEM - TEG

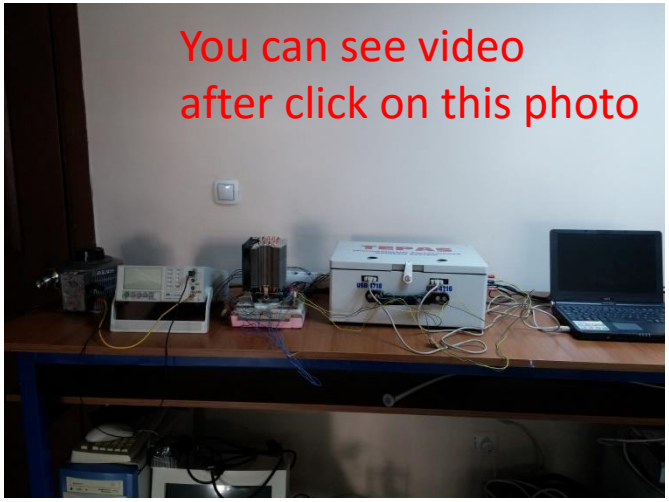
Measurement of thermoelectric parameters (materials & thermocouples)





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)

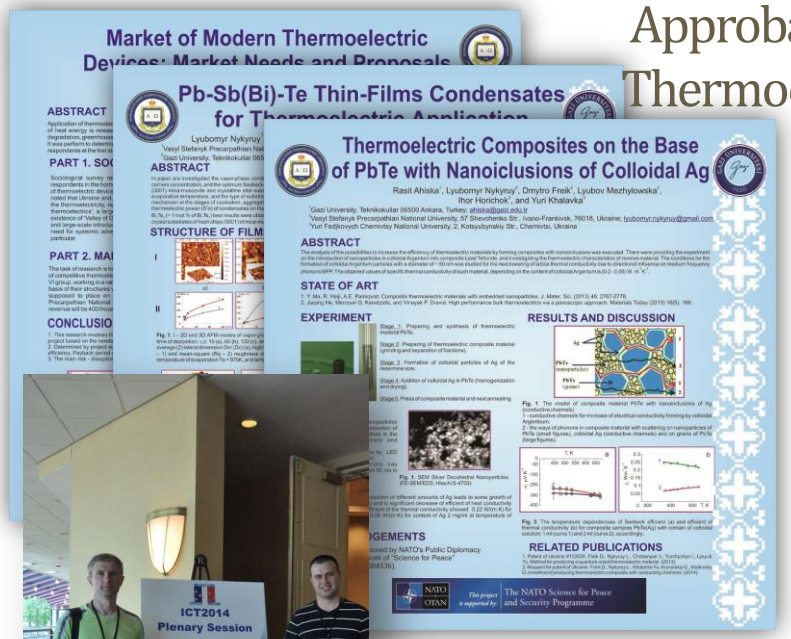
NATO OTAN
This project is supported by: The NATO Science for Peace and Security Programme

End-users and life after project

Science Park
Precarpathian University

teknopark ankara
"Teknolojinin Başkenti"

Dessimination



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

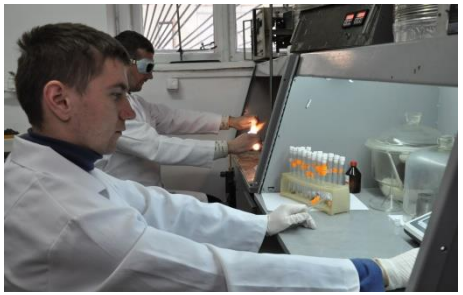
Training of young scientists :

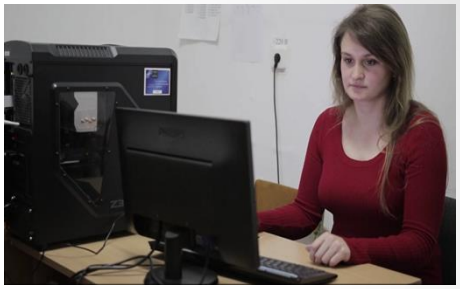
Rzeszow, Poland (2014, 2015)

International Conference on Thermoelectric ICT2015, Drezden, Germany

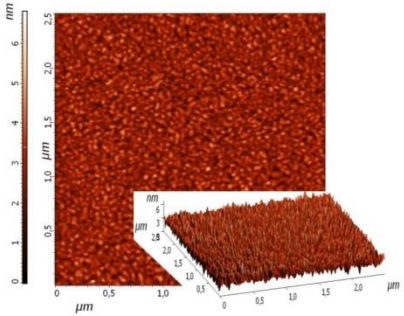
Ankara, Turkey

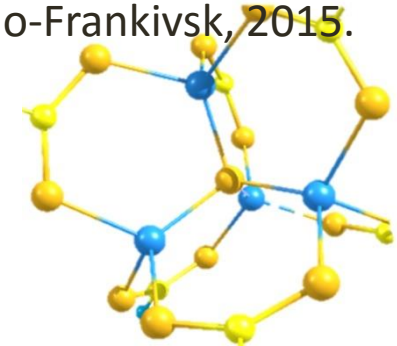
Young scientists





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.

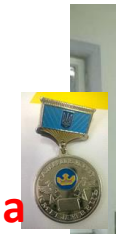




- Parashchuk T.O. Thermodynamic properties of II-VI chalcogenide crystals: modeling and calculation. Chernivtsi, 2015.

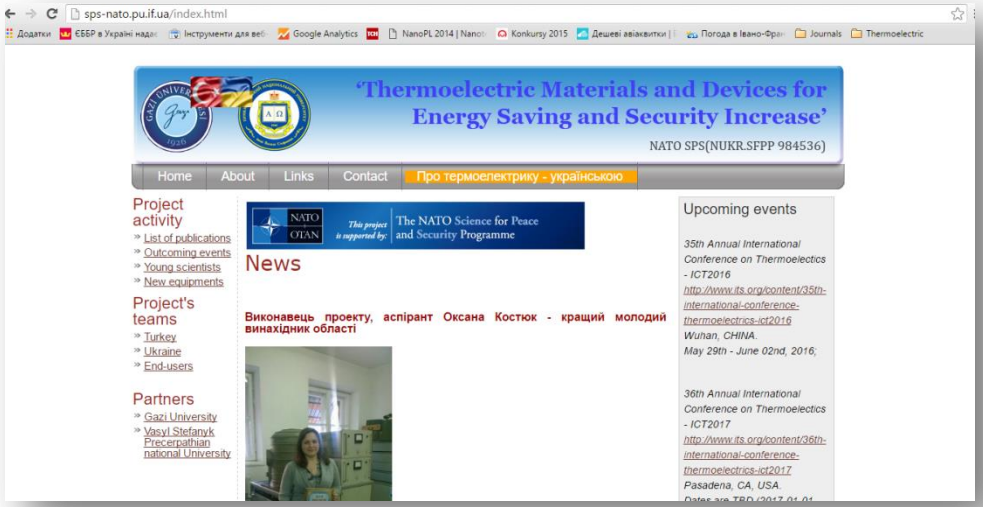
CNM-4'2015 (Uzhgorod, 2015)

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)

Devices

Planetary ball mills, Pulverisette 6 (Germany, 11 883 EURO with **analytical sieve shaker RETSCH AS 200** (3 980 EURO)

Hardness tester NEXUS 412A (Germany, 19 083 EURO)

Pure water system Smart2Pure (Germany, 6 270 EURO)

Auto pellet press 25 ton (USA, 19 999 EURO)

Circular cutting Cutting Micracut 201 (Germany, 18 252 EURO with Special Stand with rotation, 7 411 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/

Thank you for attention!

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