Subject: Thermoelectric technologies for power generation, cooling and sensor applications

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Abstract (max 150 words):

The Thermoelectric Research Laboratory (TRL), Faculty of Materials Science and Ceramics at AGH, has been at the forefront of semiconductor material and technology development for many years, with a particular focus on energy conversion. The team has developed new thermoelectric materials for direct heat-to-electricity conversion and thermoelectric cooling, a technology for manufacturing TE converters for low-parameter waste heat recovery, as well as innovative designs of prototype devices, including a Scanning Thermoelectric Microscope for analyzing the distribution of hydrogen content in steel.

The TRL team has developed thermoelectric components (TE modules) and devices with applications in a number of fields, including power systems and thermoelectric cooling for IoT-type electronic devices, as well as, the construction of large energy devices such as solid-state heat pumps and thermoelectric cogeneration systems for power generation and waste heat recovery.

Further information can be found on the TRL website: http://www.thermlab.agh.edu.pl/

Related founding (last 5 years):

- IMPRESS-U NAWA, BNP/NSF/2023/1/00010/DEC/01, „*Decoupling Structure and Composition with Zintl Phases*, National Agency for Academic Exchange, Partners: Michigan State University, University of Lviv, (2024-2026), ~ 250 000 USD
- OPUS-2023/51/B/ST11/00329/R, „*Diamond-like semiconductors as low-cost thermoelectric materials for direct conversion of waste heat into electricity*", National Science Centre (2024-2027) ~ 180 000 USD
- MAITEG, WEAVE-UNISONO 2022/04/Y/ST5/00139, „*Entropy engineering and interface optimization in materials for highly effective thermoelectric energy conversion*", National Science Centre and German Research Foundation, Partners: German Aerospace Institute (DLR) and University of Duisburg-Essen (UDE), (2024-2027), ~500 000 USD
- PRELUDIUM-21/2022/45/N/ST5/02070 „*Relationship between structural and thermoelectric properties in Cu_6Te_3S and $Cu_{9,1}TeSb_3$ based materials with close-packed tetrahedra structure*" (2023-2025), ~60 000 USD

- DIAMANT GRANT, 0025/DIA/2020/49, *„Organic Peltier Elements based on Conducting Polymers", Ministry of Science and Higher Education* (2020-2024), ~60 000 USD
- TEAM-TECH/2016-2/14, *„New approach for the development of efficient materials for direct conversion of heat into electricity"*, Foundation for Polish Science (2018-2022), ~ 900 000 USD
- TECHMATSTRATEG2/408569/5/NCBR/2019, *„Development of a technology for the production of a new type of thermoelectric modules for the conversion of low-parameter waste heat into electricity"*, National Centre for Research and Development (2019-2022), ~2 500 000 USD

and other international, national and R&D projects with several industrial partners such as: Collins Aerospace Poland, EDF Poland, Synthos, Honda, General Electric Poland and others.

Related publications:

1. Taras Parashchuk, Bartłomiej Wiendlocha, Oleksandr Cherniushok, Kacper Pryga, Kamil Ciesielski, Eric Toberer, Krzysztof T. Wojciechowski, *Multiple defect states engineering towards high thermoelectric performance in GeTe-based materials*, Chemical Engineering Journal, 499 2024, s. 1-15.
2. Maja Sajdak, Janusz Toboła, Taras Parashchuk, Maciej Krzywiecki, Paulina Powroźnik, Krzysztof T. Wojciechowski, *Probing hydrogen content in steel using the thermoelectric effect,* Chemical Engineering Journal ; 485, 2024

3. Oleksandr Cherniushok, Taras Parashchuk, Raul Cardoso-Gil, Yuri Grin, Krzysztof T. Wojciechowski *Controlled phonon transport via chemical bond stretching and defect engineering: the case study of filled -Mn-type phases*, Inorganic Chemistry ;— vol. 63,39 2024 iss. 39,
4. A. Lis, K. Zazakowny, O. Cherniushok, J. Tobola, M. Gajewska, T. Parashchuk, K.T. Wojciechowski, *Nanostructured $Cu_{12+x}Sb_4S_{13}$ tetrahedrites prepared by solvothermal synthesis in 1-(2-aminoethyl)piperazine for efficient thermal energy harvesting*, J. Alloys Compd., 977, 173337 (2024) IF 6.2, DOI: 10.1016/j.jallcom.2023.173337
5. R. Knura, M. Maksymuk, T. Parashchuk, K.T. Wojciechowski, *Achieving high thermoelectric conversion efficiency in Bi_2Te_3-based stepwise legs through bandgap tuning and chemical potential engineering*, Dalton Trans., 53, 123-135 (2024). DOI: 10.1039/D3DT03061J
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7. T. Parashchuk, O. Cherniushok, O. Smitiukh, O. Marchuk, K.T. Wojciechowski, *Structure Evolution and Bonding Inhomogeneity toward High Thermoelectric Performance in $Cu_2CoSnS_{4-x}Se_x$ Materials*, Chem. Mater., 35(12), pp. 4772–4785 (2023).
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11. O. Cherniushok, O. Smitiukh, J. Tobola, R. Knura, O. Marchuk, T. Parashchuk, K.T. Wojciechowski, *Crystal structure and thermoelectric properties of novel quaternary $Cu_2MHf_3S_8$ (M – Mn, Fe, Co, Ni) thiospinels with low thermal conductivity*, Chem. Mater., 34, 5, 2146–2160 (2022).
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2. Krzysztof Wojciechowski, Taras Parashchuk, Mykola Maksymuk *Thermoelectric Converter Based On Functionally Graded Materials* PL444240A1 ; 2023-03-29, EP4440287a, 23-08-11
3. Wojciechowski Krzysztof, Parashchuk Taras, Cherniushok Oleksandr *Gamma-Argyrodite Structure Material For Thermoelectric Conversion And The Method Of Obtaining The Same*; EP4292982A1 ;. 2023-12-20.
4. Krzysztof Wojciechowski *Method For Control Of Energy Flow In A Thermal Object, In Particular A Chemical Reactor* PL243914B1 ; 2023-08-08
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