Thermoelectric transducers based on 2D atomic monolayers

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Abstract (300 word limit)

Statement of the Problem: Using the 2D atomic monolayer materials helps fulfill a growing demand in efficient, stable, and flexible energy sources that are not tied to electric outlets or gas stations. The distributed and long lasting equipment requires reliable power supply ensuring the stable functionality during months or years. Examples are the autonomous vehicles including electric cars, whose driving range is limited by the battery capacity, and relies on the top-up at the stationary electric outlets. Ensuring the flawless functionality of the mentioned systems represents an important issue. However, currently available batteries and PV panels frequently fail to ensure the required steady power supply to the critical pieces of equipment.

We develop highly efficient thermoelectric generators (TEG) based on the heat flux transistors made of the 2D atomic monolayers like graphene, transition metal dichalcogenides and black phosphorus, which are characterized by the high figure of merit ZT ~ 10 that is far above the values reported for other known systems [1]. Our preliminary work involved carbon nanotube TEG with nanoscale dimensions [2-7]. Basic idea comprises the thermoelectric effect taking place in the TEG cell composed of two the 2DM heat flux transistors connected electrically in sequence and thermally in parallel. The small size and high efficiency allow using such the TEG devices in variety of applications requiring the autonomous electric power supply. Microscopic mechanisms of the thermal and electric transport in our heat flux transistors are governed by the local and global gates with applying appropriate electric potentials.

Conclusion & Significance: This enables controlled conversion between the electric current and the heat flux. The TEG devices are destined to fulfill an emerging and strong demand for stable, long-lasting, compact, light-weight and reliable sources of energy harvesters receiving the electricity from a variety of sources like sunlight, waste heat, etc.

Recent Publications

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[4] Shafraniuk, S.E., Reversible heat flow through the carbon tube junction. Epl, 2009. 87(5).

[5] Shafraniuk, S.E., Converting heat to electricity by a graphene stripe with heavy chiral fermions. European Physical Journal B, 2014. 87(4).

[6] Shafraniuk, S.E., Quantized magneto-thermoelectric transport in low-dimensional junctions. Epl, 2015. 109(6).

[7] Shafraniuk, S.E., Graphene thermal flux transistor. Nanoscale, 2016. 8(46): p. 19314-19325.

[8] T. Gupta, I.P.N., V. Chandrasekhar, S. Shafraniuk, Transduction between electrical energy and the heat in a carbon nanotube using a voltage-controlled doping. 2016. arXiv:1611.03040 [cond-mat.mes-hall].



Biography

Serhii Shafraniuk has completed his PhD at the age of 26 years from T. Shevchenko National University of Kyiv, and postdoctoral studies from University of Regensburg (Germany) and University of Nijmegen (the Netherlands). Among his interests were unconventional materials like metal oxides with atomic multilayered structure and novel 2D atomic monolayers. From 1990 to 2001, Serhii had been working in various leading research centers in Germany, the Netherlands, and Japan. Before his work in Tegri LLC, Serhii was a Research Professor at the Northwestern University (2001-2017, Evanston IL), Institute of Magnetism ASU (1999-2001), Research Institute for Electrical Communications, Tohoku University (Sendai, Japan, 1995-1999). Dr. Shafraniuk was a recipient of numerous prestigious awards including the DAAD award (Germany), the FOM/NWO award (the Netherlands), the COE award (government of Japan) and the US Navy NICOP award (USA). He has published books, more than 110 papers in reputed journals and organized International Conferences.

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