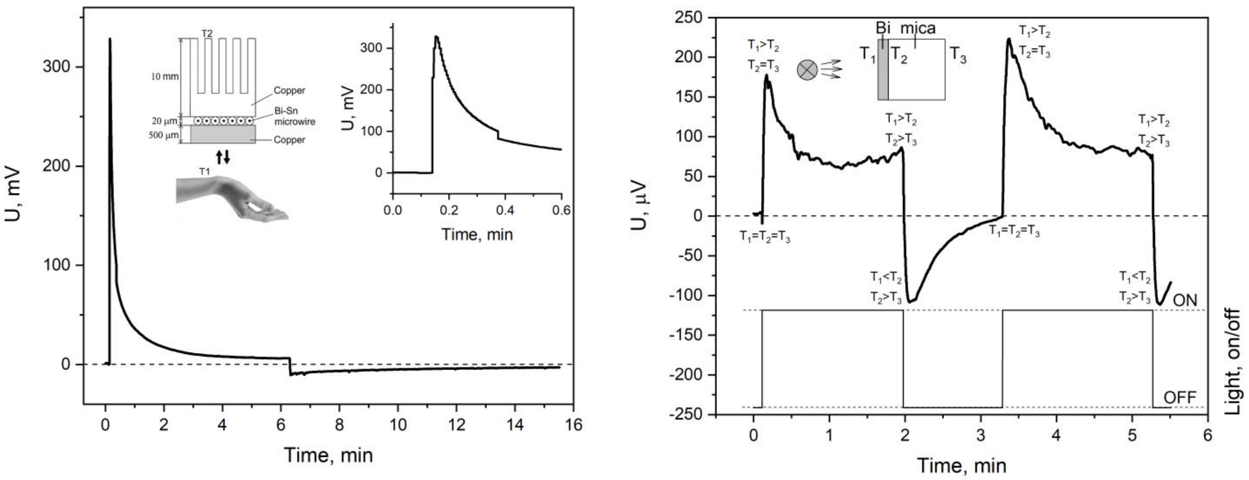
ANISOTROPIC THERMOELECTRIC DEVICES BASED ON SINGLE-CRYSTAL Bi MICROWIRES AND FILMS

L. A. Konopko[1,*], A. A. Nikolaeva[1], T. E. Huber[2], D. Shiversky[1]
[1]*Technical University of Moldova, "D.Ghitu" Institute of Electronic Engineering and Nanotechnologies, Chișinău, Republic of Moldova;*
[2]*Howard University, Washington, DC, USA*
[*]E-mail: leonid.konopko@iien.utm.md

Here, we present a demonstration of an unconventional thermoelectric energy conversion that is based on a single element made of an anisotropic material. In such materials, a heat flow generates a transverse thermoelectric electric field lying across the heat flow. A feature of anisotropic thermoelectrics is that the thermoelectric voltage is proportional to the element length and inversely proportional to the effective thickness. We have prepared an experimental sample consisting of a 10-m-long glass-insulated single-crystal tin-doped bismuth microwire (*D*=20 µm, *d*=4 µm) [1,2]. Crucial for this experiment is the ability to grow the microwire as a single-crystal using a technique of recrystallization with laser heating and under a strong electric field. The sample was wound as a spiral, bonded to a copper disk, and used in various experiments. The sensitivity of the sample to heat flow is as high as 10^{-2} V/W with a time constant s of about 0.5 s. Polycrystalline Bi films with a thickness of 2-5 µm were deposited on the mica support by the vacuum thermal evaporation method. Experimental samples of heat flux sensors were made on the basis of recrystallized Bi films under laser heating and in a strong electric field.



(a) (b)

Figure 1. (a) Dependence of the output voltage of the heat flux sensor based on 10-m-long glass-insulated single-crystal Bi–0.05 at % Sn microwire (D=20 µm, d=4 µm) on the time of contact with a human hand; (b). Dependence of the output voltage of the heat flux sensor based on the recrystallized Bi film (d=3 µm) deposited on a mica substrate on the time of illumination with an MBS-9 illuminator.

The dynamics of voltage changes at the output of the developed heat flux sensors during the registration of modulated heat fluxes (see Fig. 1) can be explained in the limit of the theory of an anisotropic thermoelement.

ACKNOWLEDGMENTS: This work was supported by the Ministry of Education and Research of R. Moldova within the program no. 020201 in Moldova. In the U.S., the work was sponsored by the U.S. National Science Foundation STC Center for Integrated Quantum Materials, Grant 1231319, The Boeing Company, and the Keck Foundation.

[1] L. Konopko, A. Nikolaeva, A. Kobylianskaya, T. Huber. *J. Electron. Mater.* **47** (2018) 3171-3176.
[2] L. Konopko, A. Nikolaeva, T. Huber, A. Kobylianskaya. *Semiconductors* **53** (2019) 662–666.