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***BRIEF PAPER***

# LOCAL (NANO) THERMOELECTRIC EFFECTS

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**Abstract.** Nano-effects, effects omitted between atomic and macroscopic, arise at different scales for different effects. For the Seebeck and Peltier diffusion thermoelectric effects, the upper boundary is naturally determined by the mean free path of the electrons. And the technology has long passed the boundary of diffuse thermoelectricity. So, in modern semiconductor structures and devices, it is necessary to take into account ballistic effects that arise at potential barriers, the research of which is devoted to the author's series of works. The paper also noted a range of promising applications of such effects, called local thermoelectric effects in accordance with the local entropy production allowing them to exist, introduced by Ilya Prigozhin.

**Keywords**: nano-scale, electron mean free path, local entropy production, local Thermo-EMF.
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## 1 Odiffuse - direct thermoelectric energy conversion

The thermoelectric Seebeck effect and the inverse electrothermal Peltier effect allowed Onsager to lay down the principles of non-equilibrium linear thermodynamics on the basis of which all heat engines in general work: generators, heat pumps and refrigerators (Ordin & Wang, 2011; Ordin, 2012, 2015). In particular, both microgenerators and heat receivers have a detecting ability specified by the Carnot cycle. However, thermoelectricity itself, originally declared as a direct energy conversion, has long reached the maximum efficiency, which is not only lower than the theoretically achievable through the Carnot cycle (Ordin, 2017a, 2018a), but about 3 times lower than the efficiency of the same internal combustion engine (ICE), converting heat energy into electrical energy indirectly, previously into mechanical energy. The thing is that the Seebeck and Peltier effects used in thermoelectricity are diffuse, i.e. indirect, due to the friction of electrons on the crystal lattice (Ordin, 2017b, 2018b). Those. their efficiency is somewhat higher than the extraction of electricity from a comb when combing, but is related by the method of indirect transformation. While still in the design of the first semiconductor devices, Tauz drew attention to the giant thermopower, which, since they did not fit into the diffuse theory, were attributed to the category of "anomalous" (Ordin, 2018c,d). Not the "anomaly", but the locality of thermo-EMF in semiconductor microstructures is determined not by their diffuse, but by barrier character and, accordingly, their gigantic EMF. As was shown in the above-mentioned works on silicon structures and confirmed in wide-gap semiconductors (Ordin et al., 2017), the currents of these thermo-EMFs are in no way negligible, which ensures, given the huge EMF, high conversion efficiency and their practical application. In particular, in view of the advantages presented below, they allow the creation of detectors on their basis to replace

standard thermal detectors based on diffuse thermoelectric effects (Ordin & Shelykalkov, 2012). Tests of mock-ups based on longitudinal and transverse local thermo-EMF have fully confirmed this possibility.

## 2 A list of ideas for using local Thermo-EMF

The ideas of the use of detectors.

1. Widely spectral registration of the image of the environment, transformed into the visible range with the ability to filter colors.
2. Microwave (Crystal) + detector.
3. Two-eyed detector + volume picture.
4. Determination of the coordinates of the source of probe radiation.
5. Replacing detectors in standard systems.
6. Registration of objects in turbid environments.

Ideas for using (micro) coolers.

1.Electronic wind - non-heating, distribution of heat generation.
2. Electronic thermal"tube" - cooling.
3. Internal cooling of detectors.
4. CPU core cooling.
5. Replacing standard coolers.

Ideas for the use of (micro) generators.

1. Autonomous low-noise power supply of microchips and microsystems.
2. Autonomous power supply of probes - elements of the detection system.
3. Replacing standard thermoelectric generators.

Ideas for the use of heat pumps.

1. Thermoelectric "skin" of aerodynamic elements in supersonic and hypersound (both for diagnostics and for increasing the maximum maximum speed
2. Heat shutter for contacts of high-temperature superconductors.
3. Thermotransistor.

At the same time, in thin-film devices based on local thermoelectric effects, there is a significant excess of the "working" local temperature difference over the average temperature, which leads to a large shift of the efficiency maximum to the area of high voltages. So, local thermo-EMF surpass the diffuse by orders of magnitude and become of the same order as the photo-EMF (Fig. 1).

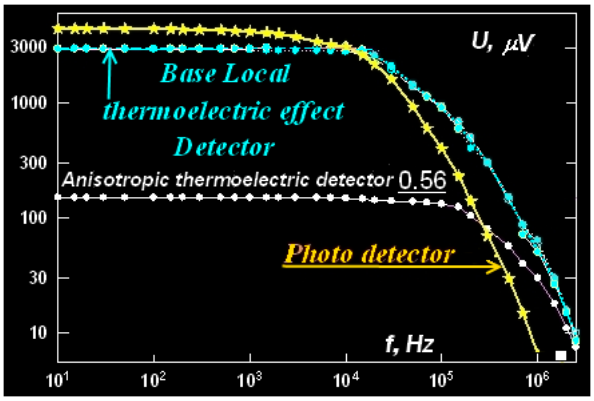


**Figure 1:** Frequency characteristics of the output voltage of the detectors

So with an approximate equality of the volt-watt sensitivity and efficiency (and therefore, detectability) of detectors based on photo-EMF and based on local thermo-EMF, the latter have high sensitivity in a much larger spectral range of wavelengths.

## 3 Instead of a conclusion - the reason for cardinally improvements

Where artisans fought for design improvements for decades and licked traditional designs to the maximum, eliminating PRINCIPAL errors in these designs opened up new possibilities. But the elimination of these errors itself required the proof of the "anomaly" of a number of traditional theories, and not the observed effects (Ordin, 2019). Thus, the thermoelectric effects not described by Joffe's theory, which were considered "anomalous," just correspond to direct energy conversion at potential barriers and allow, in principle, to increase the efficiency by 3 times.

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