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Ferroelectric based multi-type energy-harvesting device to power a mobile medical telemetry system

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We have developed a multilayer converter of heating-deformation-lighting and motion/vibration into electricity for mobile medical telemetry system. The design of the generator is shown in Fig. 1. A composite or ceramic material (2) based on $Sn_2P_2S_6$ powder is applied to the base, for which a thin aluminum plate is used (3). It simultaneously serves as a mechanical base, one of the electrodes of the multi-type transducer and another one of the plates of the triboelectric nanogenerator (TENG) transducer.

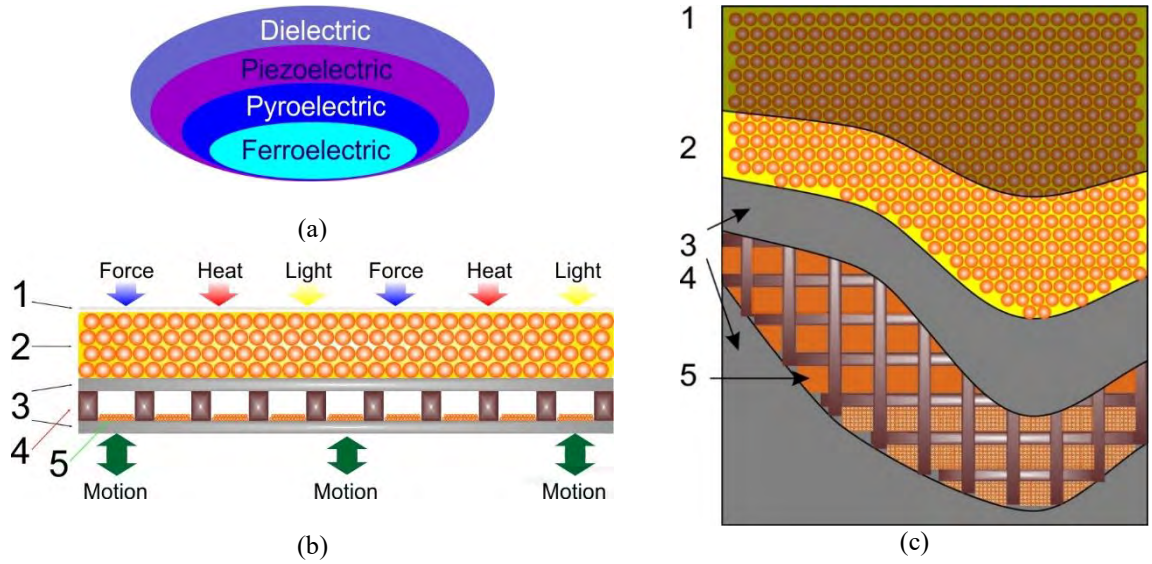

Figure 1 Piezoelectric, pyroelectric and ferroelectric material relationships (a). Sectional drawing (b,c) of a multilayer transformer of deformation-motion-lighting and heating into electric current. 1 - translucent electrode, 2 - composite based on $Sn_2P_2S_6$ powder, 3 - aluminum electrodes, 4 - rubber insulators, 5 - $Sn_2P_2S_6$ powder.

A thin translucent SnO electrode (1) was deposited on top of the composite layer by vacuum deposition. A grid of rubber insulators (4) is glued to the underside of the aluminum base electrode, which forms the elementary cells of TENG. The obtained cells of the triboelectric nanogenerator are 20% filled with $Sn_2P_2S_6$ powder (5), with a particle size of 50-100 micrometers.

During vibrations or movement, these particles rub against each other, forming a charge on the surface of the particles due to the piezoelectric effect as well as to the electrodes, accumulating and transferring the charge due to the triboelectric effect. This combination creates an 180V potential between the electrodes.

A grid of rubber partitions insulates one cell from another, which creates the effect of parallel connection of a large number of elementary generator cells (to increase the output current) and preventing the flowing of active substance from the cell to the cell.

Aluminum was not chosen as an electrode by chance, but based on its position in the triboelectric table [1]. To increase the efficiency of the triboelectric nanogenerator and improve adhesion when applying the composite layer, the aluminum plate is microstructured by etching.

The upper composite layer based on $Sn_2P_2S_6$ microcrystals provides the transformation of deformation/ compression (due to the piezoelectric effect), lighting (due to the photovoltaic effect) and temperature change (due to the pyroelectric effect) to electricity. This ferroelectric semiconductor has a number of unique characteristics. As shown earlier, in order to increase the operating temperature range $Sn_2P_2S_6$ single crystals must be doped with germanium which increases the phase transition temperature by 20 degrees without affecting its electrophysical parameters.

[1] O. Molnar, V. Gerasimov, I.P. Kurytnik, Triboelectricity and construction of power generators based on it, Przeglad Elektrotechniczny, No. 1, pp. 167-171, 2018.

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