Negative Dynamic Resistance and Memristive Effects in Zincite-Tungsten Semiconductor Junction

M. Nowicki[1,*], P. Nowak[2,*], R. Szewczyk[1,*]

[1]*Institute of Metrology and Biomedical Engineering*
Warsaw University of Technology
Boboli 8, 02-525 Warsaw, Poland
* *m.nowicki@mchtr.pw.edu.pl*, * *r.szewczyk@mchtr.pw.edu.pl*
[2]*Industrial Research Institute for Automation and Measurements PIAP*
Al. Jerozolimskie 202, 02-486 Warsaw, Poland
* *pnowak@piap.pl*

The zinc oxide, with its unique physical and chemical properties, such as high chemical stability, high electro-chemical coupling coefficient, broad range of radiation absorption and high photostability, is a truly multifunctional, or 'smart' material. The piezo- and pyroelectric properties of ZnO mean that it can be used as a sensor, converter, energy generator and photocatalyst in hydrogen production. In materials science, zinc oxide is classified as a semiconductor in group II-VI, whose covalence is on the boundary between ionic and covalent semiconductors. A broad energy band (3.37 eV), high bond energy (60 MeV) and high thermal and mechanical stability at room temperature make it attractive for potential use in electronics, optoelectronics and laser technology. Because of its hardness, rigidity and piezoelectric constant it is an important material in the ceramics industry, while its low toxicity, biocompatibility and biodegradability make it a material of interest for biomedicine and in pro-ecological systems [1,2]. The crystallized form of ZnO is called the zincite. Zincite crystals can be grown artificially, and synthetic zincite crystals are available as a unwanted by-product of zinc smelting. Synthetic crystals can be colourless or can range in colour from dark red, orange, or yellow to light green.

The measurement stand for real-time voltage-current characteristics of two -terminal devices was designed and built. The experimental crystal zincite-metallic tungsten semiconductor junctions were prepared, and their characteristics presented. Some of the samples are notable for hysteretic behaviour, other for distinct S-type negative resistance area. The differences are due to the random orientation of the crystal structure in the junction point of contact. It was shown, that the nonlinearity of the devices response is a function of the operating frequency, and changes dramatically. For 10 Hz it may operate like s-type tunnel diode, for 100 Hz like DIAC, and for 1 kHz it is similar to memristor.

The proposed methodology is especially convenient for students, during the classes on functional materials or semiconductors. The measurement stand may be used for other two terminal devices as well, such as resistors, diodes, inductors and capacitors, presenting their respective I(V) curves in real-time.

[1] A. Kołodziejczak-Radzimska, T. Jesionowski, Zinc Oxide—From Synthesis to Application: A Review, *Materials* **7**(4) (2014) 2833-2881.

[2] Ü. Özgür, Y.I. Alivov, C. Liu, A. Teke, M.A. Reshchikov, S. Dođan, V. Avrutin, S.J. Cho, H. Morkoç, A comprehensive review of ZnO materials and devices, *J. Appl. Phys.* 98 (2005).