The UV detectors based on p-n and p-i-n heterostructures (*p*-ZnO, *n*-GaN and *i*-Al_2O_3): electrical and optical properties.

E. Przeździecka[1]*, S. Chusnutidinow[1], M. Stachowicz[1], D. Snigurenko[1], R. Schifano[1], K. Kopalko[1], R. Jakieła[1], E. Guziewicz[1], M. F. Cerqueira[2], A. Kozanecki[1]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[2] *University of Minho, Center of Physics, Braga, Portugal*
**eilczuk@ifpan.edu.pl*

Zinc oxide (ZnO) is a promising candidate for applications as ultraviolet (UV) photodetectors due to its large direct band gap and the high absorption coefficient in the UV spectral range. However, it is known, that the *p*-type conductivity in ZnO is difficult to achieve due to the presence of background *n*-type centers, thus preventing the ZnO application in optoelectronic devices.

In the present work ZnO:N films were grown by plasma-assisted molecular beam epitaxy (MBE) using rf N_2 plasma cell to introduce Nitrogen. As extracted by secondary ion mass spectrometry (SIMS) a N concentration equal to $2*10^{20}$ at/cm^{-3} and acceptor-related lines in temperature dependence photoluminescence are observed. Room temperature Hall measurements clearly proved the *p*-type conductivity of a reference ZnO:N film deposited on Al_2O_3 substrate. The resulting *p-n* and *p-i-n* structures consisting of similarly grown ZnO:N films on *n*-type GaN on sapphire template and *n*-type GaN on sapphire template covered with a thin isolating Al_2O_3 layer deposited by atomic layer deposition, respectively displayed a maximum forward-to-reverse current ratio I_F/I_R 10^5-10^7 [1] These values are 2–5 orders of magnitude higher than previously reported I_F/I_R ratios for similar heterojunctions. In addition, the devices exhibited very low dark current equal to ~ $2*10^{-10}$ A/cm^2 and high breakdown voltage (<-7V). Electron Beam Induced Current (E- BIC) measurements confirmed the formation of the junctions [2] at the *p-ZnO:N/n–GaN* interface. E-BIC scan superimposed on cross-sectional SEM image indicated that the maximum of the E-BIC current was occurring in the Al_2O_3 layer in case of the *p-i-n* devices as shown in Fig.1. The diffusion length and activation energy of charge carriers equal to 134 meV, have been extracted from E-BIC scan profiles. Furthermore, it was shown that the heterostructures exhibited strong and selective absorption in the UV range and it was found that the photocurrent signal could be modified by adding the interfacial insulating Al_2O_3 layer. The difference between the light and dark reverse currents was above four orders of magnitude and it strongly depended on the powers of UV light. The investigated ZnO:N/GaN and ZnO:N/Al_2O_3/GaN structures are promising for UV sensor application.

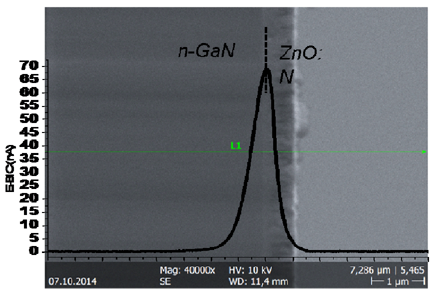

Fig. 1 Cross-sectional image of ZnO/GaN, the EBIC line scan is superimposed to the SEM image.

[1]E. Przeździecka, M. Stachowicz, S. Chusnutdinow, R. Jakieła and A. Kozanecki, *Appl. Phys. Lett.* **106**, 062106 (2015).

[2]O. Lopatiuk-Tirpak, L. Chernyak, L. J. Mandalapu , Z. Yang, J. L. Liu ,K. Gartsman,Y. Feldman, and Z. Dashevsky , *Appl. Phys. Lett.* **89**, 142114 (2006).

The research was partially supported by the NCN project DEC-2013/09/D/ST3/03750. The author R.S. was acknowledge support by the EU 7th Framework Programme project REGPOT-CT-2013-316014 (EAgLE).