n-ZnO/ZnCdO/p-Si and n-ZnCdO/ZnO/p-Si diodes: studies on the influence of the junction interlayer on electrical properties and structural defects

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Zinc oxide (ZnO) remains competitive in the wide-bandgap semiconductor family, convenient for ultraviolet and blue optoelectronics: light-emitting diodes (LEDs) and lasers. Among others, its advantages are low price and ability for bandgap engineering. Indeed, the zinc-cadmium-oxide alloy (ZnCdO) is an example of such technology, providing bandgap narrowing [1]. However, alloying ZnO with CdO is problematic in the full composition range due to the solid solubility of Cd which is limited to ~40%, as well as different stable crystal structures - wurtzite (ZnO) and rock salt (CdO). Therefore, optimisation of ZnO and ZnCdO-based structures is still challenging at hand, as well as their n-type conductivity nature is discussed.

In our work [2], we studied the pair of bilayers of n-ZnO/ZnCdO and n-ZnCdO/ZnO on a p-Si substrate grown by molecular beam epitaxy. We carried out an in-depth investigation of these heterojunctions with their electrical properties based on: current-voltage (IV) and capacitance-voltage (CV) measurements in the broad temperature range of 40 to 300 K, as well as deep-level transient spectroscopy (DLTS). Research was supported by the micro-Raman scattering for study of their structural properties and lattice dynamics.

The IV characteristics confirmed the rectifying properties of the heterojunctions, with the electrical parameters obtained: rectifying factor, ideality factor, built-in voltage, series and junction resistance. The further study of IV plots in log-log scale gave insight into the current transport mechanisms of diodes, pointing out the multi-tunneling capture-emission process and space charge limited current, which are a consequence of the presence of defects. Next, the dopant concentrations were calculated from CV characteristics with their dependences on temperature and junction depletion region width. Finally, the DLTS results confirmed the presence of typical donor-like traps (see Fig.). It was noticed that cadmium atoms affected the electrical properties and energies of trap present in the studied junctions.

Our research let us suppose that the Cd-related defect complexes, such as: Zn_i-Cd_{Zn}-V_O or Cd_{Zn}-V_O, are the most appropriate candidates for n-type conductivity of ZnCdO alloys.

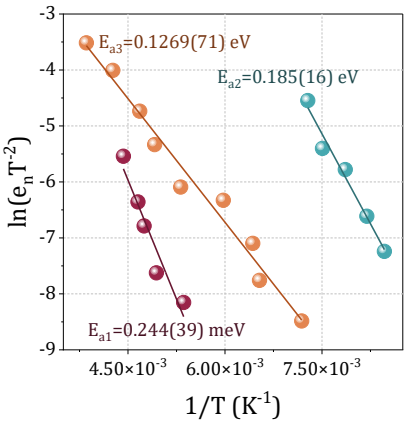

Fig. Arrhenius plot for n-ZnCdO/ZnO/p-Si junction (red and blue) and n-ZnO/ZnCdO/p-Si diode (orange).

[1] M.A. Pietrzyk, A. Wierzbicka, E. Zielony, A. Pieniazek, R. Szymon, E. Placzek-Popko, Sens. Actuator A Phys. **315**, 112305 (2020).

[2] R. Szymon, E. Zielony, A. Lysak, M.A. Pietrzyk, *Influence of the type of interlayer on current transport mechanisms and defects in n-ZnO/ZnCdO/p-Si and n-ZnCdO/ZnO/p-Si heterojunctions grown by molecular beam epitaxy*, J. All. Compd. (2023) (under review).