

# Raman spectroscopy of epitaxial $Zn_xMg_{x-1}O$ layers doped with V-group elements grown by MBE

Karolina M. Paradowska<sup>1</sup>, Ewa Przeździecka<sup>2</sup>, Ewa Płaczek-Popko<sup>1</sup>, Katarzyna Gwóźdź<sup>1</sup>, Marcin Stachowicz<sup>2</sup>, Jacek Sajkowski<sup>2</sup>, Jan Dyczewski<sup>2</sup>, Adrian Kozanecki<sup>2</sup>

<sup>1</sup>Department of Quantum Technologies, Faculty of Fundamental Problems of Technology, Wrocław University of Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland

<sup>2</sup>Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668, Warsaw, Poland

Zinc oxide has attracted more and more attention due to its interesting properties: it is a direct wide band-gap (3.37 eV) semiconductor with chemical and thermal stability in harsh environments. Possible applications of this material include short wavelength optoelectronic devices, mostly blue and white light emitting diodes [1], ultraviolet detectors [2] and more. However, technology meets large problems with fabrication of p-type ZnO, which is crucial for developing p-n junctions. The number of reports about stable p-type ZnO based materials is limited, yet some progress has been achieved. Among the proposed acceptor doping materials are, inter alia, Arsenic, Nitrogen and Antimony.

In our work, micro-Raman spectroscopy was applied to study structural properties of epitaxial  $Zn_xMg_{x-1}O$  layers doped with V-group elements. The layers were grown on commercial GaN/Al<sub>2</sub>O<sub>3</sub> substrates by plasma assisted Molecular Beam Epitaxy (PA - MBE). The substrates were chemically cleaned before growth and then out-gassed at 700°C in high vacuum. Knudsen cells were used as sources of arsenic, magnesium and zinc and an *rf* plasma cells as sources of oxygen and nitrogen. The power of the O<sub>2</sub> and N<sub>2</sub> *rf* sources were 350 W and 400 W, respectively. The growth temperature was about 450°C. Magnesium concentration was examined by low temperature luminescence as well as Rutherford backscattering spectrometry measurements. A reference GaN/Al<sub>2</sub>O<sub>3</sub> sample was also studied for comparison.

Room temperature Raman spectra were measured from 300 cm<sup>-1</sup> to 1200 cm<sup>-1</sup> in the backscattering geometry, with an excitation of the 514 nm Ar<sup>+</sup> laser line without polarization detection. Phonon modes A<sub>1</sub>(LO) and E<sub>1</sub>(LO) were observed and it was found that both were red shifted with respect to the phonon modes of bulk ZnO. Possible origin of the shift was discussed.

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## Acknowledgements

This work has been partially supported by the statutory grant Wrocław University of Technology, S50013, by the project of National Laboratory of Quantum Technologies (POIG. 02.02.00-00-003/08-00) and NCN project DEC- 013/11/B/ST7/01385. The Authors EP and MS was supported by the NCN project DEC-2013/09/D/ST3/03750.