Joint seminar of the NPI of the CAS

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Adéla Jagerová (DNP): ***Nanostructuring of crystalline semiconductors with energetic ion beams for novel optical functional materials***

Abstract:
Crystalline zinc oxide (ZnO) is a semiconductor commonly used in optoelectronics, sensors, or as a photocatalyst due to its low cost, non-toxicity, and excellent optical and photocatalytic properties. However, it exhibits a wide direct bandgap, which allows absorption of only UV light and limits its application in the visible light region. Surface nanostructuring of ZnO or its modification with noble metals and their nanoparticles can increase the photocatalytic activity and enhance ZnO visible light absorption, thereby extending its application and improving the efficiency of ZnO-based devices. Energetic ion beams offer an interesting alternative for material modification without requiring special treatments or chemical reactants. They can be used for doping solids, tailoring defect states, preparing metallic nanoparticles (NPs), or nanostructuring the surface of solid materials. However, ion beam modification can cause damage in implanted materials, making ion beam modification of crystalline materials challenging. Therefore, it is important to study ion interactions with solids to predict the material behaviour under the ion bombardment and to reach successful modification. The presentation will cover the general interaction of ion beams with different forms of ZnO, focusing on the accumulation of damage [1,2] in the ZnO structure and the potential use of ion beams for surface nanostructuring and nanoparticle synthesis [3,4,5], with possible modifications to optical and photocatalytic properties. It will primarily address the nanostructuring of various crystallographic orientations of bulk ZnO, but will also explore the prospects of ion beam methods for nanostructuring other crystalline structures [6,7].

[1] A. Macková et al., Au incorporation into various ZnO crystallographic cuts realised by ion implantation – ZnO damage characterization, Vacuum 169 (2019) 108892.

[2] A. Jagerová et al., High energy Au+ ion implantation of polar and nonpolar ZnO—Structure modification and optical properties, Surf. Interface Anal. 52 (2020) 1083–1088.

[3] A. Jagerová et al., Non-polar ZnO facet implanted with Au ions and subsequently modified using energetic O ion irradiation, Nucl. Instrum. Methods Phys. Res. Sect. B Beam Interact. Mater. At. 462 (2020) 16–23.

[4] A. Macková et al., Nanostructures in various Au ion-implanted ZnO facets modified using energetic O ions, Phys. Chem. Chem. Phys. 22 (2020) 23563–23573.

[5] A. Jagerová et al., Surface modification by high-energy heavy-ion irradiation in various crystalline ZnO facets, Phys. Chem. Chem. Phys. 23 (2021) 22673–22684.

[6] A. Macková et al., Energetic Au ion beam implantation of ZnO nanopillars for optical response modulation. Journal of Physics D: Applied Physics, volume 55, page 215101, May 2022

[7] A. Jagerová et al., Evolution of Au nanoparticles in c-plane GaN under the heavy ion implantation and their optical properties. Journal of Alloys and Compounds, volume 986, page 174035, May 2024