**Engineering of ultrafast scintillating ZnO nano- and microrods for the time-of-flight applications**

A scintillating material exposed to ionising radiation transforms the incoming energy of photons of X or γ-rays or particles (protons, electrons, neutrons, α-particles, etc.) into ultraviolet (UV)/visible photons which are detected by an ordinary photomultiplier or semiconductor detectors. One of the most important fields of the scintillators application is diseases diagnostics techniques. In particular, these are modern medical imaging methods: computer tomography (CT) and positron emission tomography (PET). In the case of the latter, the technology went even farther leading to the invention of the incredibly sensitive time-of-flight (TOF) PET. PET, in general, is based on the γ-rays detection produced by the electron-positron annihilation. This put certain constraints on the radiation detectors to be used. They should posses large response rate and high light yield to prevent a patient from negative consequences of large radiation dose. One of the eligible candidates is zinc oxide (ZnO) in the form of nanostructures as it exhibits excellent timing properties. Typically, the nanorods grown using hydrothermal method generate luminescence composed of two contributions. The first one is the ultrafast narrow UV exciton emission band with the maximum at about 3.25-3.4 eV, depending on morphology and size, and decay time of the order of 500 ps. The second one is a very broad red defect-related band with the maximum at 1.8-2.1 eV and the decay time of the order of microseconds. Doping with Mo, Er or Ga affects both bands. Moreover, the incorporation of these ions into the ZnO nanorods and their influence on morphology of the ZnO nanorods as well as other physical and chemical properties is discussed. In particular, the segregation coefficient for each type of the dopant and the size of nanorods were different. Erbium or molybdenum charge state as well as the localization of these ions in the ZnO host have been determined. The influence of the postgrowth treatment on the dopant charge state and luminescence (including kinetics) has been clarified. It should also be noted that the growth conditions (e.g., the precursor age) also changed the physical properties of the zinc oxide nanorods.