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Multiphonon resonant Raman scattering in ZnO crystals and nanostructured layers

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Abstract

Multiphonon resonant Raman scattering (RRS) was studied in unintentionally doped bulk ZnO crystals and layers, including nanostructured and highly conductive films, excited by 351.1 and 363.8 nm laser lines in the temperature interval from 10 to 300 K. The variation of resonant conditions with sample temperature and wavelength of the excitation laser line allowed us to discriminate between the incoming and outgoing exciton mediated RRS by LO phonons. The quenching of luminescence and enhancement of Raman scattering in nanostructured ZnO layers grown on single-layer opals enabled us to observe the Raman signal in resonant configuration thus making possible to study multiphonon RRS by Fröhlich-type vibrational modes related to nanocrystallites with sizes less than 50 nm . The emission spectra of highly conductive ZnO films grown on porous InP substrates were found to consist of multiphonon RRS lines superimposed on a broad asymmetric near band gap photoluminescence (PL) band. The occurrence of PL and RRS in highly conductive layers is attributed to tailing of the density of states caused by potential fluctuations and to the breakdown of the wave-vector conservation due to randomly distributed impurities (intrinsic defects).