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Space charge layer spectroscopy with optical excitation

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Since the invention of space charge spectroscopy by Schottky and Spenke in 1938, various techniques have been established and became powerful tools for the investigation of electronic defect states in semiconductors. All methods have in common, that the rates for either capture or emission of charge carriers by defect states are measured. These processes can either be thermally activated or involve optical transitions. The purely "thermal" methods like admittance and deep-level transient spectroscopy are frequently used and provide information about the approximate position of the electronic state in the band-gap and its capture cross-section for free charge carriers. However, employing optical excitation, much more information about the electronic structure of a defect state can be gained from space charge spectroscopy. For example the photo-ionisation cross-section spectra of a defect state can be measured, minority carriers can be optically generated in order to detect minority carrier traps, and -with a view on wide band-gap semiconductors- optical excitation often is the only possibility to detect midgap-levels by space charge spectroscopy.

In this talk an overview of different space charge spectroscopic methods used to study defects in the wide band-gap semiconductor ZnO will be given. The focus will be on the particularities of photo-capacitance, photo current, optical deep-level transient spectroscopy, and minority carrier transient spectroscopy. Intrinsic as well as nickel- and nitrogen-related levels in ZnO thin films shall serve as examples.