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Upsides and Downsides of Defects in Silicon Carbide

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Defects are key to semiconductor physics and technology. Whereas some defects like dopants are desired, unwanted defects can hamper device functionality. This situation is, in particular, also valid in silicon carbide (SiC) technology. The characterization and the physical understanding of defects in SiC is in the focus of today's research on SiC. In the talk, two topical cases will be discussed: undesired and device-performance limiting defects at the SiC/silicon oxide interface, and beneficial point defects in SiC that can be employed for novel quantum technology.

A material peculiarity of the SiC/silicon oxide interface is its high interface trap density as compared to silicon. Despite the development of defect passivation/reduction processes like post-oxidation annealing in nitric oxide, there is still room for substantial improvements. The performance of SiC MOSFETs is often characterized using 3-terminal electrical measurement techniques with evaluation schemes originally developed for silicon MOSFETs. Such schemes neglect the density of interface traps and estimate the charge carrier density from a simple plate capacitor approximation. This leads to an underestimation of the charge carrier mobility. We introduced a parametrization of the SiC/silicon oxide specific interface trap spectrum that reflects the body of data published in the literature. With this ingredient, we developed an analysis that targets for an accurate determination of device parameters from simple 3-terminal characteristics.

Just a few years ago, SiC was discovered as a host material for optically excitable point defects, often termed color centers, suited for novel quantum technology. Compared to diamond, which is another frequently used material to host color centers, SiC is advantageous due to its existing mature process technology from material growth to device fabrication. One of the most promising color centers for quantum technology in SiC is the silicon vacancy defect, which is well characterized. In contrast to the influence of magnetic fields on the photoluminescence of this defect, the response to an externally controlled electric field has been insufficiently investigated. We present a device that allows exerting strong electric fields by transparent epitaxial graphene electrodes on the silicon vacancy either symmetry conserving or symmetry breaking. These regimes are suited for fine-tuning the spectral properties of single-photon sources by Stark tuning or for an in-depth analysis of their quantum properties.