EPR and ODEPR as methods of characterization of nanocarbons

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The properties of carbon nanostructures are to date of the great interest among other nanomaterials. Electron paramagnetic resonance (EPR) and EPR based methods are the most informative tools for detecting defects and excitations in solids. These methods offer a uniquely sensitive probe of local structural order, the atomic-scale environment of the defect, can provide details of electron density distributions. The microscopic structure of many intrinsic and impurity defects and their clusters in diamonds and other carbon-related materials was studied by EPR. An understanding of the structure and constituents of defects in nanodiamond and other carbon nanostructures is important since their presence can greatly affect the properties of the material.

The recent development in EPR is characterized by an increasing use of high-frequency and pulse techniques. Direct measurements of EPR in nanostructures are often difficult because of the small total number of spins, therefore optically detected magnetic resonance (ODMR or ODEPR) is much better suited for the measurements in such systems. In combination with optical excitation, EPR can also yield information regarding optical transitions, thus providing a bridge between optical and magnetic resonance spectroscopy.

This review will mainly concentrate on point defects; related to the presence of nitrogen, hydrogen and silicon. EPR is also a method of choice for the study of transition ions impurities.

Specifically, we will discuss progress toward using EPR and ODEPR to study nitrogen and nitrogen-based defects in nanodiamond. Also, in this context, ODMR study of NV defects consisting of a nitrogen atom (N) and a vacancy (V) in adjacent lattice sites are of paramount importance. NV defect is the only known solid-state system where there exist possibility of detecting and manipulating the spin states of a single localized electron at room temperature. Coupling between the NV and N spins in NV –N pair due to a cross-relaxation gives rise to new possibilities for spin manipulation. Paramagnetic defects in nanodiamond and possibly carbon clusters in other materials open up an avenue to practical quantum computing.

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