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Ph.D. in Physics

An optical and magnetic resonance study of point defects in silicon, diamond, and aluminum nitride

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Optical and magnetic resonance studies of point defects in silicon, diamond, and aluminum nitride semiconducting crystals are described in this dissertation. In silicon, an optically detected magnetic resonance (ODMR) study of a sulfur-related defect with two stable configurations, Ssb{A} and Ssb{B}, each with its own photoluminescence (PL) band and associated ODMR spectrum, is discussed. Through ODMR and related linear polarization studies, the Ssb{A} configuration is conclusively determined to have Csb1 (triclinic) symmetry (which is also the tentative finding for Ssb{B}), a controversial issue in the literature. A conversion study comparing the PL and PLODMR shows a one-to-one conversion between the two configurations for each type of signal. Related findings also tentatively suggest that the Ssb{B} configuration is metastable in both the neutral and single positive charge states of the defect. In addition, an independent analysis presented of uniaxial stress data obtained at King's College, London, shows evidence that an inverted energy-level ordering of the excited electronic effective mass states (Asb1 above E) explains the data better than the opposite ordering which is usually observed for effective mass systems. The mechanism responsible for inversion is currently not known. In diamond, a 1.4 eV Ni-related band with very sharp zero-phonon lines is studied using magnetic circular dichroism in absorption (MCDA). A tunable laser was used to directly measure circular polarization properties of transitions between individual Zeeman-split spin states. The Zeeman study also provided a determination of their associated g-values. A comparison with a theoretical model involving intra-d-shell transitions of Ni indicates that a transition from a ground state of Gammasb{5,6}(sp2E) symmetry to a Gammasb4(sp2Asb1) excited state explains the experimental MCDA findings and agrees with results from a previous uniaxial stress polarization study of luminescence associated with the same transition. Finally, a PLODMR study of several aluminum nitride crystals is also presented. The crystals were observed to emit a broad PL band comprised of numerous overlapping bands, each with its own signature ODMR signal. These new spectra include four effective spin S = 1 centers and a pair of S = 1/2 centers exhibiting characteristics expected for distant-pair recombinations. Two recombination models, either of which may explain a pair of S = 1 centers that appear to be related, are discussed.

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