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The origin of charge transients in Al/undoped diamond/p-Si diodes

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Abstract

An experimental study of relaxation behaviour of Al/undoped diamond/p-Si diodes was conducted using charge deep-level transient spectroscopy (QDLTS) and feedback charge capacitance method (FCM) in the time domain. Prior to vacuum deposition of Al onto 5-μm-thick diamond films, the latter were exposed to a hydrogen discharge at 150 °C for 30 min. When measuring capacitance at delays of a few microseconds with respect to the trailing edge of the probing pulse ΔU at ambient temperatures, only the instantaneous capacitance $C(0)$ corresponding to the thickness of the diamond film was detected. After shifting the excitation and processing of the charge transients to the region of tens of milliseconds, excess capacitance (charge) is observed, its value depending on temperature. Both isothermal and thermal-scan QDLTS measurements revealed a broad spectrum of relaxation times indicating a Debye-type dielectric relaxation, i.e. the amplitude of the QDLTS peak is a linear function of ΔU. The thermal activation energy $\Delta E \approx 0.13$ eV of the spectral components corresponding to the maximum of the signal matches perfectly the activation energy of dc conductivity at equivalent temperatures. The origin of the dielectric relaxation is explained in terms of a Maxwell–Wagner polarisation due to a conducting phase embedded in the semi-insulating matrix of the diamond films, the width of the spectrum of relaxation times reflecting the spread of the sizes of microcrystallites. The results may also be useful for finding the demarcation temperature of detecting response from deep traps located within the depletion region at the Al/diamond interface.

Author Keywords: Deep-level transient spectroscopy; Diamond films; Diode; Heated filament