

Surface Phenomena of CVD Diamond Films

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Free-standing undoped MPCVD diamond films (200-300 μm thick) have been investigated by charge-based deep level transient spectroscopy (Q-DLTS). Interdigital planar Au/Cr electrodes with 50 μm spacing (12 mm^2 area) were realized on the diamond surface by lithographic technique (Fig.1). Q-DLTS was used for study of the influence adsorption and desorption processes on diamond surface states [1,2]. As with other relaxation techniques, Q-DLTS is based on measurements of the transient process of the trapped charge after application of voltage on the material. The method provides information about activation energy, capture cross-section, and density of states. Charge-based DLTS, due to measurements of the charge but not capacitance, gives one a possibility to investigate surface and bulk properties of the structures based on wide bandgap and insulating materials such as undoped diamond [3]. The measured value of the Q-DLTS signal by our ASEC-03 apparatus can be written as $\Delta Q = Q(t_1) - Q(t_2)$, where t_1 and t_2 are the times from the beginning of discharge. The charge ΔQ flowing through the circuit during the time period, $\Delta t = t_2 - t_1$, is measured as a function of parameters of the bias pulse, temperature, and rate window $\tau_m = (t_2 - t_1)/\ln(t_2/t_1)$.

The strong sensitivity of Q-DLTS spectra to the presence of the vapor water was found (Fig.2,3). For example, the density of surface states $N_t \sim \Delta Q$ (value of Q-DLTS signal) for some prepared diamond samples was increased more than in three order in presence of the vapor water. The kinetic and modification of the water-induced surface states with using different parameters of bias pulse (Fig.3) was measured and investigated also. Furthermore, it was found that Q-DLTS spectra substantially differ for water or isopropyl alcohol adsorbates. Such strong and selective surface phenomena of the CVD diamond films may be exploited in novel Q-DLTS gas sensor devices. ASEC-03 apparatus is sensitive enough to detect less than two thousand of the gas (or vapor) molecules adsorbed on the surface of CVD diamond films.

ACKNOWLEDGMENTS

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REFERENCE

1. V.I. Polyakov, A.I. Rukovishnikov, A.V. Khomich, B.L. Druz, D. Kania, A. Hayes, M.A. Prelas, R.V. Tompson, T.K. Ghosh, S.K. Loyalka, Mat. Res. Soc. Symp. Proc.,v. 555, pp.345-350 (1999).
2. L.K. Bigelow, M.P. D'Evelyn, Surface Science, p.1 (2001)
3. V.I. Polyakov, A.I. Rukovishnikov, N.M. Rossukanyi, B. Druz Mat. Res. Soc. Symp. Proc.,v. 699, pp.219-224 (2002).

Gas (vapor)

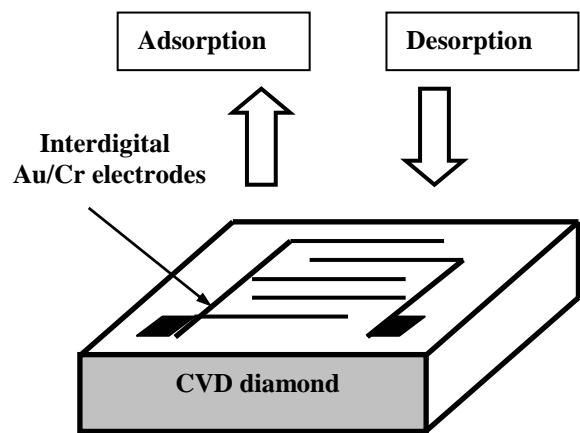


Fig.1. Schematic view of Q-DLTS gas sensor using CVD diamond film.

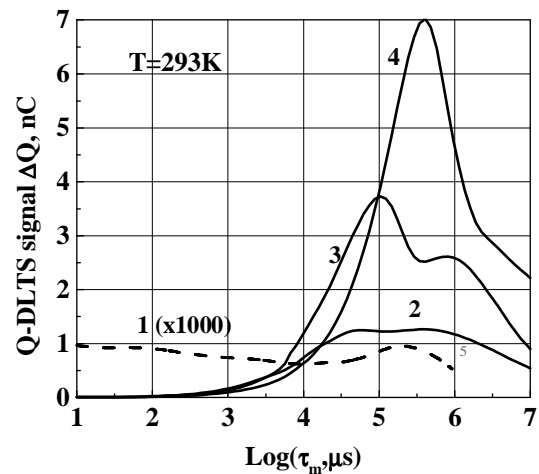


Fig.2 Q-DLTS spectra of CVD diamond film for bias pulse 10V.

- 1 – in air (duration of the bias pulse – 300 ms).
- 2 – in water vapor (duration of the bias pulse - 30 ms).
- 3 – in water vapor (duration of the bias pulse - 100 ms).
- 4 – in water vapor (duration of the bias pulse - 300 ms).

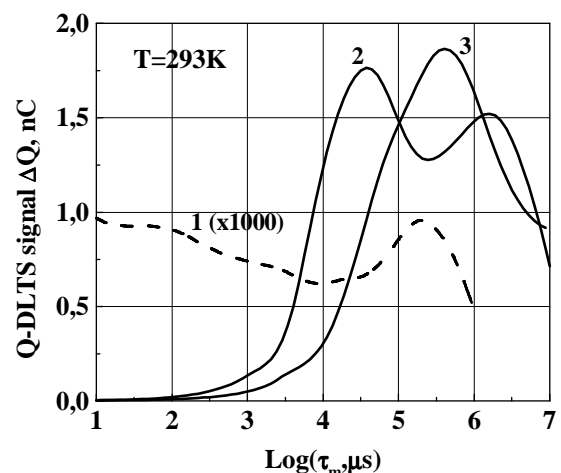


Fig.3. Q-DLTS spectra of CVD diamond film for bias pulse 10V with duration 100 ms.

- 1 – in air. 2 – in water vapor. 3 – in water vapor (after applying voltage 10V during 3 s).