# Charge sensitive deep level transient spectroscopy of mono- and polycrystalline diamonds

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Investigation of the bulk and surface electrically active defects in diamond films grown by different methods is very important for understanding fundamental processes of the defect formation in mono- and polycrystalline diamonds. In most cases, either defects, such as the impurity atoms, vacancies and their combination which form complex defects, or extended defects generate deep levels in the forbidden band gap of diamond and behave as the trapping or recombination centers. Therefore, in order to improve the performance of the diamond devices detailed information about electrically active defects in diamond is needed. In this paper we report on a study of the defects in polycrystalline and homoepitaxial undoped and boron-doped CVD diamond films which were grown by hot-filament (HF) and microwave (MW) plasma-assisted methods. The boron-doped p-type diamond single crystals synthesized by high pressure high temperature (HPHT) technique were investigated also. Isothermal Charge sensi-tive Deep Level Transient Spectroscopy (Q-DLTS) [1] was applied to explore the density - $N_t$, activation energy - $E_a$, and capture cross-section - $\sigma$ of the trapping centers (TC) – the electrically active defects in diamond samples. The Transient Spectroscopy has shown that boron-induced TC in CVD polycrystalline diamond films grown by HF and MW methods have a continuous energy spectrum with two (Fig.1) or three picks that correspond to discrete energy levels in forbidden band of diamond. While in boron-doped homoepitaxial diamond films (Fig. 2) and in HPHT single crystals (Fig.3) only one boron-induced deep level was found. This difference may reflect different way of the boron incorporation in polycrystalline films compa-red to synthetic HPHT or homoepitaxial CVD diamond. The Q-DLTS spectra measured at various conditions for the samples with different concentration of the incorpora-ted boron atoms have shown that two of the discrete levels in slightly doped polycrystalline diamond films have the values of $E_a$ approximately 0.35 and 0.25 eV with strongly difference in $\sigma$. The activation energy of these boron- induced levels decreased and their density increased with increasing boron concentration. The same changes of the one boron-induced level were observed in monocrystalline diamond. The spectrum of the diamond sample with the most boron concentration, and as result, with the least $E_a$ is shown in Fig.3. The influence of the boron concentra-tion and degree of the compensation (mostly by nitrogen) on the $E_a$ and boron impurity band formation was investigated. The difference of the boron incorporation in (111) and (100) faces of HPHT crystals was studied also. The results are discussed in comparison with data available in the literature.

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**REFERENCE**

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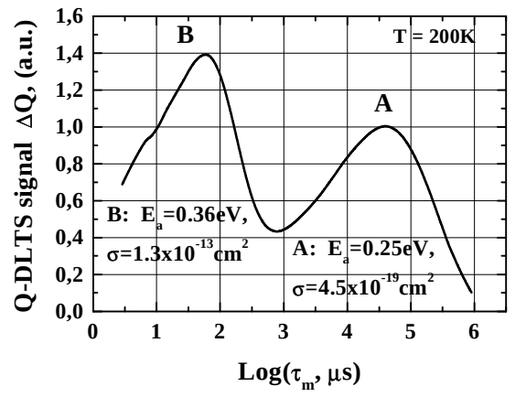



Fig.1. Q-DLTS spectrum of the boron-doped CVD polycrystalline diamond film. The range of the two boron-induced levels.

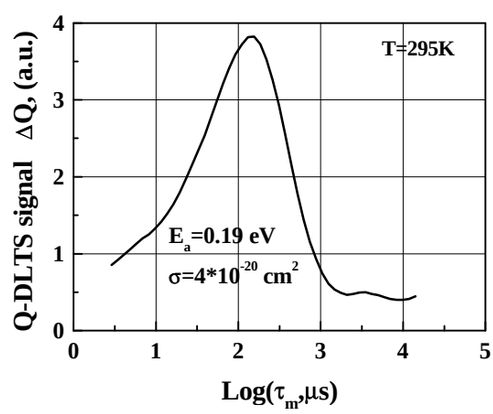
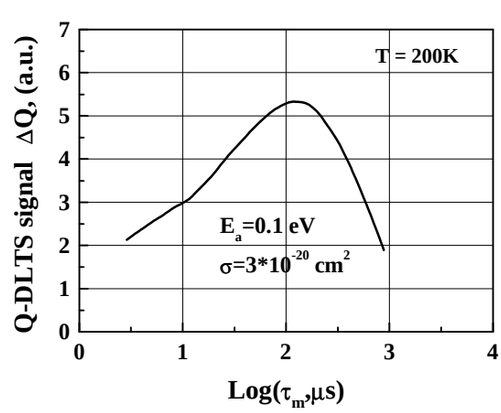



Fig.2. Q-DLTS spectrum f the boron-doped homoepitaxial




HF CVD diamond film. The range of the boron-induced level.

Fig.3. Q-DLTS spectrum of the boron-doped HPHT single crystal ((111) face). The  range of the boron-induced level.