OPTICAL ACTIVE DIAGNOSTICS OF THERMAL AND ELECTRONIC PROPERTIES OF DIAMOND OF DIFFERENT STRUCTURES

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Diamond is fairly recognized as a material of 21 century due to unchallenged combination of physical parameters, chemical and radiation resistance, biological inertness and so on. Unprecedented development of CVD – technology has increased essentially an interest to the material, especially in view of promising potentials of diamond application in microelectronics, optoelectronics, sensors, optics and laser physics .

The problems of optical diagnostics and physical interpretation of thermal and electronic parameters of CVD-diamond as being a parameters of significance from point of view of practical application are solved in this project. Two teams of scientists from the Institute of Applied Research (Vilnius) and Institute of Physics, Academy of Sciences (Minsk) are involved in the project. New effective methods of measurement and special scientific equipment based on up-to-date lasers and detectors of optical signals have been developed. The measuring techniques are of contactless nature, provide high temporal resolution and are currently realized in system OPTOPICOTEST (Minsk) and module HOLO-3 (Vilnius) .

The current project is a consequence and further evaluation of early implemented joint investigations in the same field via two-sided scientific and technical cooperation in 2002-2005, as well as through the grant CBP.EAP.EV 982483 (2007 г.) in the framework of NATO program of scientific and technical cooperation.

Investigations currently conducted are aimed to clarify physical factors that affect the free charge carrier (FCC) dynamics as well as the processes of heat transfer in CVD (polycrystals) and HPHT (synthetic monocrystals) diamonds of different structure and impurities content.. Two-photon absorption in diamond at 351 nm is proposed for FCC excitation. It enabled to carry out the volumetric excitation of samples and to measure the recombination time and diffusion coefficient within wide intervals of FCC density (10^{15} - $3\cdot10^{17}$ cm^{-3}) and sample temperature (80-800K).

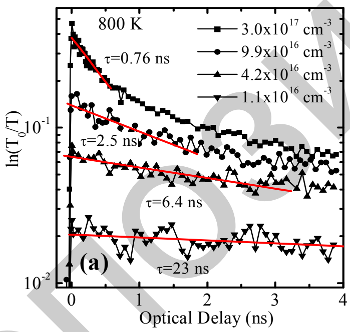

Fig. 1

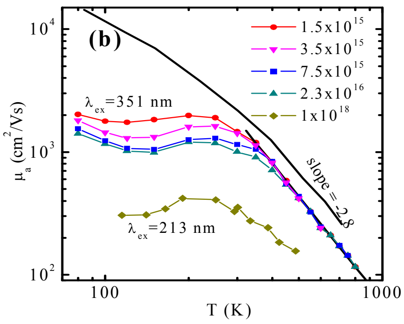

Fig.2

Besides, the FCC lifetime was controlled via induced absorption caused by FCC generation. A set of transmittance kinetics for HPHT diamond of IIa type at different pumping levels is shown in Fig.1. Probing at 1053 nm, sample temperature T=800K. The initial FCC density and lifetime are given by the figures. The temperature dependence of ambipolar mobility μ of FCC, as deduced from transient gratings excitation experiments are given in Fig.2.

Thermal investigations of diamond samples was conducted by the method of transient gratings as well. Nevertheless in contrast to studies mentioned above, thermal gratings were probed with beam from CW He-Ne laser (wavelength 632 nm) because lifetime of thermal gratings was typically larger. The temporal behavior of the diffracted signal for CVD-diamond under excitation at 213 nm one can see in Fig.3. The two component of kinetics are well defined. The first pike downward – is electronic component whereas slow part – the thermal grating decay which is recorded due to non-radiative recombination of FCC. Electronic component has been studied by the equipment of high temporal resolution as it is described above. As it seen in Fig.3, thermal component has the light induced refractive index of opposite sigh with respect to electronic one. It enables the in-plane thermal diffusivity measurement.

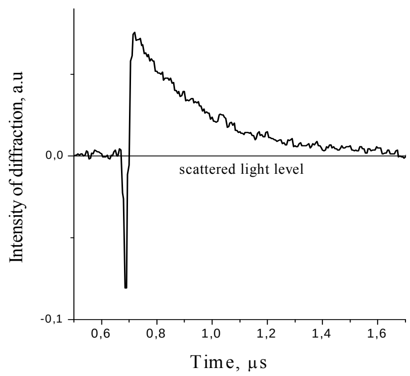

Fig.3

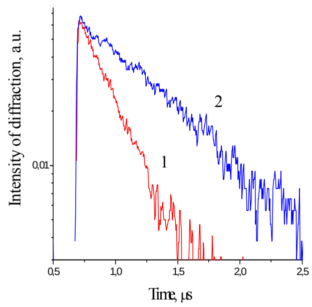

Fig.4

The columnar- conical internal structure of crystallites in CVD-diamond was confirmed by the depth resolved thermal diffusivity measurement. The crystallites are oriented along normal to sample surface. Two kinetics one can see in Fig.4 that are obtained under diamond slab excitation at 213 nm with grating recording on growth (1) and nucleation (2) sides. As it shown by analysis conducted, thermal diffusivity of diamond may be several time larger for growth side as compared to nucleation side. The reason for this is that the crossection size of crystallite near nucleation side is typically less than that near the growth side.

The results obtained by conducted studies provide new data on CVD-diamond in comparison with monocrystalline samples. It gives the possibility to estimate the prospects of the material application in electronics and optoelectronics especially as hard radiation detectors and effective heat spreaders. Besides, the data obtained may be used for growth technologies development to produce the material of desired parameters.