Photoluminescence and Raman analysis of CVD diamond films

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In recent years, individual colour centres in diamond attract great attention due to interesting potential applications, such as fluorescent markers for bio-imaging based on if they are incorporated in diamond nanoparticles. Recently, the nitrogen vacancy colour centre, in particular negatively charged complex of substitutional nitrogen atom with vacancy in neighbour position (NV^-) was considered as a convenient candidate, because of pronounced room-temperature emission at 638 nm [1] accompanied with more intensive phonon sideband, which is its major disadvantage. As a promising alternative, it seems to be use of silicon vacancy (SiV) colour centres, with silicon atom incorporated between two vacant lattice positions. A main merit of these centres is the possibility to excite their luminescence by red light and narrow emission in IR/NIR spectral range, falling into the transmission window of biological tissues. Namely, at room temperature, spectrum consists of zero-phonon line (ZPL) at vicinity of 738 nm [2] and weak, practically insensible phonon sideband. Therefore, large effort is devoted to the development of controlled and reproducible methods for fabrication of SiV centres in synthetic diamond.

In this contribution, we focus on steady-state photoluminescence of diamond thin films grown using microwave plasma assisted CVD together with Raman spectroscopy. SEM was used to characterize the film morphology. The film quality was characterized by Raman spectroscopy and correlated by photoluminescence measurements. To recognize optimal preparation conditions, the systematic study on a number of samples series was performed. We investigated influences of gas composition (addition of CO_2 and N_2 in the range 0-4.5 vol. % and 0.5-6.0 vol. %, respectively), substrate temperature in the range 350–1100 °C, and substrate type (Si, quartz, Al_2O_3, and Mo). Our measurements suggest optimal substrate temperature around 800 °C, optical activity independent on substrate material and substantial suppression of luminescence intensity with rising content of CO_2 and N_2 in the gas mixture.

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