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Electrical stimulation of non-classical photon emission from diamond color centers by means of sub-superficial graphitic electrodes

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Focused MeV ion beams with micrometric resolution are suitable tools for the direct writing of conductive graphitic channels buried in an insulating diamond bulk, as already demonstrated for different device applications. In this work we apply this fabrication method to the electrical excitation of color centers in diamond, demonstrating the potential of electrical stimulation in diamond-based single-photon sources. Differently from optically-stimulated light emission from color centers in diamond, electroluminescence (EL) requires a high current flowing in the diamond subgap states between the electrodes. With this purpose, buried graphitic electrode pairs, 10 μm spaced, were fabricated in the bulk of a single-crystal diamond sample using a 6 MeV C microbeam. The electrical characterization of the structure showed a significant current injection above an effective voltage threshold of 150 V, which enabled the stimulation of a stable EL emission. The EL imaging allowed to identify the electroluminescent regions and the residual vacancy distribution associated with the fabrication technique. Measurements evidenced isolated electroluminescent spots where non-classical light emission in the 560–700 nm spectral range was observed. The spectral and auto-correlation features of the EL emission were investigated to qualify the non-classical properties of the color centers.

In the last decade diamond has gained increasing interest as a promising material for the development of efficient single-photon sources[1,2], due to the discovery, the characterization and the integration in photonic structures of several luminescent centers associated with impurities and defects in its crystal matrix[3–7]. Their high quantum efficiency and stability at room temperature prefigure appealing applications in the emerging field of quantum communication[8,9] as a competing candidate with respect to alternative platforms, such as quantum dots[10] and silicon carbide[11]. In particular, the electrical stimulation of the lluminescence from a single-photon emitter by means of a controlled current injection would enable a straightforward development of solid-state opto-electronic devices, paving the way to integrated on-demand single-photon sources. The observation of electrically-stimulated photon emission in diamond was recently discussed in few works based on p-i-n junction devices, where emission from neutral nitrogen-vacancy (NV^0) centers was reported, both in ensemble[12] and as single-photon sources[13,14], as well as from Xe-related[15] and Si-V[16] color centers ensembles. Particularly, the stimulation of non-classical electroluminescence (EL) required articulated device fabrication methods, relying either on the controlled homoepitaxial growth of suitably doped layers[13] or on the co-implantation of

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