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Single-Photon-Emitting Optical Centers in Diamond Fabricated upon Sn Implantation

S. Ditalia Tchernij,[†,‡] T. Herzig,[§] J. Forneris,[*,‡,†] J. Küpper,[§] S. Pezzagna,[§] P. Traina,[∥] E. Moreva,[∥] I. P. Degiovanni,[∥] G. Brida,[∥] N. Skukan,[⊥] M. Genovese,[‡,∥] M. Jakšić,[⊥] J. Meijer,[§] and P. Olivero[†,‡]

[†]Physics Department and "NIS" Inter-departmental Centre - University of Torino; via P. Giuria 1, 10125, Torino, Italy

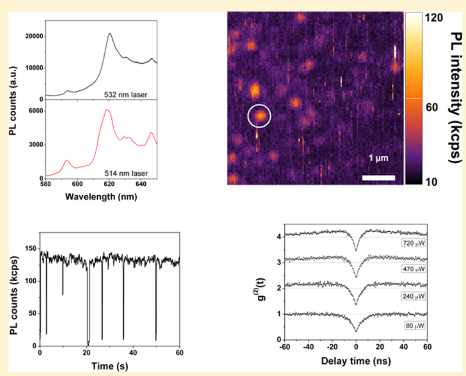
[‡]Istituto Nazionale di Fisica Nucleare (INFN) - Sez. Torino; via P. Giuria 1, 10125, Torino, Italy

[§]Department of Nuclear Solid State Physics, University of Leipzig, 04103, Leipzig, Germany

[∥]Istituto Nazionale di Ricerca Metrologica (INRiM); Strada delle Cacce 91, 10135, Torino, Italy

[⊥]Ruđer Bošković Institute; Bijenicka 54, P.O. Box 180, 10002, Zagreb, Croatia

ABSTRACT: The fabrication of luminescent defects in single-crystal diamond upon Sn implantation and annealing is reported. The relevant spectral features of the optical centers (emission peaks at 593.5, 620.3, 630.7, and 646.7 nm) are attributed to Sn-related defects through the correlation of their photoluminescence (PL) intensity with the implantation fluence. Single Sn-related defects were identified and characterized through the acquisition of their second-order autocorrelation emission functions, by means of Hanbury-Brown and Twiss interferometry. The investigation of their single-photon emission regime as a function of excitation laser power revealed that Sn-related defects are based on three-level systems with a 6 ns radiative decay lifetime. In a fraction of the studied centers, the observation of a blinking PL emission is indicative of the existence of a dark state. Furthermore, absorption dependence on the polarization of the excitation radiation with ~45% contrast was measured. This work shed light on the existence of a new optical center associated with a group-IV impurity in diamond, with similar photophysical properties to the already well-known Si−V and Ge−V emitters, thus, providing results of interest from both the fundamental and applicative points of view.



KEYWORDS: *diamond, color centers, ion implantation, single-photon, tin*

Single-photon sources (SPS) are essential building blocks for the development of quantum technologies, ranging from fundamental quantum optics experiments to quantum metrology and quantum key distribution.[1−4] In recent years, a large number of materials and systems have been explored with the purpose of identifying reliable SPS, such as quantum dots,[5,6] 2-dimensional,[7] and wide bandgap materials.[8−11] Among these systems, diamond is an appealing material, as its lattice can host different defects with bright and photostable single-photon emission at room temperature. The quest for single-photon emitters with desirable opto-physical properties has led to the discovery and characterization of several classes of optical centers in diamond, from the nitrogen-vacancy complex (NV center)[12] to alternative emitters based on Si[13,14] and Ge[15] impurities, as well as additional centers in the visible[16,17] and near-infrared[18−20] spectral range.

Since Si−V and Ge−V centers are among the most appealing optical centers in diamond for applications as SPS, due to their photostability and short emission lifetime, the existence of additional optically active defects associated with group IV impurities in diamond and the assessment of their opto-physical properties would be of high interest, from both fundamental and applicative points of view.

Here we report for the first time, to the best of our knowledge, on the evidence of Sn-related single-photon emitters in single-crystal diamond fabricated upon ion implantation and subsequent annealing. In particular, the PL characterization of the peculiar emission features is performed for different ion implantation fluences to unambiguously attribute them to Sn-related defects. Their emission lifetime is evaluated from the acquisition of the second-order autocorrelation function of individual emitters. The photostability and the polarized absorption of the centers are also discussed on the basis of the experimental results at the single-photon emitter level.

EXPERIMENTAL SECTION

The measurements were performed on a high-purity single-crystal diamond substrate. Several ~200 × 200 μm^2 regions were implanted through a collimator at different Sn energies and fluences. One region underwent a 10 MeV Sn implantation at 5×10^{13} cm^{-2} fluence. Five additional regions were implanted with 60 keV Sn ions in the $2 \times 10^{10} - 1 \times 10^{11}$ cm^{-2}

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