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Bright single-photon emission from a GeV center in diamond under a microfabricated solid immersion lens at room temperature

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ABSTRACT

We report on the metrological characterization of the emission from a germanium-vacancy center in diamond under a microfabricated solid immersion lens in a confocal laser-scanning microscope setup. Ge ions were implanted into a synthetic diamond at 3 MeV, and germanium-vacancy centers were then formed by subsequent annealing. Afterward, solid immersion lenses were fabricated in a focused ion beam scanning electron microscope. The photoluminescence was investigated at room temperature in terms of the spectral distribution, the excited state lifetime, the second-order correlation function, and the saturation behavior, proving simultaneous high single-photon purity and high brightness. Two methods were exploited to minimize the residual multi-photon probability: spectral filtering and temporal filtering. According to these results, we assume that Raman scattered photons and emission from neighboring color centers play an important role in the residual multi-photon emission probability. The system efficiency of the single-photon source was investigated and found to be in accordance with the value calculated from all sources of loss in the setup. The branching ratio of the germanium-vacancy center for the decay into the ground state and into metastable state was calculated. The results enable the usage of the single-photon source in future quantum radiometric experiments.

I. INTRODUCTION

Single-photon sources are of interest in many applications, such as quantum key distribution, quantum information processing,[1,2] as well as in quantum metrology.[3,4] The nitrogen-vacancy (NV) center in diamond is well-studied[4–12] and easily accessible due to the natural presence of nitrogen and NV centers in type Ib diamond.[13] Recently, color centers based on germanium-vacancy (GeV),[14–18] tin-vacancy (SnV),[19–23] lead-vacancy (PbV),[24,25] and magnesium-vacancy (MgV)[26] grew in interest because of their narrow luminescence spectrum and their bright emission. The broad spectral distribution was the most significant contributor to the standard uncertainty in the determination of the spectral photon flux for an NV center in recent quantum metrological experiments.[27] Therefore, the reduction of the spectral width of the single-photon emission from diamond color centers is of utmost importance. The GeV center has a strong zero-phonon line emission at 602 nm[14,15,28] with a Full Width at Half