Femtosecond direct laser writing for fabricating structures with NV centers

Lucas K. Nolasco[1,2], Filipe A. Couto[1], Lucas N.S. Andrare[1], Sergio R. Muniz[1], Cleber R. Mendonça[2,*]

[1]São Carlos Institute of Physics, University of São Paulo, São Carlos, SP, Brazil
[2]Dept. of Materials Engineering, School of Engineering of São Carlos, University of São Paulo, São Carlos, SP, Brazil
*Corresponding author email: crmendon@ifsc.usp.br

The integration of devices for applications in photonics and quantum information technologies requires the development of platforms combining basic elements, such as resonators and waveguides. One promising solid-state optically active systems currently studied for such applications is the nitrogen-vacancy (NV) center in diamond, which is usually produced by irradiating diamond with beams of electrons or nitrogen ions. NV centers can be optically initialized and read out, present long coherence times at room temperature and allows creating protocols to manipulate its spin-state by combining optical and magnetic methods. Furthermore, NV centers can also be used as quantum sensors to detect temperature and magnetic and electric fields. The controlled production and placement of NV centers in photonic structures is of high relevance to engineer devices.

In this direction, this work presents results obtained from our efforts to use of fs-laser pulses to generate active and spatially localized NV centers in CVD diamond, as well as the fabrication of polymeric optical microcavities, via two-photon polymerization, incorporated with nanodiamonts containing NV centers. Upon excitation of diamond using femtosecond pulses from an YKGW laser operating at 1030 nm, 515 nm and 343 nm, we have determined the pulse fluence range to generate the NV centers, as well as studied the influence of wavelength and pulse duration on the defect generation. A phenomenological model was used to interpret the observed results. Furthermore, fs-pulse at ~800 nm (86 MHz repetition rate) were used to fabricate, via the two-photon polymerization (2PP), cylindrical resonators incorporated with nanodiamonds presenting NV centers. Even though the cavity quality factor (Q) decreases with the amount of nanodiamonds, for a cavity with 0.01 wt% of nanodiamonds Q ~10^3 is achieved. More interestingly, we were able to collect the NV-center emission from specific positions in such microvities, that display the typical features of the NV-centers. In summary, the results reported here demonstrate the use of fs-laser pulses to generate localized NV^- center in diamond by using 150-fs pulses (775 nm) with fluences higher than 11 mJ/cm^2. Also 2PP was sucefuly used to fabricate microresonatores containg nanodiamonds, with Q of about 10^3.

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