Mie Resonances in Luminescent Diamond Particles

Dmitry Obydennov[1*], Vitaly Yaroshenko[2], Ekaterina Elias[3], Daniil Shilkin[1], Evgeny Lyubin[1], Evgeny Ekimov[4], Oleg Kudryavtsev[5], Dmitry Zuev[2], Igor Vlasov[5] and Andrey Fedyanin[1]

[1] *Quantum Electronics Department and Quantum Technology Center, Faculty of Physics, Lomonosov Moscow State University, Moscow, Russia*
[2] *Faculty of Physics and Engineering, ITMO University, St. Petersburg, Russia*
[3] *Sevastopol Campus of Lomonosov Moscow State University, Sevastopol, Russia*
[4] *Institute for High Pressure Physics, Russian Academy of Sciences, Troitsk, Russia*
[5] *Prokhorov General Physics Institute, Russian Academy of Sciences, Moscow, Russia*
*E-mail: obydennov@nanolab.phys.msu.ru

Luminescent diamond particles are widely used are widely used as quantum emitters, biomarkers, and high-precise sensors at the nanoscale. The size of diamond particles affects the luminescence of embedded color centers [1, 2]. Recently, fundamental Mie resonances of subwavelength diamonds have been revealed using dark-field scattering spectroscopy and shown to red shift with increasing particle size [3].

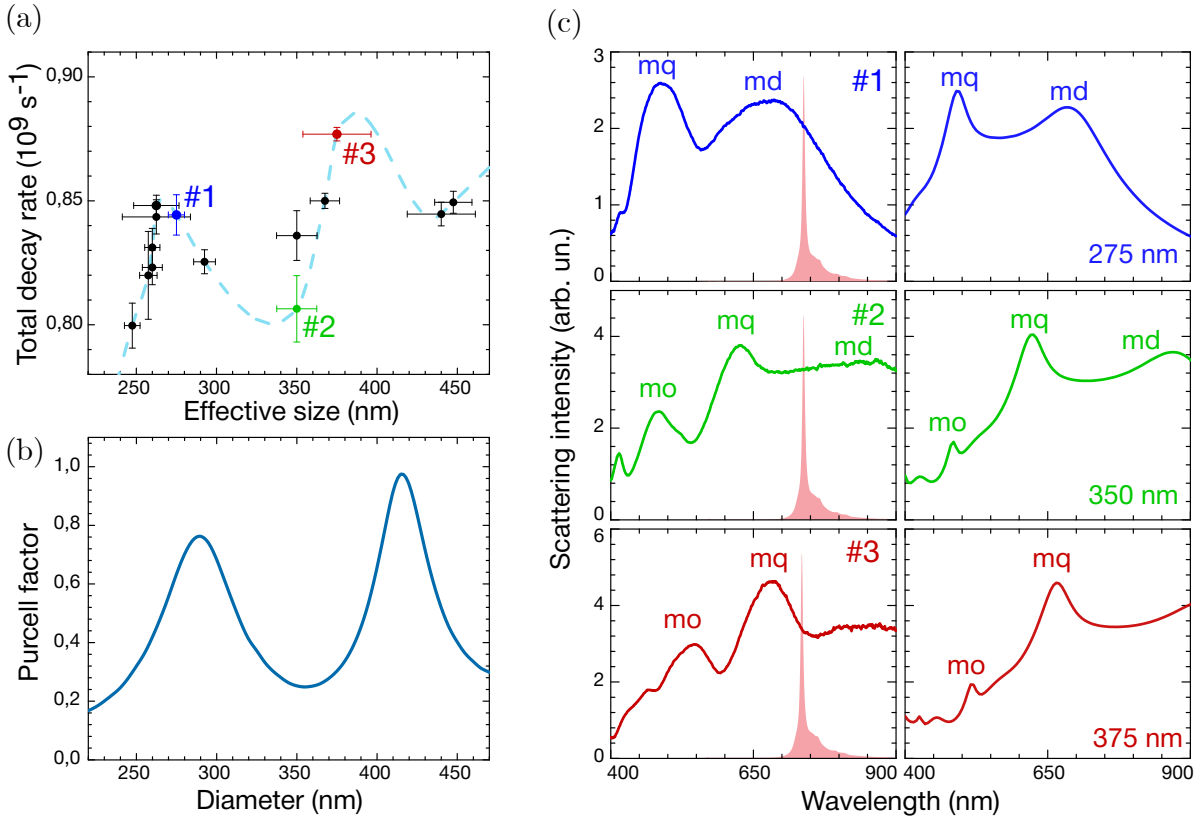

Figure 1: (*a*) — Experimental measurements (dots) of luminescence decay rate. Dashed blue line is a guideline for eyes. The seleced points are denoted by numbers. (*b*) — Numerical calculations of the Purcel factor. (*c*) Left column — experimental scattering spectra for selected particles. Pink areas indicates the SiV centers luminescence spectrum; Right column — calculated scattering spectra. Corresponding diameters used in calculations are shown.

Here we study diamond particles of 250–450 nm in size containing silicon-vacancy (SiV) centers. Measuring the excited state lifetime, we observe that the total decay rate for such particles vary by 5 percent for particles of different size, as shown in Figure 1 (*a*). Considering the fact that a typical value of the quantum yield for SiV centers is about 5 percent, the obtained variance corresponds to a multifold

enhancement of the radiative decay rate. To estimate the dependence of the radiative rate on the particle size, we perform numerical calculations of the Purcell factor for a dipole emitter placed within a diamond sphere standing on a glass surface. The calculations were performed using commercial software *Lumerical FDTD Solutions*. For every particle size the value of the Purcell factor was averaged over the particle volume and all possible orientations of the emitter. The resulting dependence of the averaged Purcell factor is shown in Figure 1 (*b*). This dependence oscillates versus particle size in a similar way as the measured decay rate. Using the dark-field single-particle scattering spectroscopy we have shown that the magnetic dipole and quadrupole modes are excited in the luminescence spectral range for the the studied particles. The measured scattering spectra for 3 selected particles and corresponding numerically calculated curves are shown in Figure 1 (*c*).

In conclusion, we have experimentally demonstrated the effect of Mie resonances in diamond particles on the lifetime of luminescence from their SiV centers. The results demonstrate that the efficiency of diamond-based devices can be improved with particles of a proper size.

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