

# Correlation between Crystal Size and Photo Luminescence Intensity of SiV Centres in HTHP Nanodiamonds

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Over the past decades, colour centres in diamond have attracted interest for applications in many applications such as quantum sensing, quantum communication, and quantum computing. In this paper we have investigated correlation between the size of the nanodiamonds and photo luminescence intensity of silicon-vacancy (SiV) colour centres [1] present in diamond crystals grown using high-temperature high-pressure (HTHP) method. To do this, we have compared the intensities of luminescence and Rayleigh scattering for crystals of different sizes. Because our particles are much smaller than 532 nm, the wavelength of excitation light, the scattering can be accurately described using Rayleigh approximation. In the case of a particle shaped as a perfect sphere, the scattered intensity is proportional to  $d^6$ , the sixth power of the particle diameter. Thus, one can use the rate of scattered photons detected by the photodetector to estimate the size of the spheres.

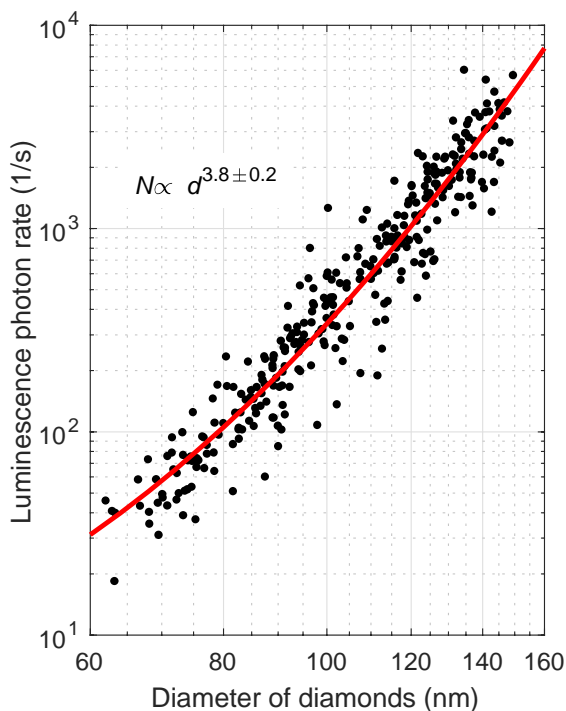


Fig. 1. Correlation between the photon emission rate and the size of nanodiamonds. The red line is the best fit to the model explained in the text.

It has been observed that the luminescence intensity is linearly proportional to the intensity of scattered light, suggesting that the luminescence rate is proportional to the volume of the particles. This result is surprising because a naïve expectation is that the concentration of SiV centres is independent on the size of particles and therefore the luminescence should be proportional to the volume of the particle.

The results have been explained by considering several effects. The first two effects are related to electrodynamics which predicts that the high reflectivity of diamonds affects both, the photo excitation efficiency, and the rate of the radiative transition from the electronically excited state to the ground state. We have also assumed that  $N$ , the number of SiV centres in a crystal is proportional to  $d^n$ , where  $n$  is a fitting parameter. The best fit is achieved if  $n$  is  $3.8 \pm 0.2$ . This value of  $n$  is in a reasonable agreement with kinetics of the crystal growth [2]

and a reasonable assumption that the formation rate of the SiV centres is proportional to the area of the crystal surface. The model predicts that  $N \propto d^4$ . These results explain difficulty of making ultra-small crystals sufficiently bright to facilitate their applications for optical sensing and other fields.

[1] L. J. Rogers et al, *Phys. Rev. B*, **89**, 235101 (2014).

[2] N. T. K. Thanh, N. Maclean, and S. Mahiddine, *Chem. Rev.* **114**, 7610 (2014).