The behavior of electromagnetic waves in disordered media has been a subject of intense studies in the past decade [1–6]. In particular, the regime of strong scattering where the mean free path of a photon becomes comparable to its wavelength has fascinated scientists. In such systems, constructive and destructive interference can lead to the modification of the local density of states (LDOS) in various spatial modes and to the localization of light [7–9]. In an ideal "gedanken" experiment, one might imagine to map the fluctuations of LDOS directly at the subwavelength level. However, so far, light scattering phenomena have been studied via transmission and reflection intensity measurements on macroscopic samples, where separation of the effects of absorption and scattering has posed a challenge [1–3, 6, 10]. In this work, we probe the variations of LDOS by measuring the modification of the spontaneous emission rate of individual nanoscopic emitters. Our experimental strategy is to characterize the fluorescence decay of each emitter first and then trace its change after covering them by a scattering disordered medium.

As emitters, we used nitrogen-vacancy (NV) color centers in diamond nanocrystals (DNC). The size of the DNCs ranged between 10 and 500 nm with an average size of 60 nm, as measured by electron microscopy. The DNCs were treated by irradiation with 1.5 MeV electrons during 8 hours with a total dose of 3 10^{18} e/cm^2. Annealing at 850 C for 4 hours resulted in approximately 1-10 NV color centers in each DNC. Aside from having a high quantum yield, our choice of emitter has two crucial advantages. First, NV centers in diamond are indefinitely photostable so that repeated quantitative measurements can be performed. Second, the color centers are well protected in the diamond lattice against surface effects upon contact with other material [11].

Our scattering sample consisted of a powder of rutile TiO_2 particles (DuPont, Ti-Pure R706) with a mean size of 250 nm and a distribution of 150-350 nm as revealed by electron microscopy. Particles were coated with silica (SiO2, 3 wt %) and alumina (Al_2O_3 2.5 wt %) and had a refractive index of 2.8 [3]. We produced a disordered medium in half space by sprinkling the powder on a cover glass carrying the DNCs. We then compressed the powder manually by applying a gentle pressure via another glass cover slide. The final thickness of the medium was typically about 0.4 mm. Based on the volume and weight of the material that was deposited, we estimated the volume fraction occupied by particles in the compressed powder to be about 30%.

The schematics of the experiment are shown in Fig. 1. The sample was placed on a