Combination of optical microtransmission and microphotoluminescence techniques for local characterization of rare earth doped glass microspheres

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We present an optical characterization of single rare earth doped glass microspheres by means of an innovative experimental setup that combines μ-transmission and μ-photoluminescence (μ-PL) measurements. The microspheres under study were fabricated with the method of G. R. Elliot et al. [1] from bulk borate glass doped with neodymium (Nd^{3+}) ions. [2] The detection stage allows collecting light coming out from a reduced physical region around a lateral edge of the sphere, which reduces the spectral inhomogeneous broadening of the supported modes due to deviations from perfect sphericity. The experimental setup used for realizing μ-PL and μ-transmission measurements is schematized in Figure 1.

We demonstrate that, in μ-transmission, it is possible to obtain significant WGM coupling efficiency even if the external beam is in free space. In addition, a robust oscillating-like signal is clearly revealed, which we explain in terms of excitation of a closed polygonal trajectory experimenting at least 5 internal reflections. By comparing the results of both techniques for a given single microsphere we demonstrate their consistency and complementarity for achieving a more extensive characterization of its optical and geometrical properties.

To illustrate the above, on Figure 2 we show the comparison of the μ-transmission (already normalized by the transmission signal obtained without microsphere) and μ-PL spectra of a microsphere with a radius of R=9.5 μm for TR (orthogonal to the sphere surface) and TM (tangential to the sphere surface) polarizations. The μ-transmission spectra (black curves) consist on oscillating-like signals with sharp signal dips superimposed to them that are associated to WGM. On the other hand, the μ-PL spectra, which are generated by the radiative recombination of optically pumped Nd^{3+} ions, are composed by an offset signal generated by ions that do not couple to microsphere modes and sharp peaks associated to PL signal exciting the WGM of the microcavity. It is remarkable the agreement in the WGM spectral positions showed by both techniques for both polarizations, which indicates that there is no sizeable effect on the microsphere modal structure due to the presence of the pump over the microsphere.

Finally, we discuss how these results may enhance the potentiality of light emitting isolated spheres for sensing applications, since the combination of both techniques can provide trustful information of refractive index changes on the sphere surroundings.

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References

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Figures

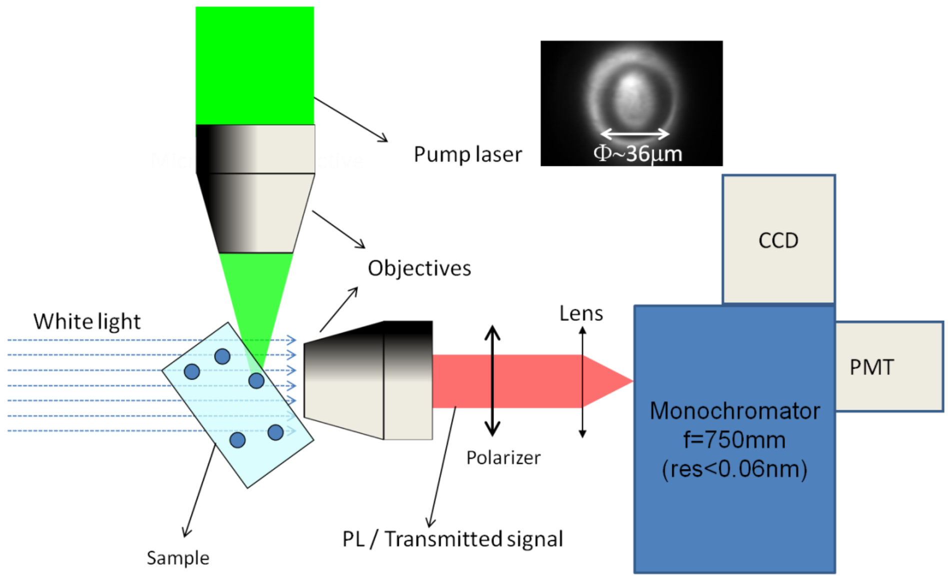

Figure 1. Scheme of the combined μ-transmission and μ-PL setup. It is also shown an image of a microsphere taken with a CCD when the monochromator is in the zero order and the slit of the monochromator widely opened.

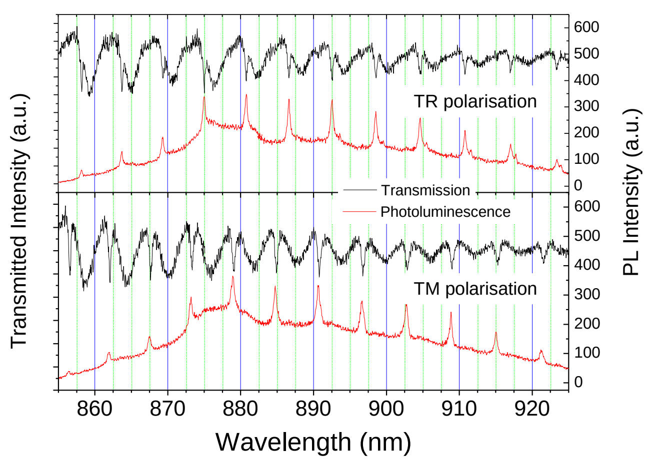

Figure 2. μ-PL (red) and μ-transmission (black) measurements for TM (bottom panel) and TR (top panel) polarizations for a microspheres of R=9.5 μm.