Self-assembled Cadmium-free Semiconductor Microspheres Based on Colloidal Quantum Dots

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A method for the fabrication of cadmium-free, photoluminescent (PL) quantum dot supracrystal microspheres (MS) is implemented, creating red emitting MS. The overall aim is to characterise and develop MS acting as optical microresonators, and to explore their applications in miniature lasers for bioimaging and biosensing using non-toxic semiconductor materials.

Fabrication of whispering gallery mode (WGM) microlasers via self-assembly of colloidal quantum dots (CQDs) has been previously achieved with the caveat of employing toxic metals, and resulting in MS with low solubility [1,2]. Non-toxic InP/ZnS CQDs represent a heavy-metal free alternative for luminescent applications and have been demonstrated as a laser material [3]. By utilising the self-assembly of oleate capped CQDs via an oil-in-water emulsion technique, MS were formed and suspended in water with polyvinyl alcohol as a surfactant. The following step included the addition of polyvinylpyrrolildone, then ammonia and tetraethyl orthosilicate for a thin (<5 nm) coating of silica to allow for improved solubility in water. The MS characterisation consisted of: (i) optical microscope imaging to ascertain the size and size distribution of 5-45 µm; (ii) UV-visible absorption spectroscopy and Scanning Electron Microscopy; (iii) optical pumping with a 355 nm, 5 ns pulsed Nd:YAG laser at a 10 Hz repetition rate with a beam spot area of 2.6 ± 1.5 x10^{-5} cm^2 for PL spectra measurements.

Optical pumping demonstrated the resulting MS PL ability, which differs significantly from their QD precursor's comparatively Gaussian PL. Details of the results of the MS synthesis and of the optical characterisation at different wavelengths will be discussed.

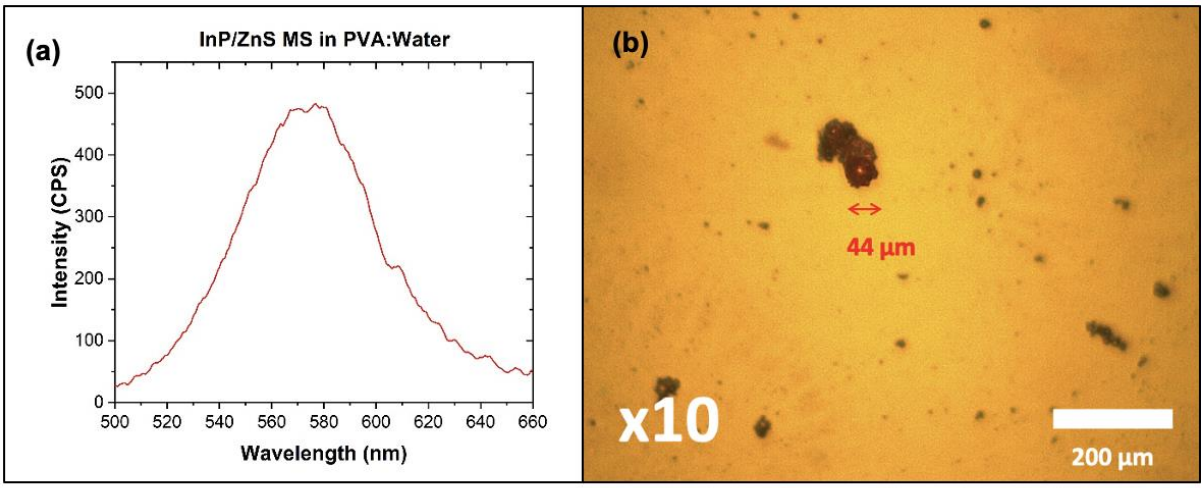

Figure 1. (a) PL spectra of the InP/ZnS MS dropcast on a glass slide and pumped with a 3.237 µJ beam; (b) Image of the MS of 44 µm in diameter corresponding to the PL spectra.

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[3] Jalali, H. B., Sadeghi, S., Yuksel, I. B. D., *et al. Nano Res.*, p1-22, (2022).

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