HORIBA
Scientific

Near-IR Photoluminescence of Quantum Dots

FL-05

ELEMENTAL ANALYSIS
FLUORESCENCE
GRATINGS & OEM SPECTROMETERS
OPTICAL COMPONENTS
FORENSICS
PARTICLE CHARACTERIZATION
RAMAN
SPECTROSCOPIC ELLIPSOMETRY
SPR IMAGING

Introduction

HORIBA Jobin Yvon's NanoLog® spectrofluorometer, specially optimized for recording near-IR fluorescence from nanoparticles, includes a double-grating excitation monochromator, imaging emission spectrograph with a selectable-grating turret, and a variety of detectors. It has optimal excitation optics[1] for single-wall carbon nanotube (SWNT) research or *any* solid sample in right angle or front-face mirror configurations.

Quantum-dot photoluminescence is becoming an important tool in materials science, biology, medicine, and energy. The NanoLog® can be customized to provide steady-state and lifetime information about quantum dots.

Photoluminesce lifetimes

The NanoLog® can be fitted with a time-correlated single-photon counting (TCSPC) multichannel-scaling (MCS) accessory (Fig. 1). A variety of quantum-dot samples, supplied by Evident Technologies[2], were examined with this scheme. In Fig. 2, the sample was a dispersion of quantum dots (PbS + polycarbonate) in $CHCl_3$. A pulsed laser-diode (50 kHz, λ = 980 nm, pulse-width ≈ 450 ps) excited the sample. Emission was recorded at 1465 nm with a bandpass of 64 nm using MCS on a Hamamatsu 10330-75 near-IR photomultiplier tube.[3] (With our TCSPC and MCS cards, the 10330-75 can resolve lifetimes from 60 ps to DC.) Time per channel was 100 ns. Measurements were continued until the peak channel reached 100,000 counts. Reconvolution was unnecessary when fitting the decay, for the laser pulse occupied only one channel.

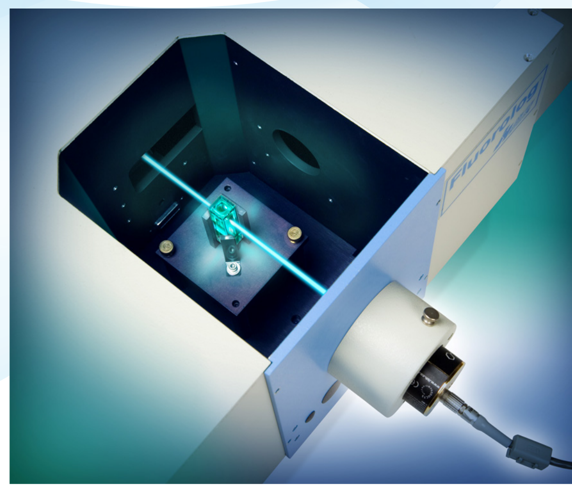

Fig. 1. TCSPC/MCS accessory attached to the sample compartment of a NanoLog®.

Using a bi-exponential model, the X^2 = 1.001 and a Durbin-Watson statistic = 1.957 were found, indicating an excellent fit to the data in Fig. 2. The two recovered lifetimes for the quantum dots were τ_1 = 242 ns and τ_2 = 928 ns.

A second sample of quantum dots (PbS and polymethylmethacrylate, PMMA) dispersed in toluene was examined in the NanoLog®. Experimental parameters were similar to the previous sample, except that emission was recorded at 1115 nm. Results are provided in Fig. 3.

[1] Xe lamp and reference diode operate from 250–1000 nm; excitation monochromator's gratings blazed at 500 nm for excitation at 333–1000 nm.
[2] Evident Technologies, 216 River Street, Suite 200, Troy, NY 12180.
[3] Sensitivity = 950–1700 nm, time-transit spread = 300 ps.

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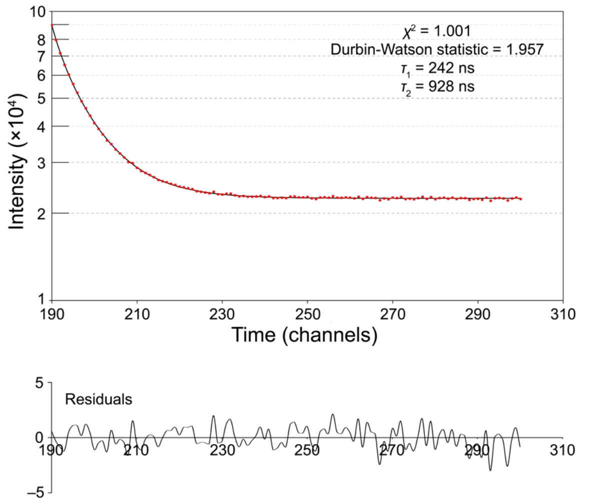

Fig. 2. Fluorescence decay (upper plot) of PbSpolycarbonate quantum dots in $CHCl_3$ (Evident Technologies), and residuals to the fit (lower plot). Low residuals plus excellent X^2 and Durbin-Watson statistics show that the data fit well to the model.

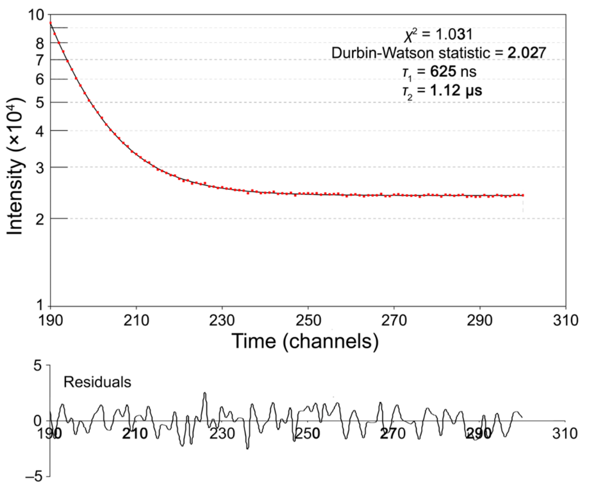

Fig. 3. Fluorescence decay of PbS-PMMA quantum dots in toluene, supplied by Evident Technologies. The upper plot shows the decay; the lower plot is the residuals to the fit. As with Fig. 2, small residuals plus excellent X^2 and Durbin-Watson statistics indicate that the data fit well to the model.

From the same bi-exponential model, X^2 = 1.031 and a Durbin-Watson statistic = 2.027 were found, also indicating an excellent fit to the data in Fig. 3. The two recovered lifetimes for these quantum dots were τ_1 = 625 ns and τ_2 =1.12 µs.

A table of results for a variety of PbS quantum-dot dispersions is given below:

Dispersant	τ_1 **(µs)**	τ_2 **(µs)**	X^2
λ_{abs} = 1040 nm; λ_{exc} = 980 nm			
Polystyrene	1.82	0.69	0.91
PMMA	2.52	1.37	0.97
Polycarbonate	2.22	0.79	1.10
Flexographic ink	0.57	0.17	1.10
λ_{abs} = 1400 nm			
Polystyrene (λ_{exc} = 980 nm)	1.00	0.61	1.14
Polystyrene (λ_{exc} = 635 nm)	0.93	0.57	1.19
PMMA (λ_{exc} = 980 nm)	1.12	0.62	1.03
PMMA (λ_{exc} = 635 nm)	1.11	0.62	1.20
Polycarbonate (λ_{exc} = 980 nm)	0.93	0.24	1.00
Polycarbonate (λ_{exc} = 635 nm)	0.96	0.40	1.13
Flexographic ink (λ_{exc} = 980 nm)	0.30	0.14	0.95

Conclusions

The NanoLog® is an indispensable tool for studying fluorescence lifetimes of samples whose luminescence is primarily in the near-IR, such as quantum dots. Other uses for the NanoLog® include solid-state research, biosensing, and cancer studies. The NanoLog® is also available with TCSPC multichannel-scaling options of 500 ns/channel and 2 ns/channel, as well as a broadband 5509 photomultiplier tube, sensitive from 300–1700 nm, with a time-transit spread of 1.5 ns.