HORIBA Scientific

New Hybrid Picosecond Photon Detector (HPPD) Series

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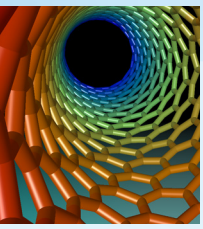
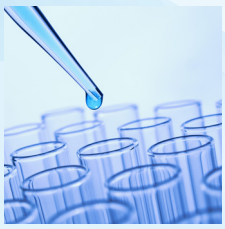
GRATINGS & OEM SPECTROMETERS
OPTICAL COMPONENTS
FORFNSICS
PARTICLE CHARACTERIZATION
RAMAN
SPECTROSCOPIC ELLIPSOMETRY
SPR IMAGING





HORIBA's latest development in TCSPC detector technology

Background

The HPPD is our latest development in TCSPC detector technology that combines the benefits of conventional PMT design (wide spectral response and large active area) with the advantages of solid state APD technology (good detection efficiency, negligible after-pulsing and exceptional temporal resolution). Hybrid detectors are becoming the first choice for FLIM and short lifetime determination. An illustration of the layout of the HPPD module is shown below in Figure 1.

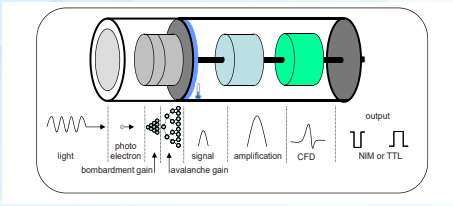


Figure 1: Schematic of HPPD detection module. Detector head includes Hybrid PMT tube, high voltage bias generators, GHz pre-amplifier, tuned CFD, microprocesor, and TE cooler in compact package.

HPPD Benefits

-5ps lifetime resolution
-High quantum efficiency (QE)
-Reduced afterpulsing resulting in better decay residuals
-Temperature controlled for stability (Peltier)
-USB interface
-Fully shielded design

Figure 2 shows QE curves of the 5 different HPPD variants, available at the time of product launch. Note that the different models have different specifications that are summarized in Table 1. Some variants (-650, -860) excel in timing performance.

Choosing the correct model will depend on the application requirements. If the application involves measuring a short fluorescence lifetime, then a model capable of measuring a fast IRF would be recommended (HPPD-650, HPPD-860). On the other hand, for applications with low light levels, such as FLIM, a detector offering a higher QE will be desired. (i.e. HPPD-720).

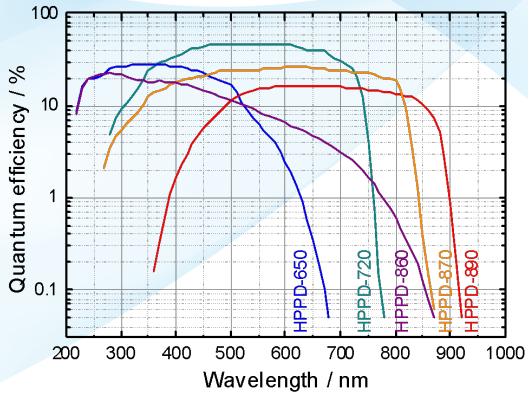


Figure 2: QE curves of HPPD series

	Spectral Range	IRF (FWHM) @ 400nm	Max QE (%)	Active Area (mm)	Dark Counts
HPPD-650	220-650nm	~50ps	28% (340nm)	6	<100cps
HPPD-720	300-720nm	~120ps	47% (530nm)	3	<1000cps
HPPD-860	220-860nm	~50ps	23% (280nm)	3	<200cps
HPPD-870	300-870nm	~130ps	26% (630nm)	3	<500cps
HPPD-890	380-890nm	~160ps	16% (630nm)	3	<1000cps

Table 1: Specification of HPPD series

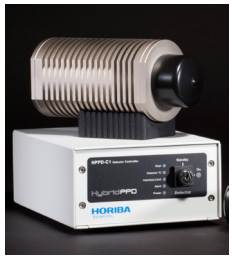


Figure 3: HPPD-C1 controller is included with the module, with simple turn key operation. It is interchangeable with HORIBA's PPD detectors.

Data with HPPD modules

The responses measured using a DeltaDiode-405L and DeltaDiode-635L with the FluoroHub-A+ timing electronics and HPPD-650 are shown in Figure 4. The FWHM was obtained 36ps and 52ps, respectively. The general rule of thumb when measuring fluorescence lifetimes is that with reconvolution it is possible to resolve 1/10 of the FWHM of the IRF. Using this as a guide, the shortest lifetime value that can be measured with these HPPD modules approaches the limit of TCSPC (~5ps). This is comparable to what can be measured using an expensive and fragile MCP-PMT detection module. Note that the source and the timing jitter of the electronics also play a key role in determining such short lifetimes.

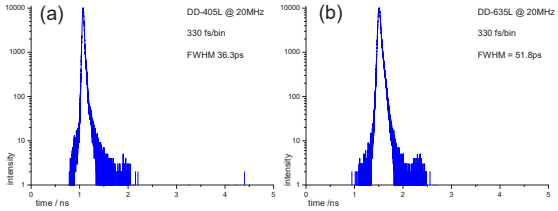


Figure 4: Typical IRF measured with HPPD-860

Figure 5 shows a comparison of DASPI (τ ~ 60ps lifetime) acquired on a DeltaFlex-01-DD equipped with DD-405L, FluoroHub-A+ with a HPPD-860 vs. MCP-PMT.

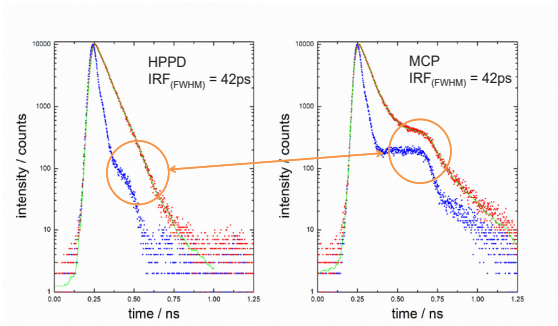


Figure 5: Comparison of DASPI decay data with HPPD vs MCP.

Although both detectors, HPPD and MCP, are able to measure a IRF FWHM of 42ps, the response measured on the MCP has an afterpulse which can make it more difficult to measure shorter lifetimes. Note that in Figure 5 the afterpulse, characteristic of the MCP-PMT, becomes more clear with the use of higher resolution electronics, such as the FluoroHub-A+ with a timing jitter of ~ 8ps.

A comparison between the HPPD-860 and MCP-PMT is shown below.

	HPPD-860	MCP-PMT (R3809-50) COOLED
Typical IRF FWHM at 400nm	40 - 45ps	40 - 45ps
Shortest measurable lifetime	5ps (lower afterpulse) √	5ps
Wavelength response	220 - 860nm	160 - 850nm
Max counting rate	5M cps √	50k cps
Amplifier + CFD	Integrated (no cable) √	External
High voltage bias	Integrated (no cable) √	External
Compatible with Phos and steady state	Yes √	No (requires 2nd detector)
Cooling	Integrated TEC (air-cooled) √	External (water-cooled)
Dark count rate (Cooled)	<200 cps	<20 cps √
PC interface	USB √	N/A

Table 2: Comparison of HPPD-860 and MCP-PMT specifications

Use of HPPD for Steady State Measurements

The HPPD-650 was also integrated into the Fluorolog-11 system. The water Raman s/n was calculated to be slightly better (~5%) than that of the standard R928 tube.

Linearity of the HPPD-650 was compared to the R928 by measuring the water Raman signal at 397nm, 8nm slits as a function of increasing attenuation of signal by adding ND filters. As seen in figure 6 below, the linearity is similar between the HPPD-650 and R928. Although it is not recommended to expose the R928 to light levels >2MHz, the HPPD modules have a linear response beyond 10MHz.

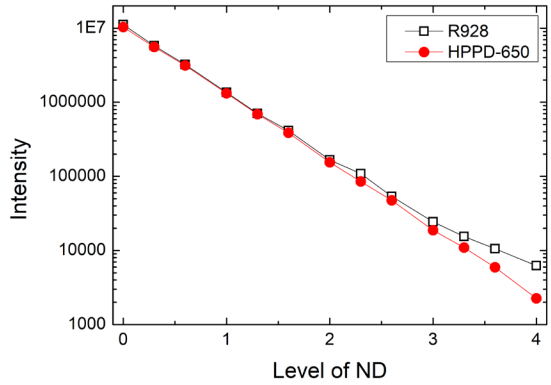


Figure 6: HPPD vs. R928 on Fluorolog

Conclusions

These new HORIBA HPPD detectors offer performance and specifications superior to all competition. Choosing the correct variant depends on the application. We recommend the HPPD-860 for most fluorescence lifetimes due to the spectral range and TTS of <50ps enabling the determination of lifetimes to the limit of TCSPC (~5ps). For FLIM applications, we would recommend the HPPD-720 because of its high QE allowing for the efficient collection of photons.

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