IPD Position Sensing Photomultipliers

Photograph shows the IPD425 and 440 models

Features

- Simple photon counting
- High resolution 62 micron FWHM
- Fast response - less than 5ns
- Resistive film anode
- High gain - 5x107
- Compact end - on geometry
- Broad spectral response - UV to IR

Applications

Time resolved fluorescence imaging

- Time resolved spectroscopy
- Tracking and position sensing
- Speckle interferometry
- UV flame detection
- Replacement for ITT F4146

Introduction

The IPD (Imaging Photon Detector) is a two dimensional imaging sensor capable of detecting extremely weak radiation and when used in conjunction with Photek's IPD processing electronics, is capable of presenting the information in digital form immediately for computer processing and in analogue form for a real time display on an oscilloscope. It can also be used to time - tag individual events, enabling quantitative measurements to be made in both space and time.

The IPD system is able to generate a TV quality picture with an input light level of a few photons per second, approximately one million times more sensitive than the average night surveillance (LLTV) camera.

The 25mm format is most commonly used for microscopy, whereas the larger format detectors (40mm and above) are commonly used for X-ray crystallography and auto radiography.

General Description

The IPD is a position-sensing high gain photomultiplier tube using a cascaded stack of four microchannel plates as the imaging electron multiplier. Single photoelectron event charge pulses generated by the MCP stack are collected by a special two dimensional resistive anode, which splits the charge pulse proportionally among four output corner electrodes. Electronic processing of the four simultaneous output charge pulses determines the x-y address and time of occurrence of each detected input photon event.

The IPD incorporates a flat, 'end-on' input window and photocathode and is available is 25 or 40mm active diameter versions. The proximity focused gap between the photocathode and the MCP can be electronically gated for device protection and for time - sensitive detection.

Principles of Operation
Photoelectrons released from the photocathode by incident photons of suitable energy, are drawn to the microchannel plate (MCP) by means of a strong electric field, causing the electrons to reach the MCP before they have time to drift laterally. The cathode is said to be proximity focused to the MCP. This imaging technique is inherently free of distortion and gives excellent temporal and spatial response. On entering one of the micro channels, a primary photoelectron strikes the channel wall, liberating a shower of secondary electrons which are all accelerated down the channel, hitting the wall and producing further secondary electrons in the process.

In order to achieve sufficient gain, a stack of four MCP's are usually employed with their bias angles arranged in such a way as to reduce the feedback ions and consequent degradation of the photocathode. The electron multiplication achieved in the MCP 'stack' is about 5x107 electrons per event. The rear plate runs in a 'saturated' gain mode, where space charge effects in the channels limit the gain, giving rise to a well peaked pulse height distribution.

The electrons are drawn by an electric field to a position sensitive anode. When a charge cloud strikes the anode, a fraction of the charge leaves via each of the four corners, which are at 'virtual' earth. The resultant pulses are amplified by fast preamplifiers (one for each corner of the anode), shaped, buffered and then fed to a signal processing unit.

Resolution and Distortion
The resolution and any distortion of the image produced by the IPD system are caused by contributions from the IPD tube, anode design, the charge pre-amplifiers and the processing electronics. The Photek IPD image tube is a proximity focused device which has zero inherent distortion. The inherent resolution of the tube itself is approximately 30 microns FWHM, but the final resolution depends upon the electronics read-out system used.

Position Detection Algorithm
The position of a photon event may be calculated by measuring the peak voltage of the pre-amplifiers for each corner A,B,C,D of the anode. The following algorithm is then used to obtain the X and Y positions:

X = (A-B)*scale / (A+B+C+D)
Y = (B-C)*scale / (A+B+C+D)

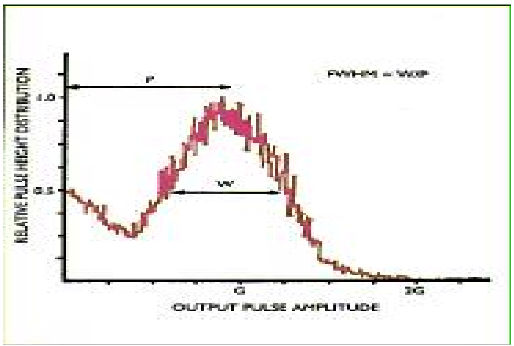
Specification

	IPD 425	IPD 440
Resolution	60 microns FWHM*	100 microns FWHM*
Distortion	5%	5%
Uniformity	+/- 15% max**	+/- 20% max***
Pulse rise time	Less than 5ns	
Gain	50,000,000	
Pulse height, width/peak	200% Max	
Peak/valley ratio	1.5 : 1	

Spectral Response
While the quantum efficiency is much lower than that of silicon, it has to be remembered that the usual practice in CCD systems is that several photo electrons are 'binned' into each ADC count, whereas with the IPD each photo electron registers as one count. The IPD therefore has a better detected quantum efficiency (DQE) than silicon CCD systems at short wavelengths.

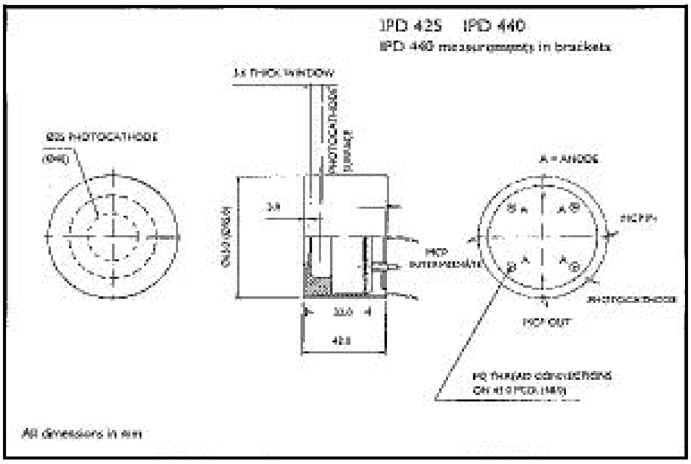
High energy photons, such as X-rays and Tritium Beta particles can be counted and imaged at close to 100% counting efficiency. The UV response is not only defined by the type of cathode but also by the input window material. Stock windows include MgF2, fused silica, glass and fibre optics. Photek also supplies detectors mounted on vacuum flanges for vacuum UV and particle detection.

Pulse Height Distribution
In order to obtain consistent results with good resolution, it is essential that the rear MCP operates in the saturated mode. The pulse height is controlled by the MCP voltage and is pre-set in the factory to match the head pre-amplifier sensitivity. Typical pulse height distribution is shown below.



Count Rate
Average count rates should be kept below 100,000 counts/ sec in order to avoid significant coincident losses. Local count rates are limited to around ten photons per pixel per second by the recovery time of the MCP's. Special high conductivity MCP's can be built into the IPD allowing local count rates of

Mechanical



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