Detector Selection Guide

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8/13/09

Introduction

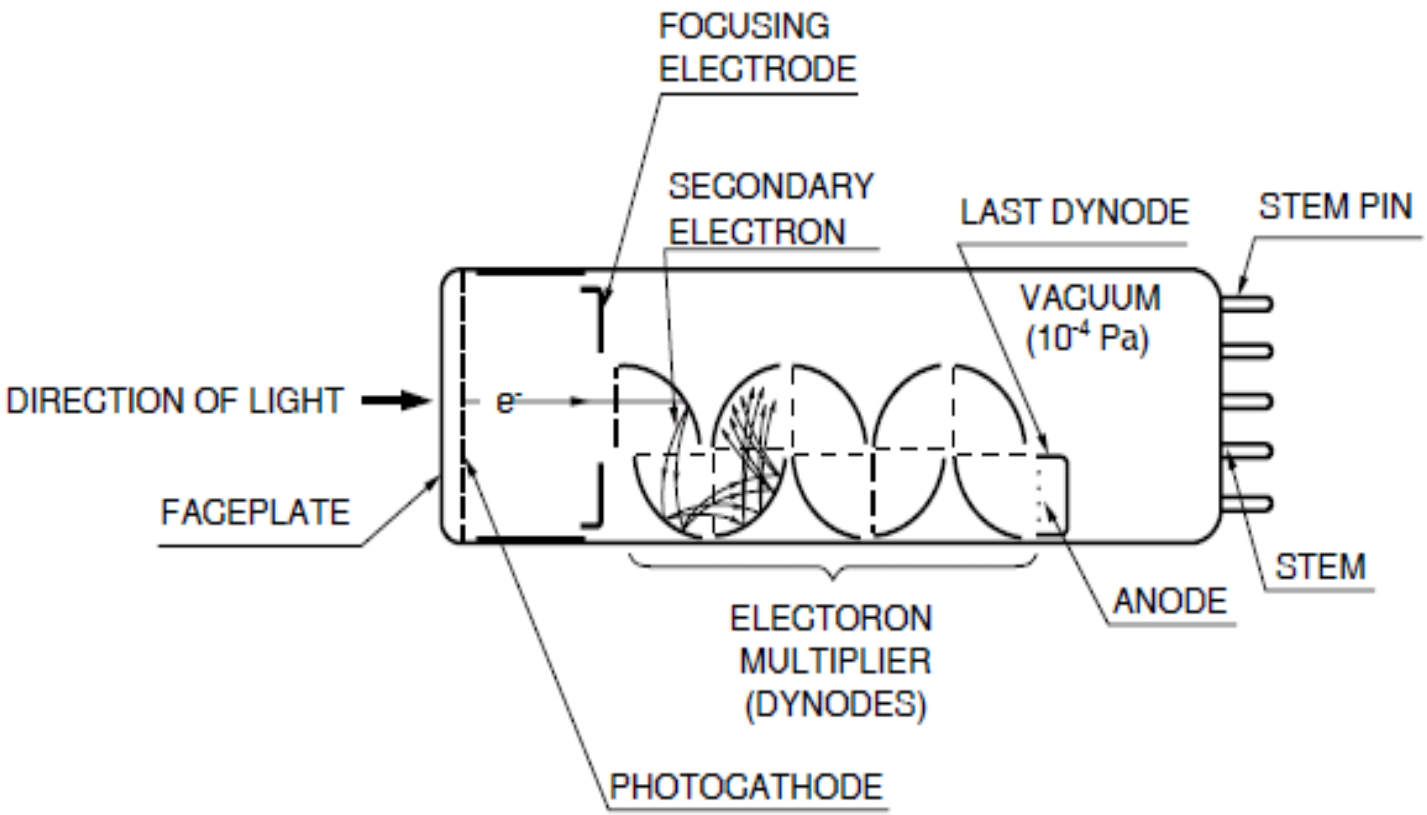
- Introduction
- PMT
- Photodiode
- APD
- CCD
- Summary

HAMAMATSU Photonics

PMT

HAMAMATSU Photonics

PMT – Operation Principle



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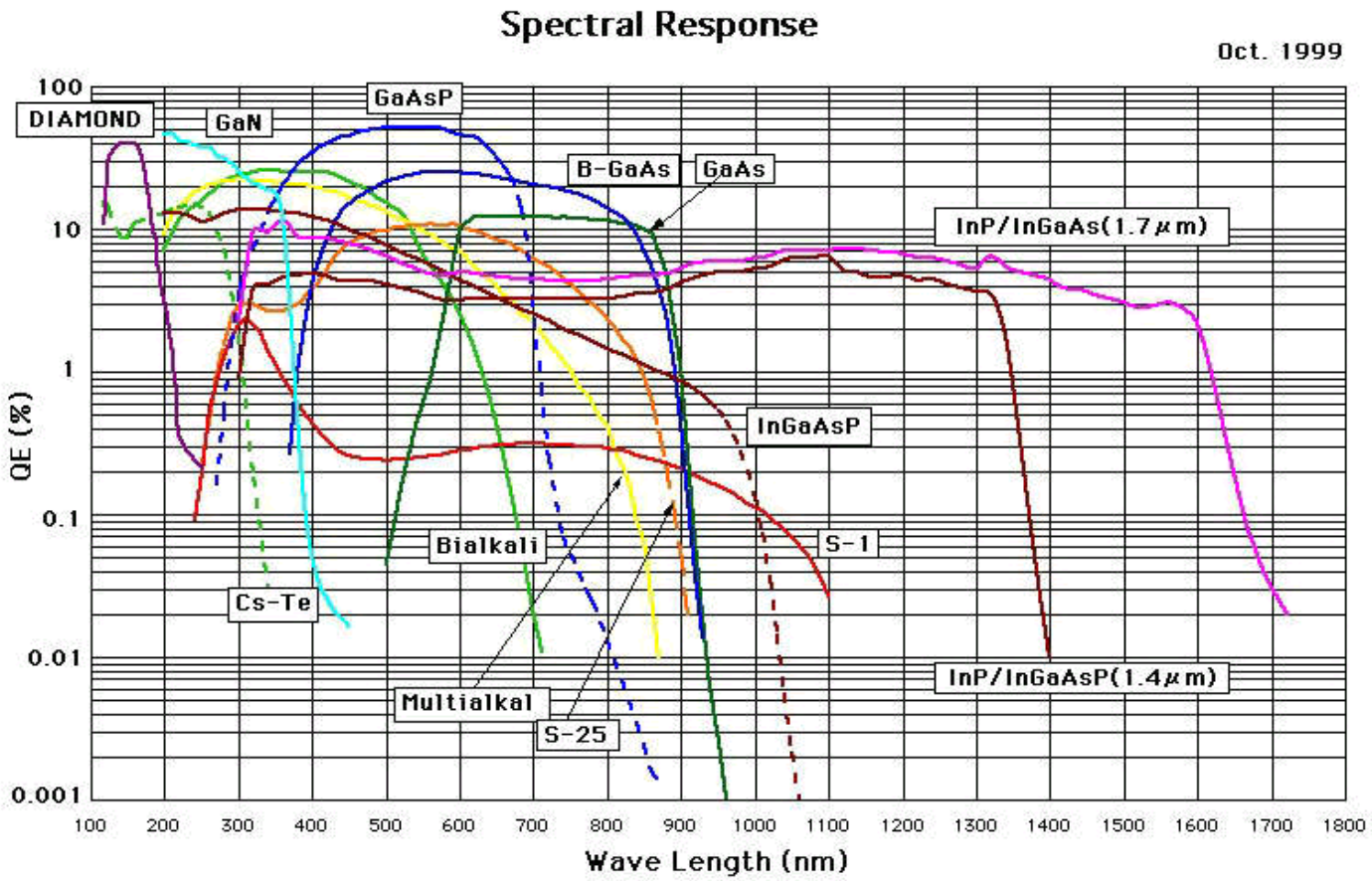
PMT – QE



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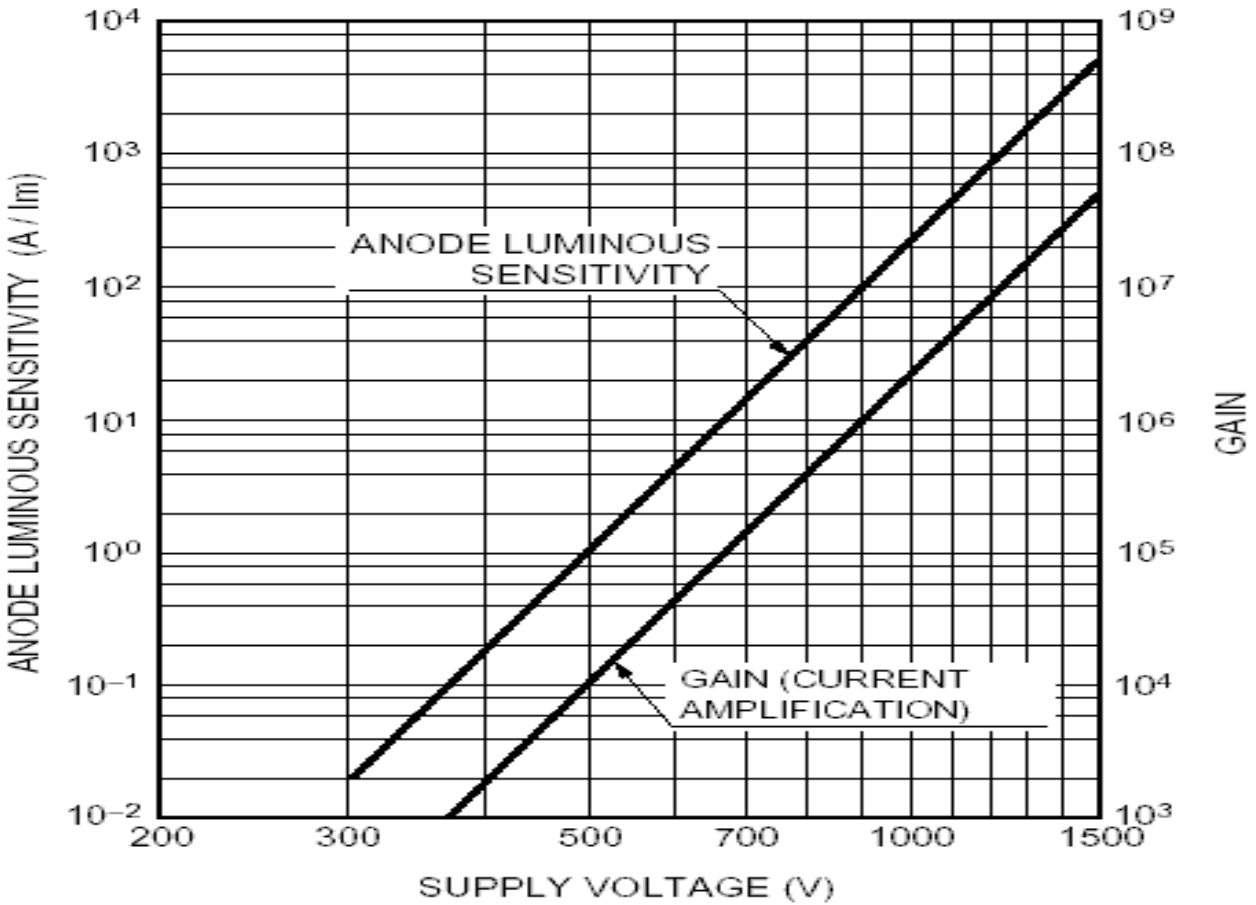
PMT – Gain



TPMOB0058EB

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PMT - Strength

- Strength
  - Gain (1M to 10M)
  - Excess Noise Factor (F = 1.2 typ)
  - Large Area (1/2 in to 2 in)
  - Speed (Tr = few nsec)

Excess Noise Factor

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PMT - Weakness

- Weakness
  - QE (1% to 40%)
  - Easily Damaged
  - High Voltage (1000V)
  - Piece to Piece Variation (Sens, Dark, etc)

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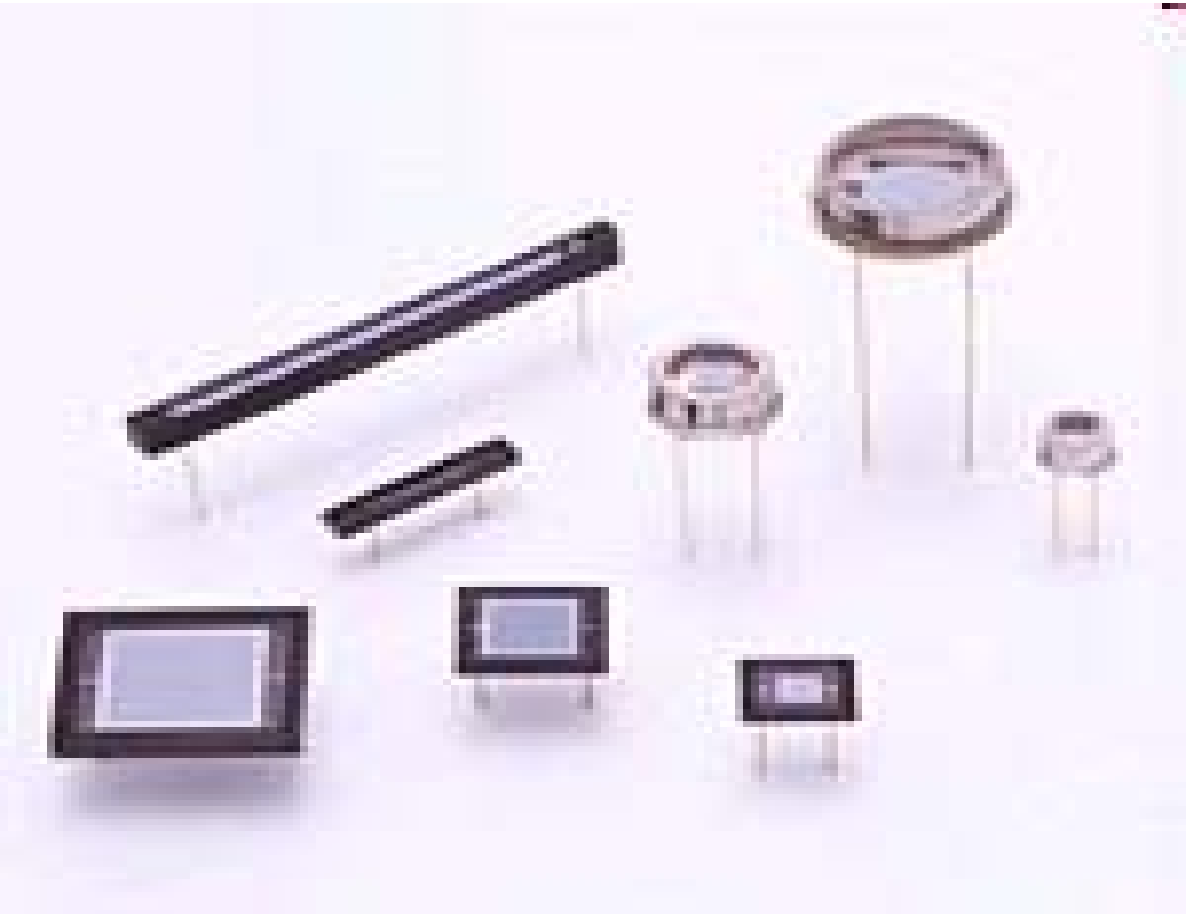
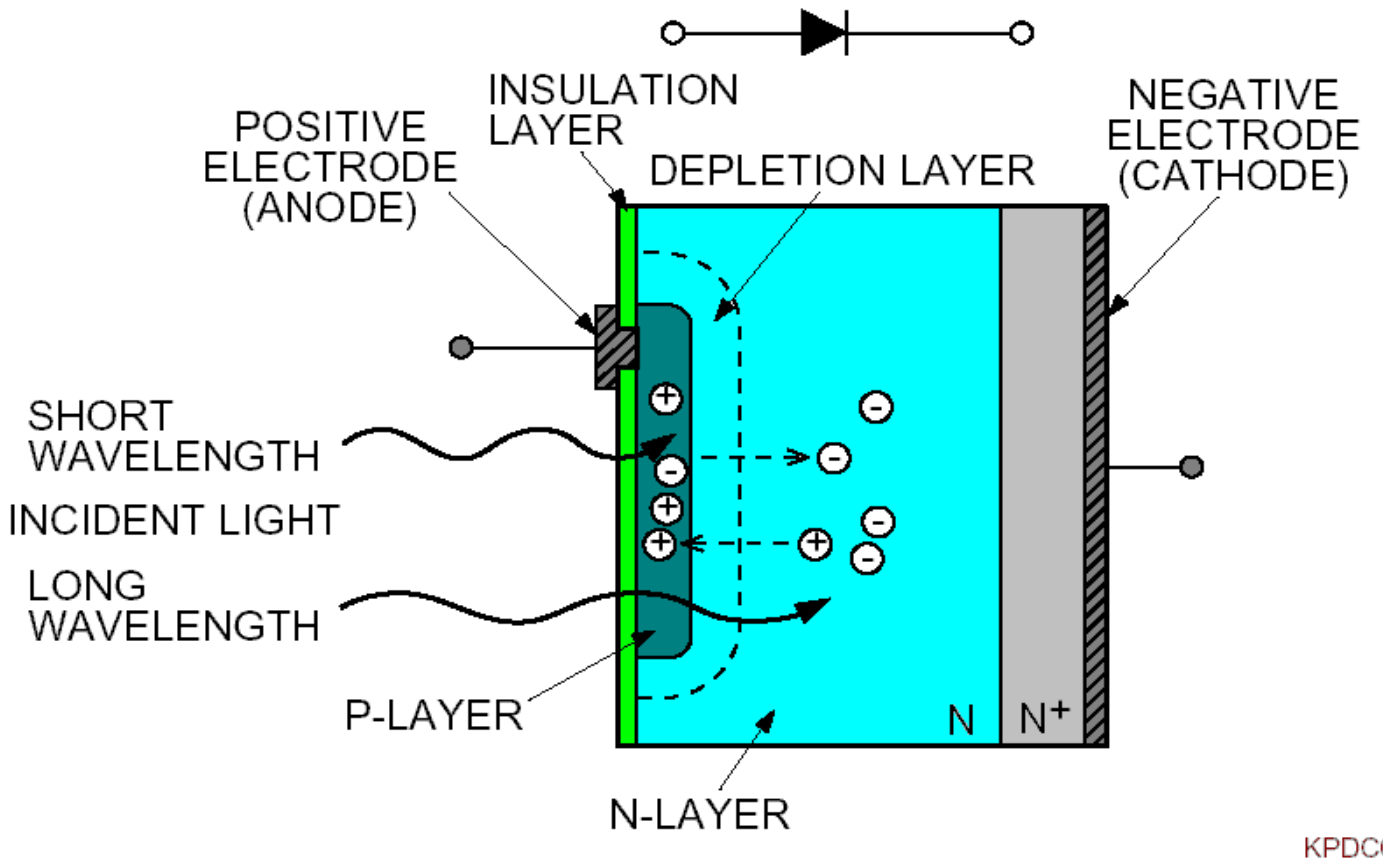
Photodiode



HAMAMATSU Photonics

Photodiode – Operation Principle



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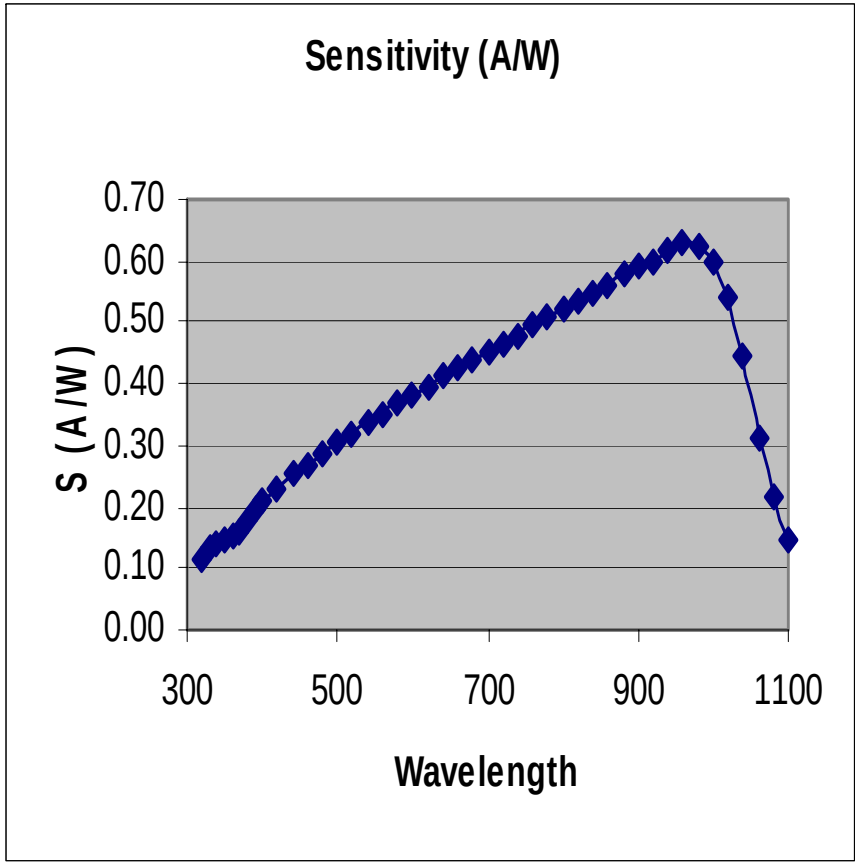
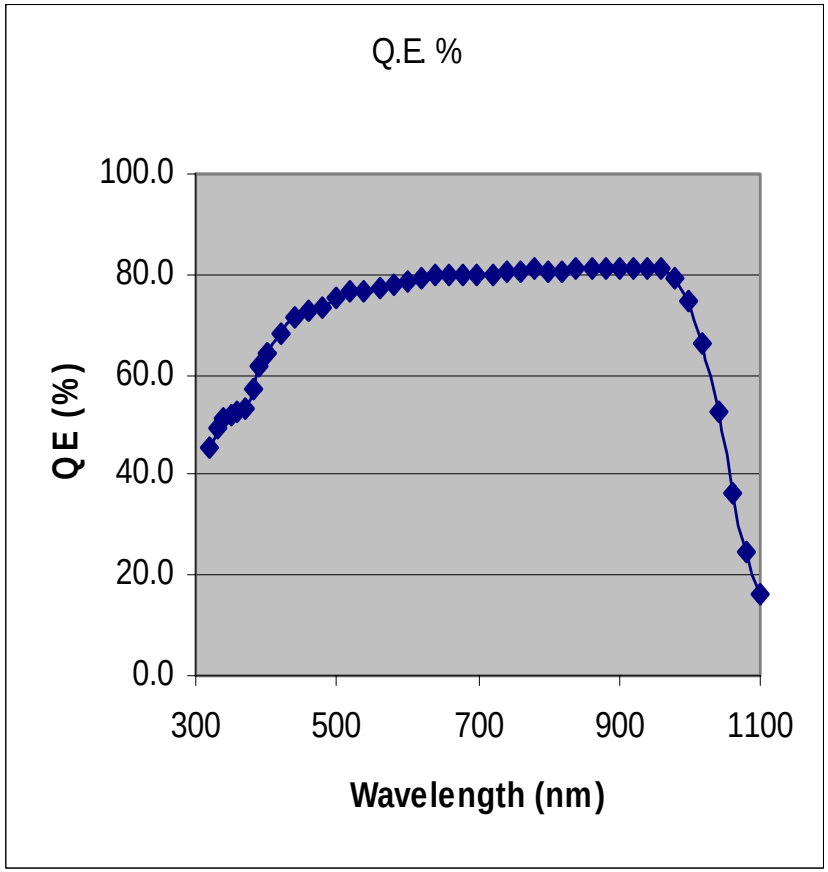
HAMAMATSU Photonics

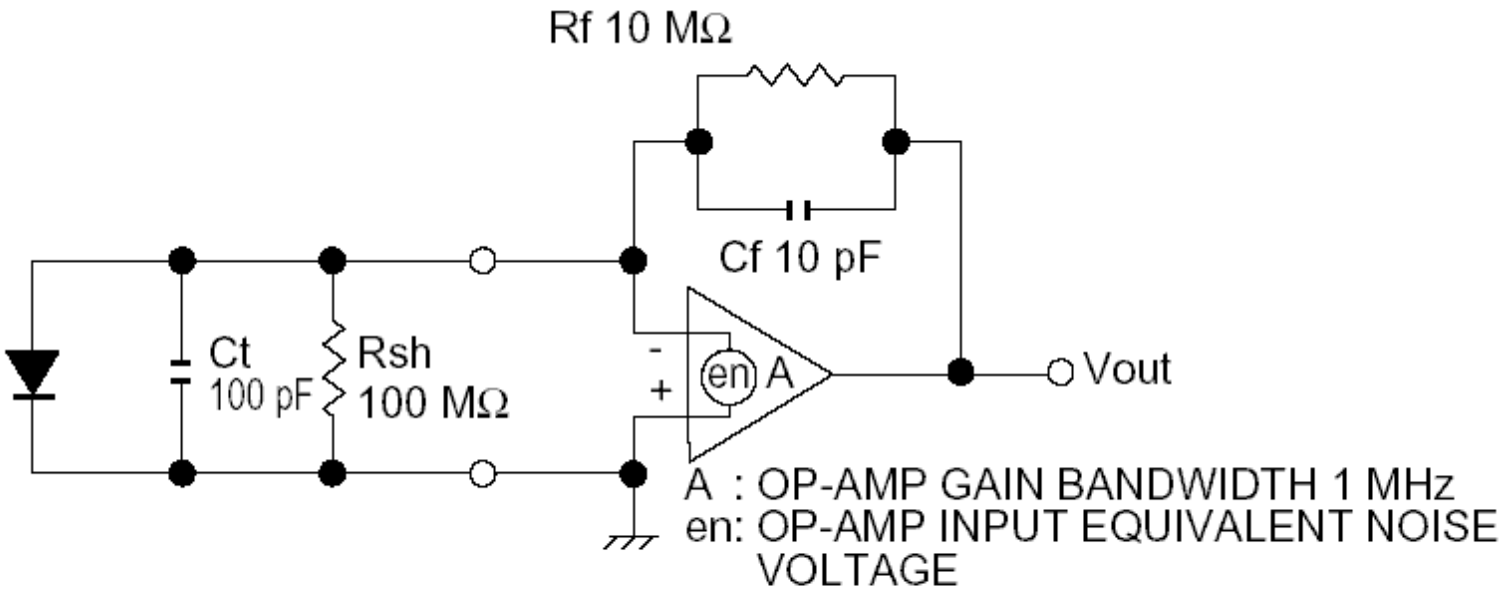
Photodiode - QE





HAMAMATSU Photonics

Photodiode - Gain



Amp Noise

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Photodiode - Strength

- Strength
  - Cost (sub$ to $100)
  - Large Area (- few cm)
  - QE (40 - 80%)

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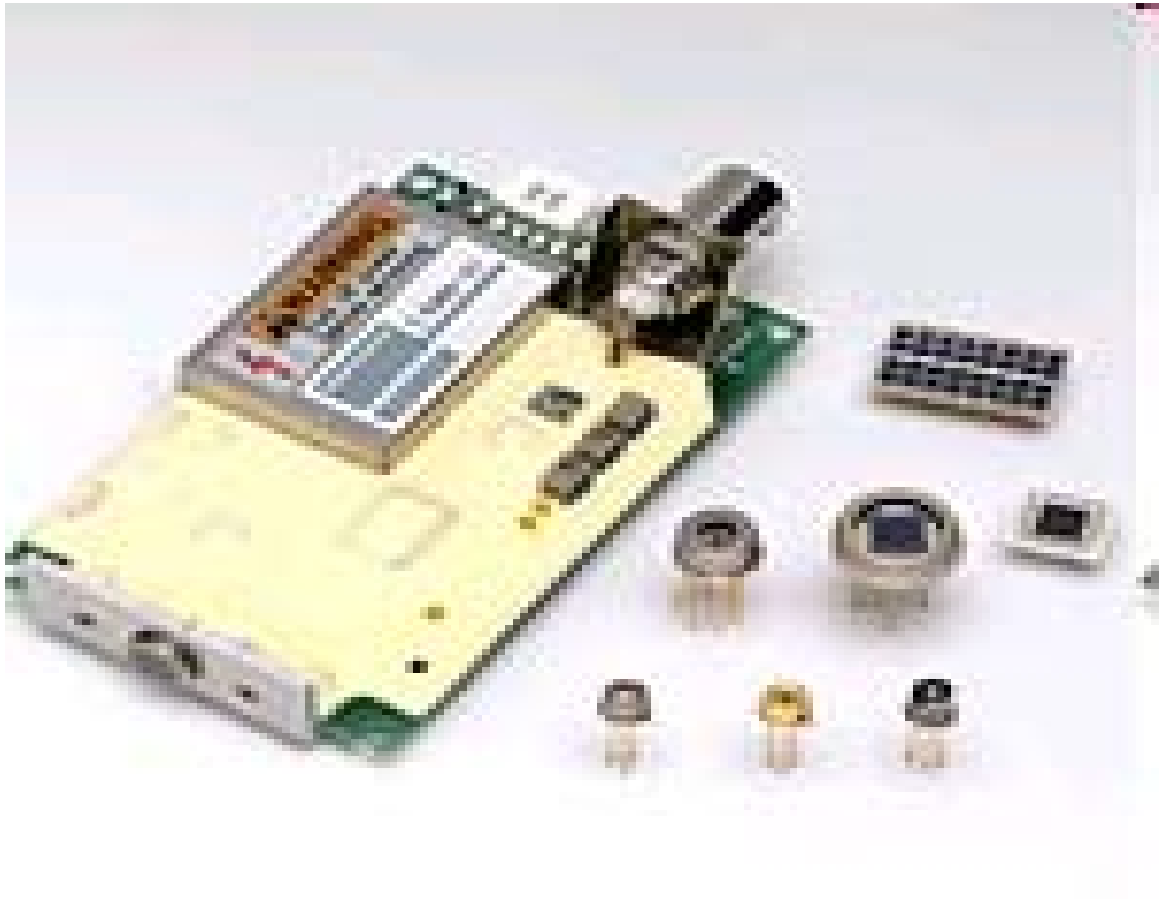
Photodiode -Weakness

- Weakness
  - No gain
  - Amp noise

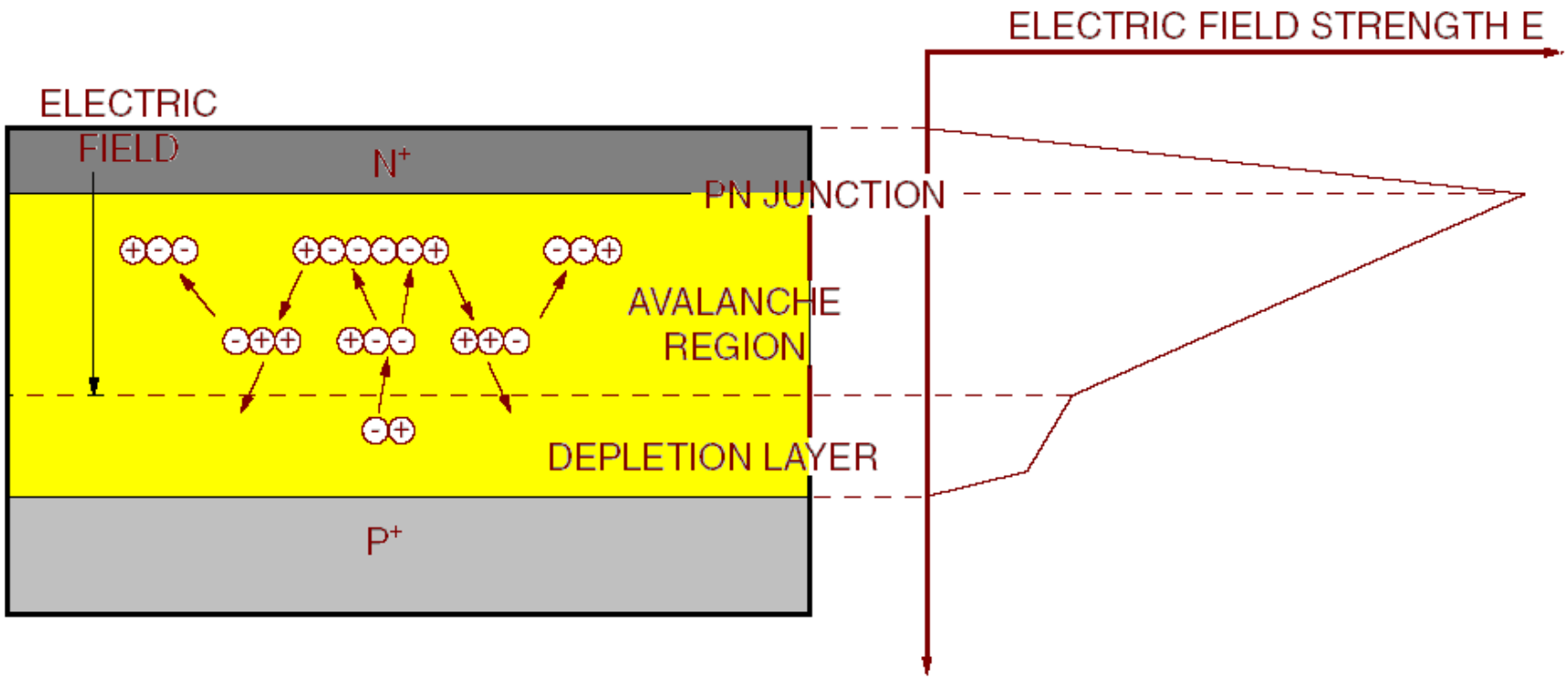
HAMAMATSU Photonics

APD



HAMAMATSU Photonics

APD - Operation Principle



VIS Type

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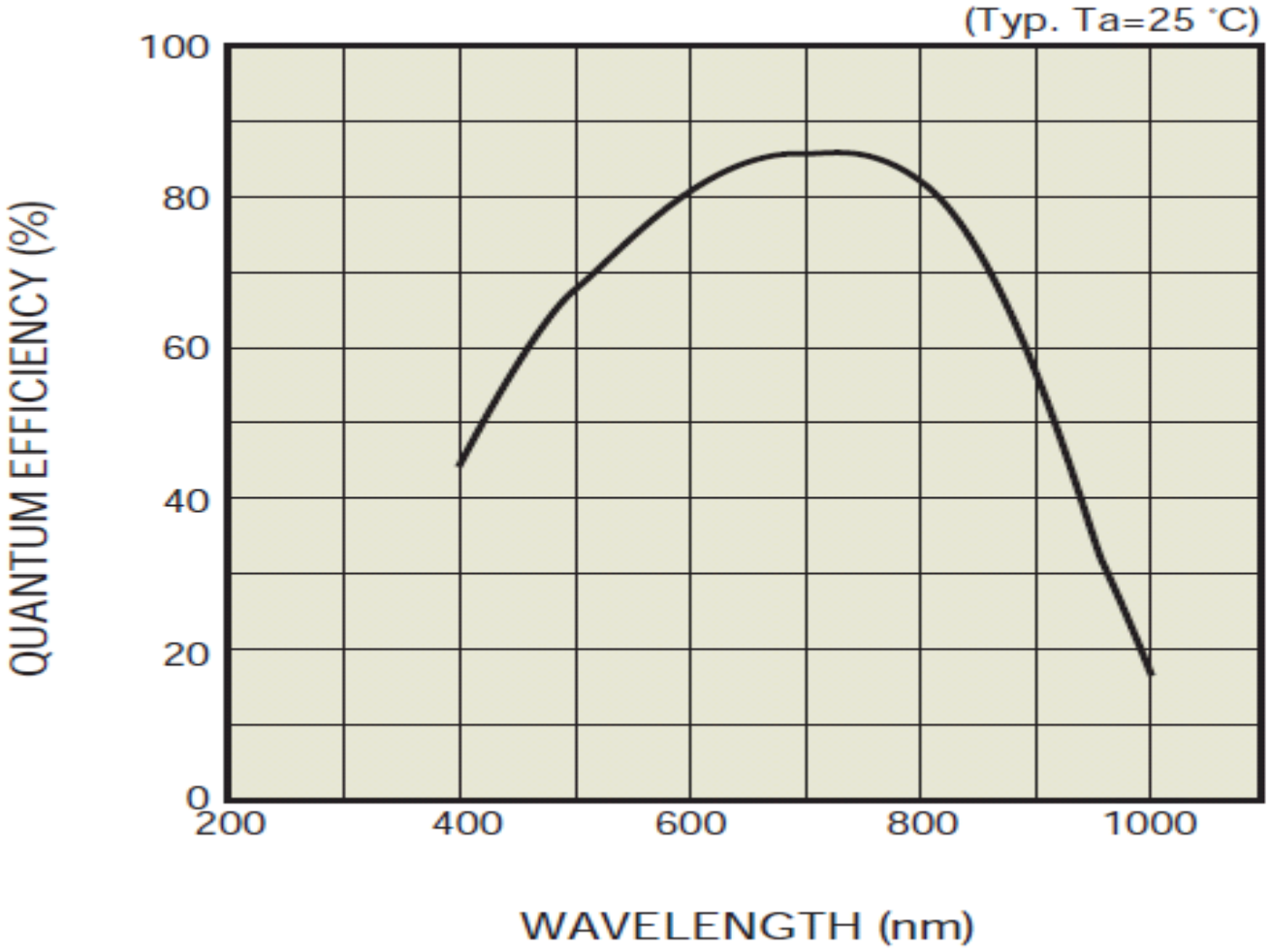
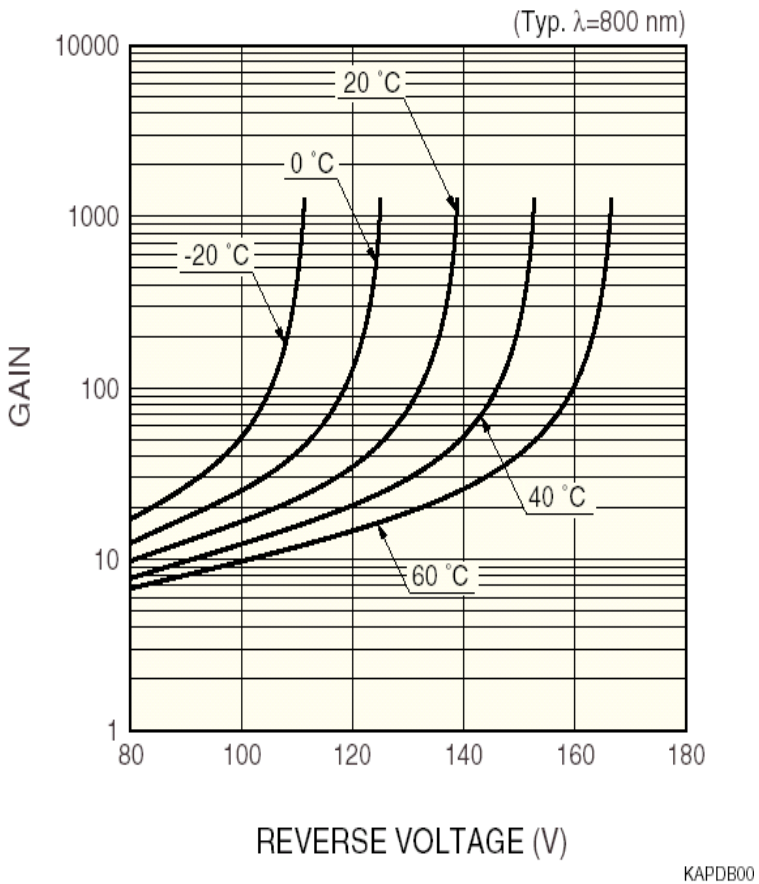
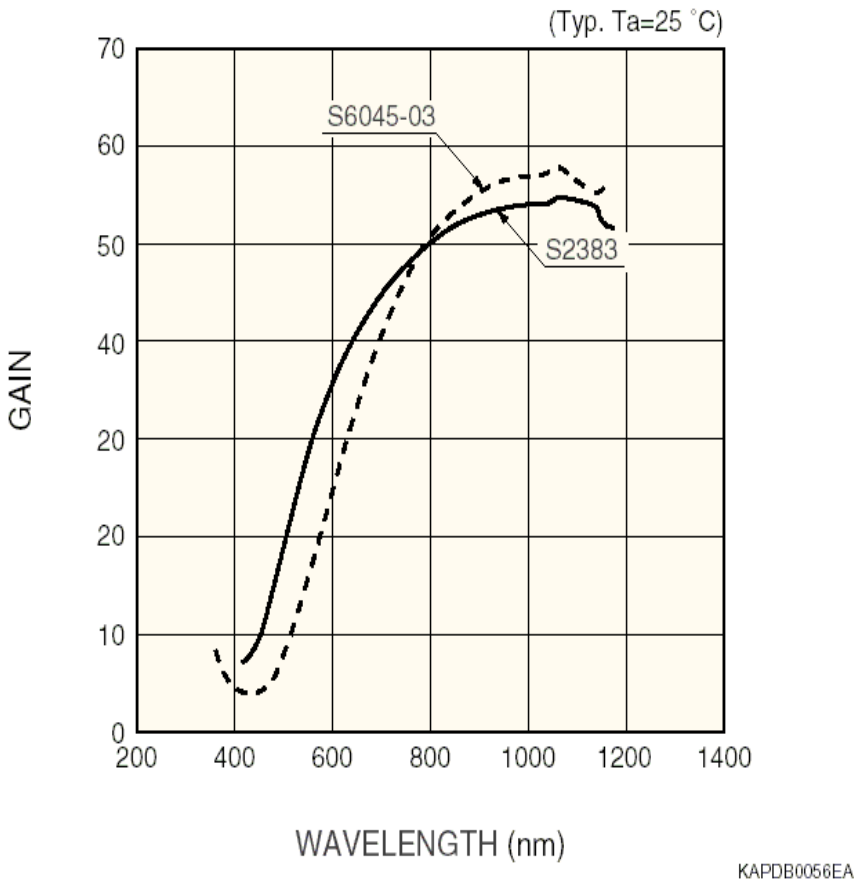
APD – QE



HAMAMATSU Photonics

APD - Gain





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APD - Strength

- Strength
  - QE (40% to 80%)
  - Gain (M=100)
  - High Speed (few 100Mhz to 1Ghz)

  - MPPC (Geiger mode photon counting APD)

MPPC

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APD - Weakness

- Weakness
  - Excess Noise Factor (F=2 to 9)
  - Temperature Stability
  - Wavelength Dependant Gain
  - Small Area (sub mm to few cm)

Excess Noise Factor

F Graph

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CCD

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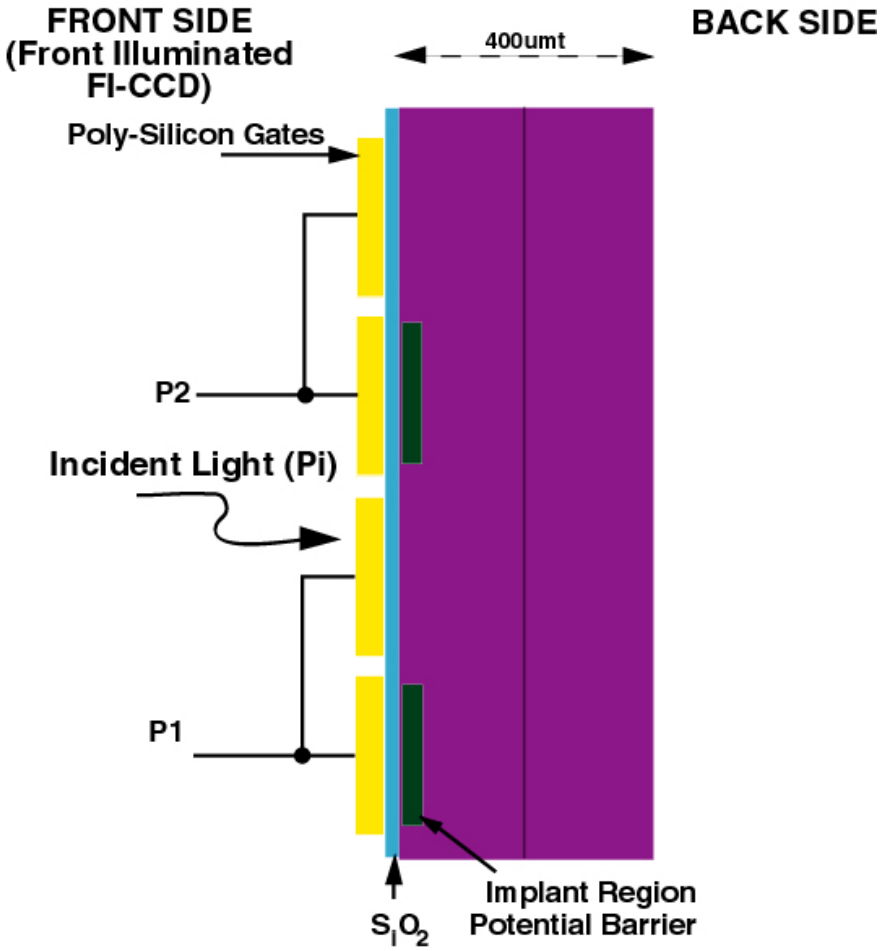
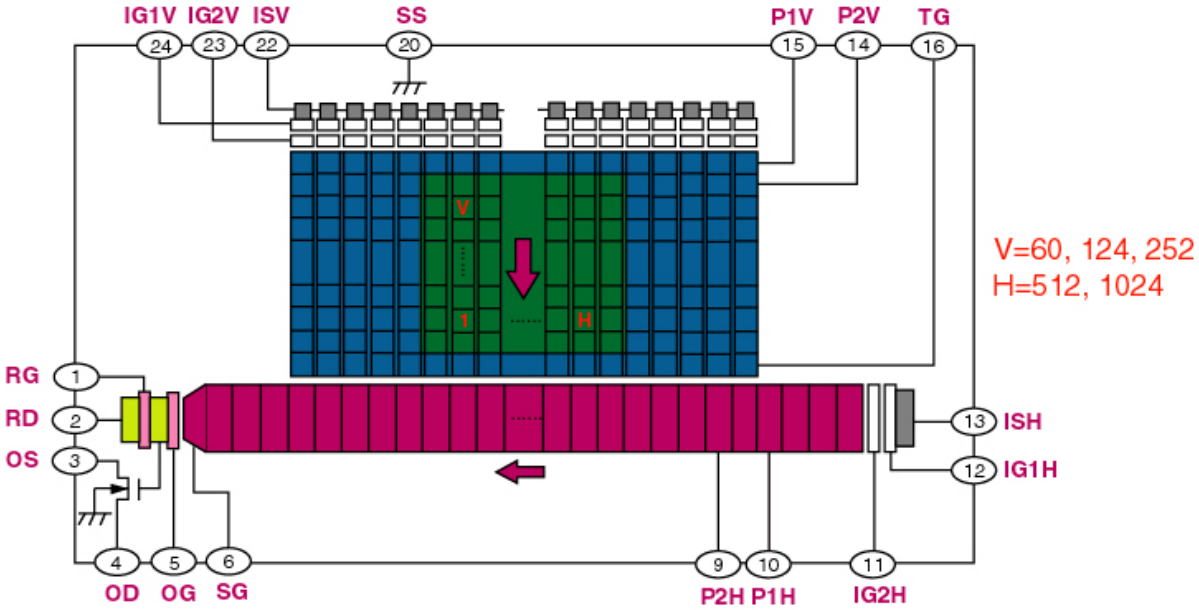
CCD – Operation Principle

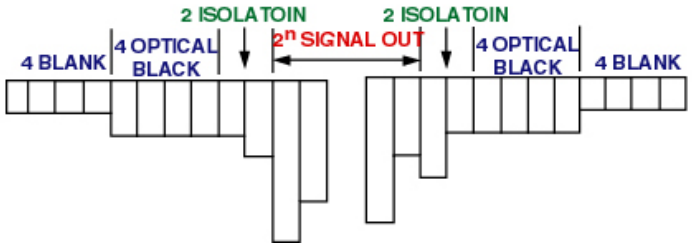


HAMAMATSU Photonics

CCD – Operation Principle

Device Structure (S7010/S7011/S7015 Series)





Line Binning

Pixel Binning

KMPDC0015EA

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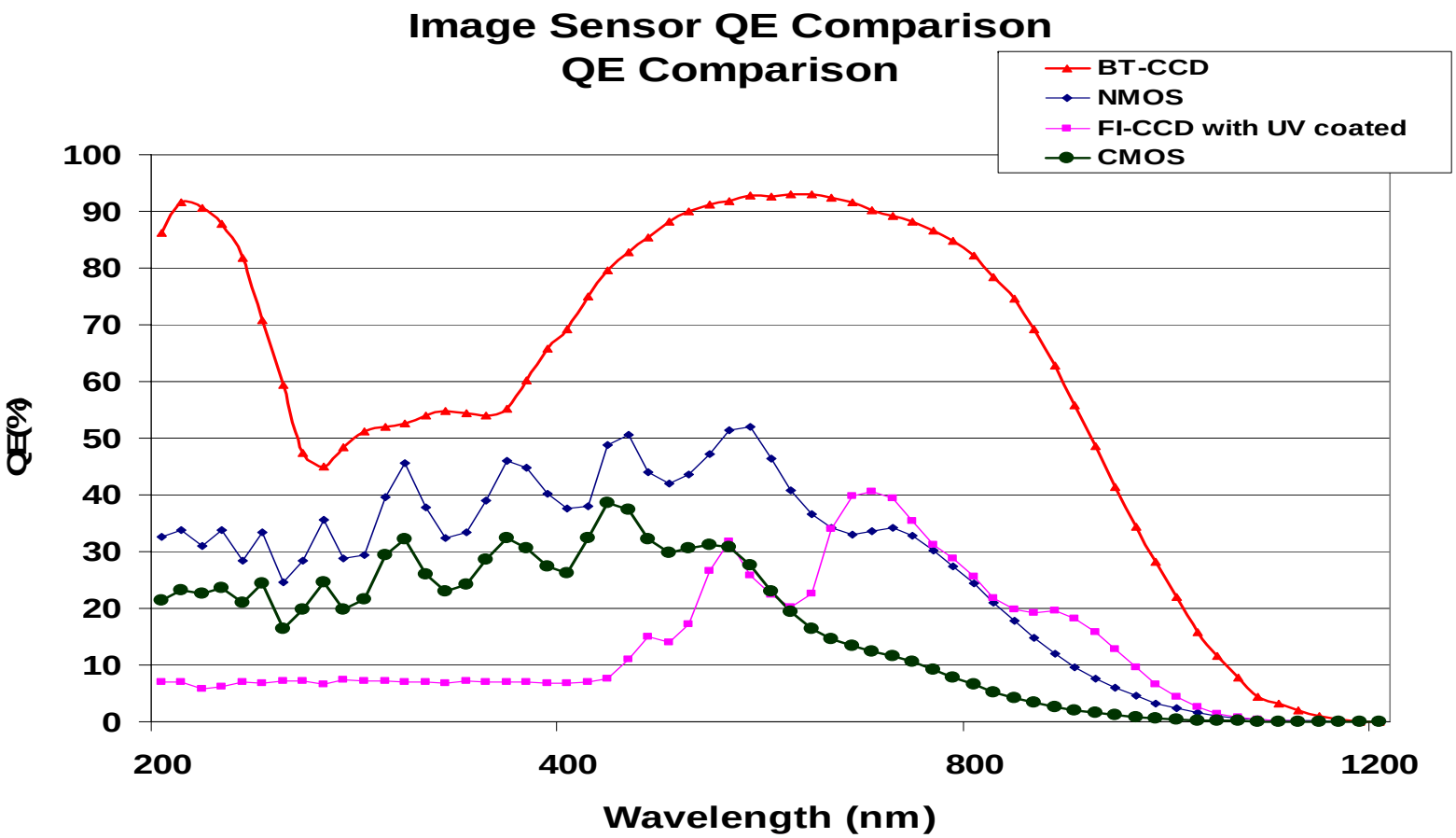
CCD - QE



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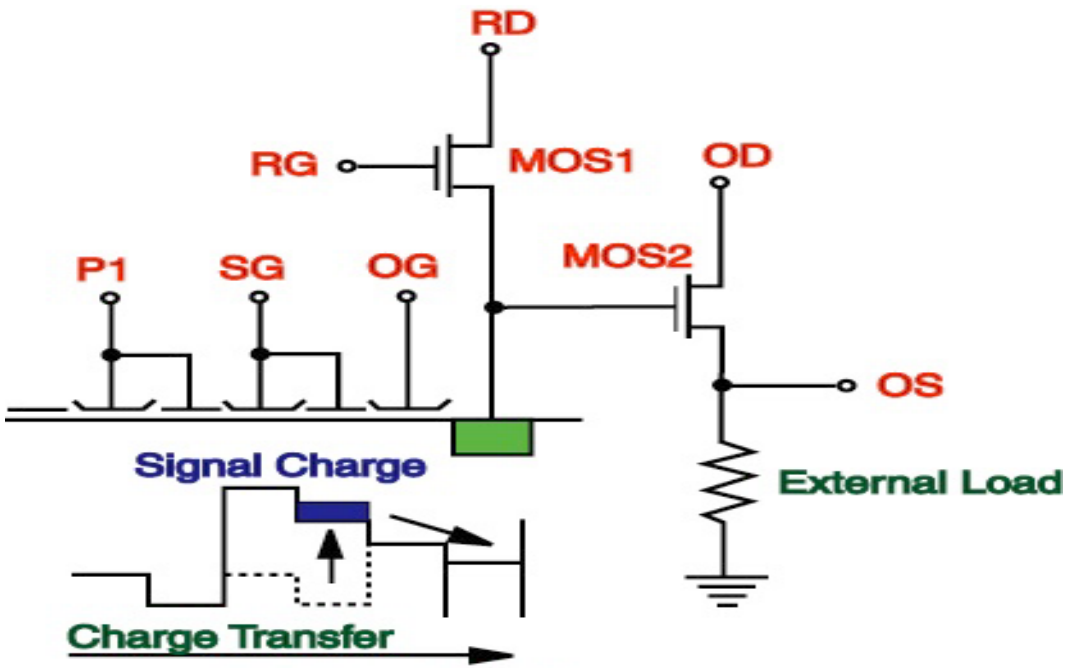
CCD - Gain



Output Voltage

$$\Delta Vo = \frac{(Av \times q)}{Cfd}$$

CCD Node Sensitivity

$$Sv = 1.6 \times 10^{-19} \left[\frac{\Delta Vo}{Av}\right] \ V/e$$

MOS Comparison

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CCD - Strength

- Strength
  - Floating Diffusion Amplifier (FDA)
    - Node Sens = 5 (uV/e-)
    - Readout Noise = 4 (e-)
  - QE (BT; QE = 40-90%)

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CCD - Weakness

- Weakness
  - Pixel Size (Specs based on 12um to 24um)
  - Dynamic Range (1e4)
  - Cost (few $100 to few $1000)
  - TE Cooler
  - CLKs (+ Driver)
  - Low Speed (Integration Measurement)

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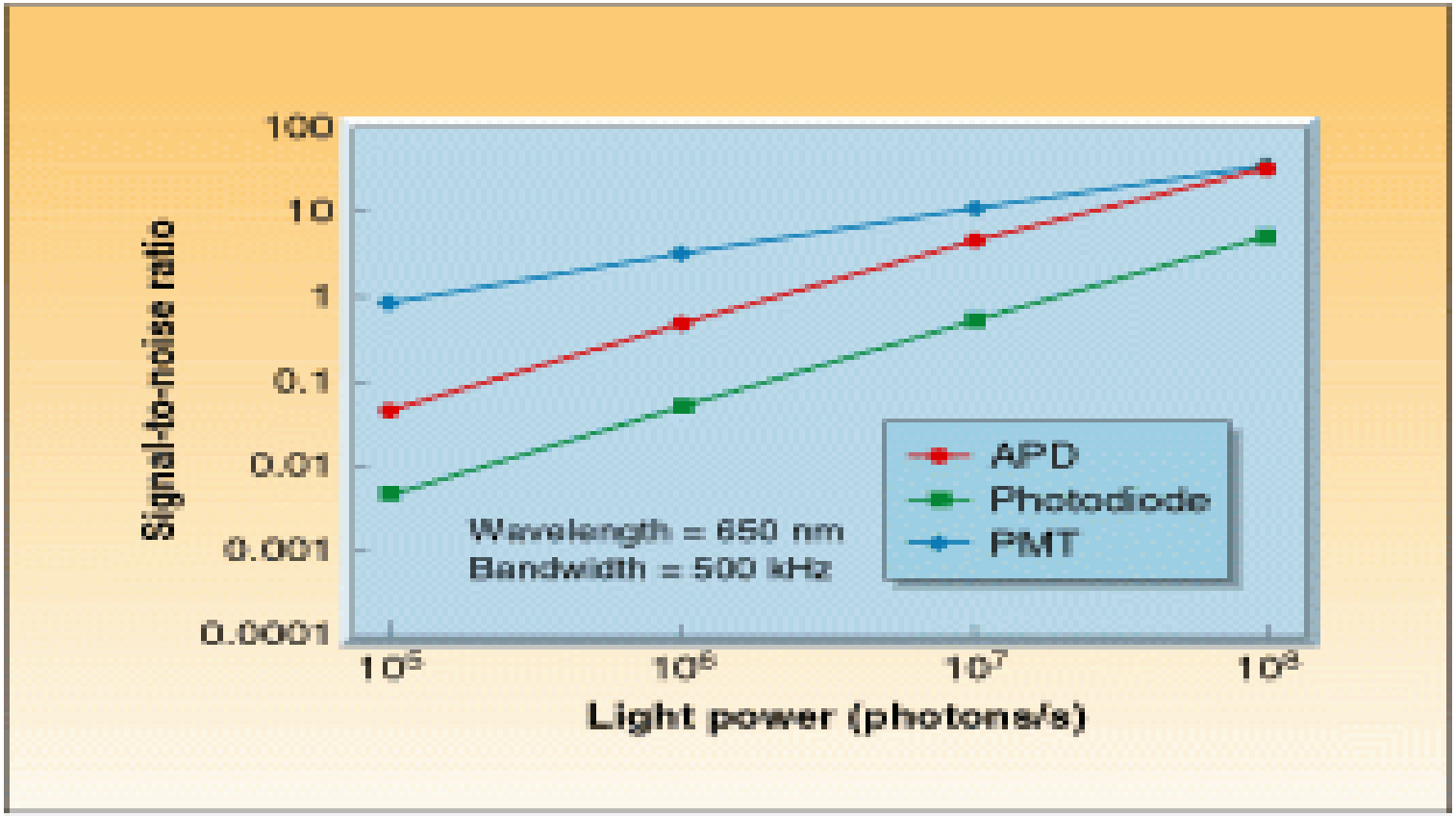
Summary – S/N comparison



3-DH-1 97 Sidebar Fig.

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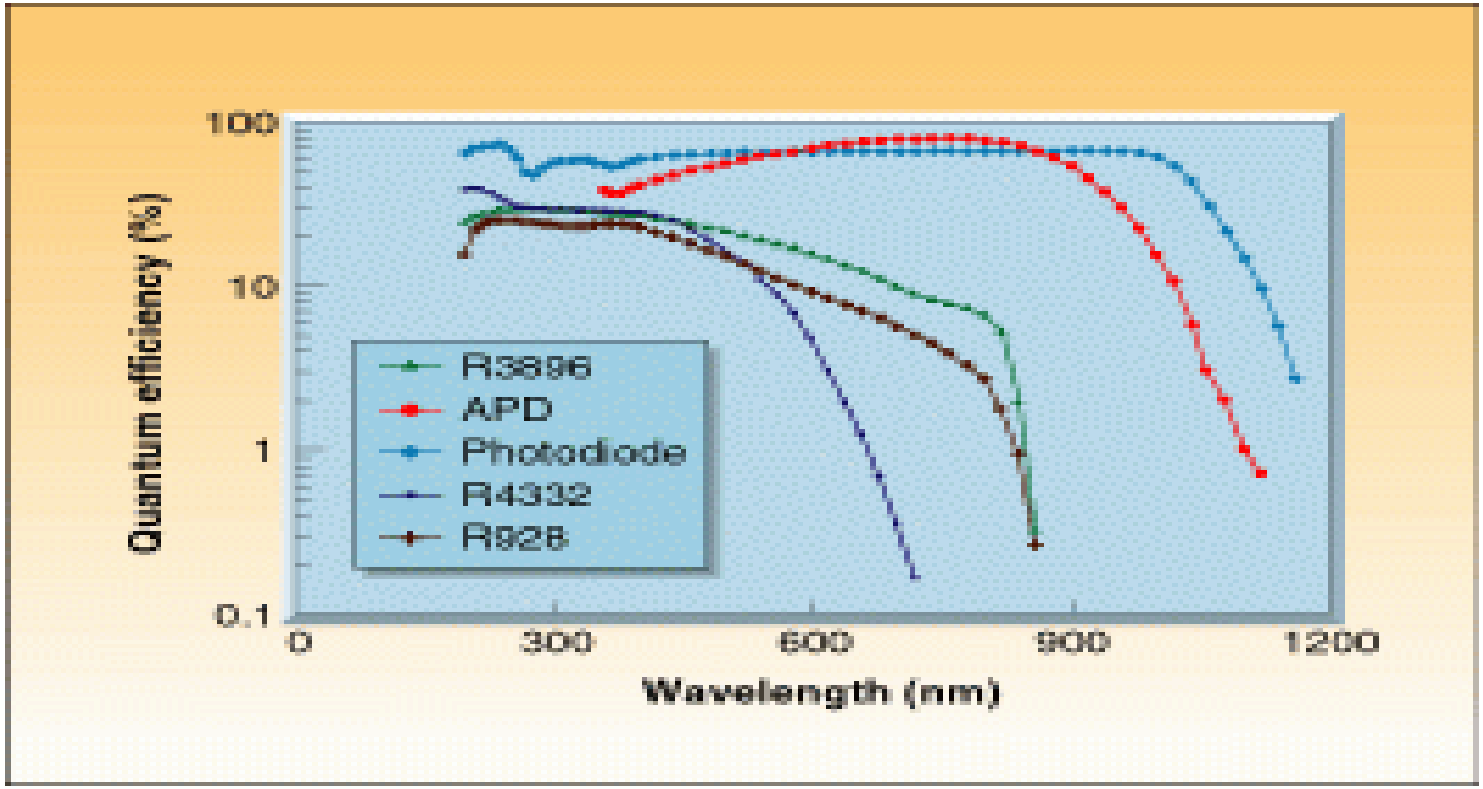
Summary – QE comparison



3-DH-1 97 Fig. 3

HAMAMATSU Photonics

Summary – Quick Guide

- PD
  - uW
  - Low cost
- APD
  - nW
  - red
  - Ghz
- CCD
  - Small area(line/2D),
  - Integration
  - 10-10k photon/readout
- PMT
  - nW to fW
  - Photon Counting

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Thank you

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